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16. Abstract

Microsurfacing is a unique pavement preservation tool in the arsenal of maintenance agencies. It is known to perform well when applied to the right pavement at the right time for the right distress. In order to ensure microsurfacing performs well, an agency must know what constitutes the right road, right time and right distress. Texas uses microsurfacing and wishes to answer these questions as well as uncover other factors leading to successful use of this treatment.

This report describes 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 a 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 microsurfacings. It was concluded that project selection is the most important contributor to a successful microsurfacing followed by construction practices. Reliance on contractors for input into proper project selection places the agency in a vulnerable position. A certification course to educate personnel is recommended.

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MICROSURFACING IN TEXAS

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permit purposes. The researcher in charge of the project was Dr. Soon-Jae Lee.

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Finally, the authors also acknowledge the support provided by Debra Howell of Texas State University in editing the final report.

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CHAPTER I:
INTRODUCTION

This study seeks to provide a thorough analysis of and report on the state of practice of microsurfacing in Texas. The findings will be compared to the state of practice of microsurfacing in other Departments of Transportation and to established best practices. The research team synthesized information gathered from a literature review, survey of TxDOT personnel, microsurfacing contractors and microsurfacing emulsion suppliers in Texas, site visits to microsurfacings in Texas and interviews of relevant stakeholders.

The survey utilized in this study was developed by the research team and based off of a survey by the National Cooperative Highway Research Program (NCHRP) created to study chip seals. The survey was sent to 138 personnel within TxDOT and received responses 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 and one of the two major emulsion suppliers responded. In the middle of performing this synthesis research, NCHRP Synthesis 411 study on microsurfacing was released. Due to the thorough analysis of pertinent literature and insightful conclusions included in the NCHRP study, the research team relied heavily on this seminal work from the point of its publication. The focus of this study then became to compare the state of practice of microsurfacing in Texas to the current state of practice nationwide as reported by NCHRP.

Due to the inclusion of data from both the NCHRP survey and the survey from this study it needs to be clarified that, unless otherwise noted, references in this report to a survey are references to the survey created and administered by this research team for this project.

Microsurfacing is a road maintenance tool that involves laying a mixture of dense-graded aggregate, asphalt emulsion (about 7% by weight), water, polymer additive (about 3 % by weight) and mineral fillers (about 1% of weight of total dry mix) to correct or prevent certain deficiencies in pavement conditions (*22*). 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 (*40*).

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 microsurfacing as in slurry seals, microsurfacing is sometimes referred to as a "polymer-modified slurry seal." The primary difference between the two treatments stems from slurry seals curing through a thermal process while microsurfacing utilizes a chemically controlled curing process (*8*). 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.

Despite the chemically controlled breaking process, microsurfacing should not be applied if either the pavement or air temperature is below 50°F (10°C) nor if there is a possibility of the treatment freezing within 24 hours of placement (*8*). Additionally, since the use of a polymer-modified binder results in greater mix stability, microsurfacing can be placed in multi-stone thicknesses, unlike slurry seals. Due to the increased viscosity of the mix, more powerful mixers are needed for microsurfacing than are required for slurry seals and in order to provide a uniform flow of the mixture into the spreader box, a twin-shafted paddle or spiral auger is needed (*29*).

Generally microsurfacing is classified as a preventative maintenance treatment as opposed to a corrective maintenance treatment because of the significant ability of microsurfacing to seal and restore pavement surfaces but the inability of microsurfacing to improve structural defects (*19*). Due to this classification by agencies involved in road repair and maintenance, microsurfacing is most often used as a surface treatment to correct rutting, improve surface friction, and extend pavement life by sealing any cracks in the pavement surface (*49*). In the survey conducted for this study, the main reasons reported by TxDOT personnel for using microsurfacing were "fill wheel ruts" and "stop bleeding on the surface." Table 1-1, taken from

NCHRP Synthesis 411, shows the relationship to pavement preservation guidelines that microsurfacing finds in most agencies that utilize the treatment.

Table 1-1. Microsurfacing's Relationship to Pavement Preservation Guidelines *(21)*

Pavement Preservation Guidelines						Micro-surfacing
	Type of Activity	Increase Capacity	Increase Strength	Reduce Aging	Restore Serviceability	
	New Construction	X	X	X	X	
	Reconstruction	X	X	X	X	
	Major Rehabilitation		X	X	X	
	Structural Overlay		X	X	X	
Pavement Preservation	Minor Rehabilitation			X	X	
	Preventive Maintenance			X	X	X
	Routine Maintenance				X	X
	Corrective (reactive) Maintenance				X	X
	Catastrophic Maintenance				X	

HISTORY

Developed in Germany in the late 1960s and early 1970s, microsurfacing was pioneered as a way to apply a conventional slurry in thick enough layers to fill deep wheel ruts, but in narrow enough courses so that the expensive road striping lines on the autobahns would not be destroyed (*69*). Dr. Frederick Raschig introduced microsurfacing to the United States in 1980 when he presented his new slurry system, Ralumac, at the International Slurry Surfacing Association (ISSA) convention. Microsurfacing is now used throughout Europe, the US, Australia, and is making inroads into many other areas (*1, 32*). Table 1-2 shows the program statistics on microsurfacing use from respondents to the survey included as part of NCHRP Synthesis 411.

Table 1-2. Summary of Microsurfacing Program Statistics from Survey Respondents *(21)*

Characteristic	**U.S. DOT**	**Canada**
Percent of Rural Local Roads with Microsurfacing	2.2%	0.0%
Percent of Interstate Roads with Microsurfacing	5.6%	9.1%
Percent of Urban Local Roads with Microsurfacing	6.0%	0.0%
Percent of Urban Interstate Roads with Microsurfacing	10.7%	0.3%
Percent Total Network with Microsurfacing	3.1%	6.9%
Average Microsurfacing Approximate Annual Volume	$3.0 million	$4.0 million*
High Reported	$12.0 million	$10.0 million*
Low Reported	$0.5 million	$0.06 million*
Average Microsurfacing Annual Program Size	60 miles (96.6 km)	57 miles (92 km)
High Reported	150 miles (241.4 km)	124 miles (200 km)
Low Reported	12 miles (19.3 km)	10 miles (16 km)
Agencies with Microsurfacing Installed by In-house Crews	1	2
Agencies with Microsurfacing Installed by Contractor Crews	30	6

* These are Canadian dollars, which at the time of this writing is trading at roughly par to the U.S. dollar.

Microsurfacing is universally considered a preventative maintenance treatment that should be used to extend the life of the underlying pavement. Failures of microsurfacing can be spectacular if applied to a roadway that is structurally unsound. Due to the fact that such applications and resulting failures have occurred on Texas pavements, combined with the high level of technique needed to design and construct microsurfacing, relatively low usage of microsurfacing and a lack of comprehensive analysis of microsurfacing on a statewide scale in

Texas, microsurfacing experiences mixed levels of understanding and confidence within TxDOT. The purpose of this study is to educate and inform TxDOT on the actual state of microsurfacing within Texas via a synthesis study on the topic.

To accomplish the project objectives, the researchers carried out a comprehensive work plan that covered the following tasks:

- To review current TxDOT and other state's practice on microsurfacing as well as a comprehensive review of previous literatures dealing with microsurfacing;
- To conduct a survey of TxDOT personnel, contractors, and emulsion suppliers involved in microsurfacing in Texas;
- To perform site visits to selected microsurfacings in Texas for validation and analysis; and
- To summarize the results with conclusions and recommendations.

The following chapters of this report document each of the tasks conducted in this project.

Chapter I - Introduction
Chapter II – Review of Literature
Chapter III – Mix Design Method and Material Selection
Chapter IV – Equipment Practices
Chapter V – Constructions Practices
Chapter VI – Microsurfacing Performance Measures
Chapter VII – Microsurfacing Successes and Failures
Chapter VIII - Conclusion and Recommendations

CHAPTER II:
REVIEW OF LITERATURE

The researchers conducted a comprehensive search of the literature and found relevant reports or papers pertaining to microsurfacing. This chapter presents the findings from the review conducted by researchers to outline items to be considered in this study.

A study by Queiroz et al (*51*) demonstrated the relationship between a country's economic development and well-being, and the quality and quantity of its road infrastructure, as Figure 2-1 illustrates. 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 in order 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 (*61*).

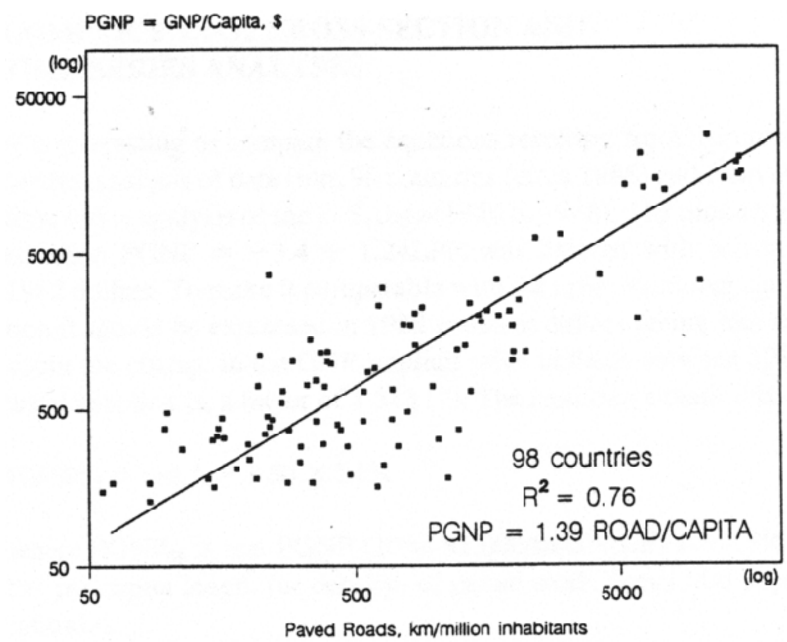

Figure 2-1. Relationship Between Per Capita Gross National Product (PGNP) and the Distance of Paved Roads (in km) Per Million Inhabitants of 98 Countries
PGNP=1.39 x LPR, where PGNP is per capita GNP ($/inhabitant) and LPR is the per capita length (or density) of paved roads (km/1 million inhabitants) (*51*)

Many studies have been done with the goal of developing a set of criteria which will accurately guide decision-makers in choosing a preventative maintenance strategy that produces the most cost-effective improvements in pavement quality and life (*9, 10, 13, 23, 24, 38, 39, 43, 48*). 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 (*43*). Chan et al. (*9*) 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 crucial to providing an affordable and usable road system (*24, 39*). Among different preventative maintenance treatments, microsurfacing is known to have economical and ecological advantages when used correctly (*62*).

DEFINITION

Preventative maintenance (PM) is performed early in a pavement's life-cycle and defined as a "program strategy intended to arrest light deterioration, retard progressive failures, and reduce the need for routine maintenance" (*24*). PM is differentiated from corrective maintenance which is performed after some deficiency manifests in the pavement (*24*). The National Cooperative Highway Research Program (NCHRP) Synthesis 223 indicates that for every dollar spent on preventative maintenance at the correct time in a pavement's life cycle, \$3~4 in future rehabilitation costs could be saved (*19*). As shown in Figure 2-2 these future rehabilitation costs are now \$6~10 saved for every \$1 spent on preventative maintenance (*18*).

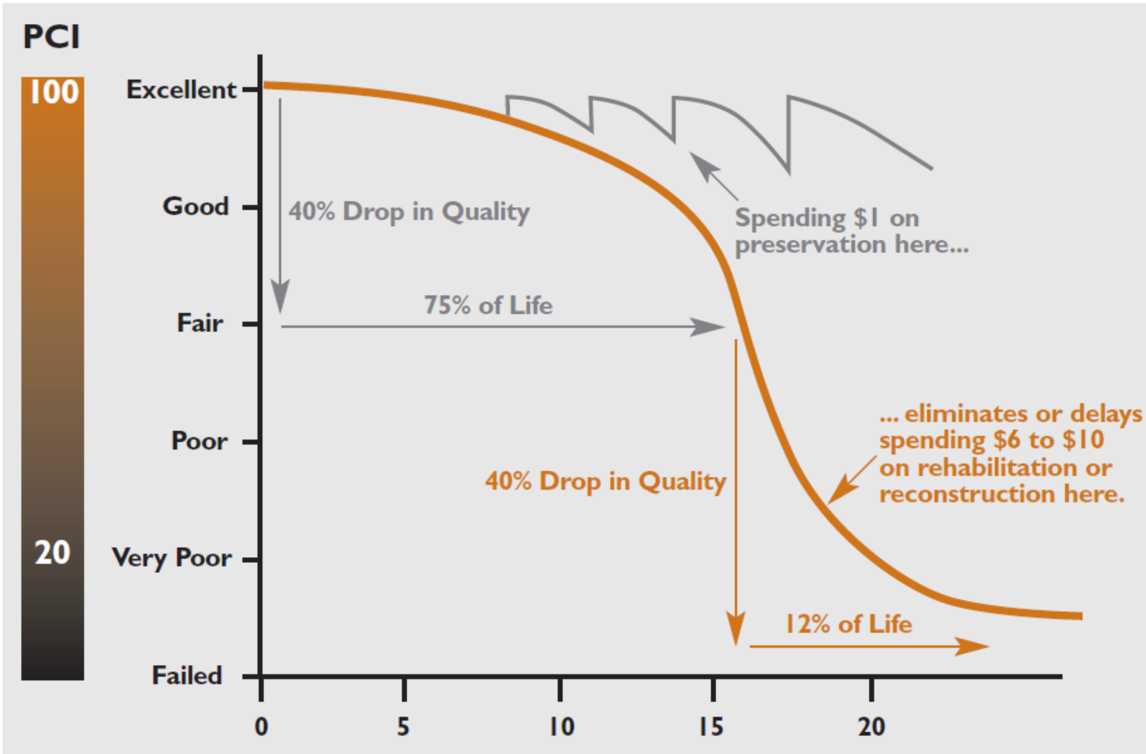

Figure 2-2. Relationship between Condition of Pavement when Treatments are Applied and Cost of Treatment. PCI = Pavement Condition Index, X-axis is in years (*18*)

An effective PM program should include periodic application of preventive maintenance treatments. In order to be cost-effective, preventive maintenance techniques should regularly be analyzed in order to determine if they are achieving their goal efficiently and economically in light of advancing technology. Microsurfacing to date, when applied by highly-trained professionals, can extend pavement life by more than ten years, but often performs poorly when applied using subpar workmanship and practices (*36*).

PROCESS

When utilizing microsurfacing as a treatment to existing flexible pavement, the first step is to ensure the pavement is structurally sound and able to be prepared properly to accept the treatment. Proper preparation of the pavement surface includes cleaning and sealing tight cracks, filling wide cracks, and thoroughly brooming and cleaning the pavement to remove loose dirt and contaminants. A tack coat is not normally applied but can be required in specific applications. The application requires a continuous-flow mixing unit, a multiblade, double-shafted mixer, and a spreader box.

The microsurfacing is mixed in the continuous-flow mixing unit which accurately mixes the materials and discharges the microsurfacing on a continuous flow basis. The mixture is spread uniformly by a spreader box with a rear seal as the final strike off and is automatically feathered at the edges. When filling ruts that are deeper than one pass will fill, 24 hours must pass to allow the microsurfacing to cure under traffic before placing additional material (*8*).

A REVIEW OF MICROSURFACING

Limitations

Factors that reportedly limit the application of microsurfacing consist of established limitations and debated limitations that may act more as suggested guidelines for use. Microsurfacing is shown to be most effective under certain conditions as Labi et al. (*42*) demonstrated that treatment effectiveness is influenced by climate, traffic loading and highway class, with greater long-term effectiveness generally associated with lower freeze and traffic conditions, and lower pavement class. While this appears to indicate microsurfacing would not be suitable for use on high-traffic roadways, there is a comparable decrease in efficiency of other treatments under heavy traffic loads. Watson and Jared (*66*) found microsurfacing to perform well for 3-4 years on heavily travelled roads, and Wood et al. (*70*) found microsurfacing treatments can be expected to last at least seven years when placed on medium to high volume roads. Additionally, Peshkin et al. (*50*) stated that microsurfacing is very successful on both low and high volume roadways and is recommended for night applications on heavy-traffic streets (*29*).

In addition to differing reports on traffic load, reports on the effect of pre-treated pavement conditions on microsurfacing are also incongruent. The concerns in literature are enough to place this in the limitations section of microsurfacing, although a case can be made on both sides. Hixon and Ooten (*26*) found that microsurfacing may have a moderate resistance to reflective cracking although it provides no increase in the load-supporting ability of pavement. Temple et al. (*63*) also reported significantly fewer cracks detected after treatment with microsurfacing. Watson and Jared (*66*) concluded that microsurfacing may be suitable for use on cracked pavements in lieu of more conventional rehabilitations such as crack sealing, leveling and double surface treatments, while Raza (*53*) also stated that microsurfacing will address cracking. Bae and Stoffels (*4*) concluded that microsurfacing could be a cost-effective maintenance technique for cracks for one year, and that if more than 3 cracks were detected in the field, microsurfacing would still be a cost-effective maintenance method for any severity crack level. Reflective cracking is the most serious threat to microsurfacing. As other types of cracks may not be structural, much of the debate centers on addressing this type of crack with microsurfacing. Marquis (*44*) does not claim microsurfacing will stop reflective cracking but does report that microsurfacing slows the progression of reflective cracking. However, other studies are not as optimistic about microsurfacing's ability to positively affect cracking as Kazmierowski and Bradbury (*36*) declared that it does not inhibit reflective cracking or provide structural support. It is suggested that premature failure of microsurfacing is normally due to placement on unstable, cracked, dirty or poorly prepared surfaces (resulting in delamination) (*3*). Additionally, in a study performed for the Texas Department of Transportation (TxDOT) on six maintenance treatments, microsurfacing was shown to perform the worst at stopping cracks when the base pavement was in poor condition upon application (*17*). A reasonable conclusion may be that microsurfacing may at times be used on structurally deficient roads, but it is done so as a stop gap and to limit water intrusion into existing cracks until money is available for more extensive repairs. This fact makes applying microsurfacing treatments at the correct time of the pavement life-cycle paramount, before structural issues develop.

An undisputed limitation of microsurfacing is that it does not level humps in the road. Microsurfacing will fill depressions and ruts but cannot address humps and will, in fact, reproduce a hump in the treatment surface. Any humps should be leveled before applying microsurfacing, and any pothole or crack patches should not be left high (*71*).

Such limitations are overcome by utilizing timely and appropriate applications of microsurfacing (*36*). Untimely applications should be avoided if at all possible as pavement rehabilitation done at the appropriate time often does not require an increase in the pavement's structural strength or thickness, but mainly a restoration or rejuvenation of its riding surface. When these limitations are considered, microsurfacing has been proven to be a powerful and versatile tool in pavement preventative maintenance.

Benefits

Microsurfacing generally receives positive reports in scientific literature. Most studies done on the effectiveness of microsurfacing encourage its use as a preventative maintenance treatment (*15, 26, 35, 42, 46, 49, 65, 66*). *Per contra*, emphasis is placed on the importance of applying microsurfacing at the correct time in a pavement's life cycle to achieve maximum durability and cost-effectiveness before the pavement has deteriorated structurally (*11, 15, 19, 24, 50, 52*).

One of the early studies done on microsurfacing in the United States foreshadowed the favorable conclusions of further research by recommending that microsurfacing be approved for routine use in restoring flexible pavements to fill surface ruts and cracks, seal the surface and restore skid resistance (*49*). The Georgia DOT had great success with microsurfacing in correcting smoothness and friction deficiencies, and stopping raveling and load cracking without an increase in pavement noise levels. A good aesthetic value was also achieved with these applications (*66*).

When a composite index score was calculated based on 11 performance criteria, microsurfacing had the highest score out of thin HMA overlays, slurry seals and chip seals (*25*). Hicks et al. (*24*) also documented microsurfacing as an appropriate maintenance strategy for more types of pavement distress than any other commonly used strategy, as well as having a longer life expectancy than all but thin HMA overlays which cost 30% more. HMA overlay is the treatment that most consistently vies with microsurfacing at addressing the broadest range of defects in the most durable manner. The ISSA reports that to address rutted and polished pavement, microsurfacing costs $17,600 per lane mile, while milling and HMA cost $50,000 per lane mile (*30*). Also, Labi et al. (*42*) found that in terms of agency costs, microsurfacing is consistently more cost-effective than thin HMA overlays. It is noteworthy that Marquis (*44*) concluded overall microsurfacing is performing as well as 9.5 mm HMA at a lower cost. Labi et al. (*42*) reported that severe climate has deleterious effects on microsurfacing. This is true of any treatment, however, and Reincke et al. (*54*) reported that microsurfacing will resist deformation, and, because of the polymer content, will also resist movement at high temperatures and cracking at low temperatures. Additionally, Kazmierowski and Bradbury (*36*) indicated microsurfacing performs well in a wet-freeze environment. Ducasse et al. (*14*) revealed that enhancing the binder with SBR latex will improve the temperature susceptibility of the binder, although it is not to be applied if freezing is a possibility. Ducasse et al. (*14*) also pointed out that worker safety is improved due to the cold-application.

Reincke et al. (*54*) and Ducasse et al. (*14*) both commented on microsurfacing's lower energy requirement due to ambient temperature applications, lack of harmful emissions associated with HMAs, and conservation of the non-renewable resources asphalt cement and aggregates because of its thin lift volume. Along these ecological lines, after performing an eco-efficiency analysis, Takamura et al. (*62*) concluded that microsurfacing "provides a better balance between cost-effectiveness and environmental impact than does a thin hot mix overlay. As Table 2-1 shows, enjoys immense energy savings over HMA's. After microsurfacing in the York region of Canada, Erwin and Tighe (*15*) found positive safety effects, including crash reduction factors as high as 54%, and suggested more research be done on the appreciable safety benefits gained from microsurfacing.

Table 2-1. Environmental Impact Comparison of Microsurfacing versus Hot Mix Asphalt Overlay (*12*)

Treatment	Compo-sition	Energy Use		Greenhouse Gas Emissions		Life Extension	Annualized Percent Savings vs. 2-in. Hot-Mix Overlay	
		BTU/CY	*MJ/CM*	*Lbs/SY*	*Kg/SM*			
Hot-Mix Asphalt Overlay	1.5 in. (3.8 cm)	46,300	59	9.0	4.9	5-10 yr	*Energy Use Savings*	*Greenhouse Gas Savings*
	2.0 in. (5.0 cm)	61,500	77	12.3	6.7	5-10 yr		
Micro-surfacing	Type III	5,130	6.5	0.6	0.3	3-5 yr	83-86%	90-92%
	Type II	3,870	4.9	0.4	0.2	2-4 yr	83-84%	91-92%

Improvements in rutting and friction characteristics are the most frequently mentioned benefits gained from microsurfacing (*15, 26, 41, 49, 66*). Hixon and Ooten (*26*) found a 40% reduction in the amount of original rutting, and substantial increases in the friction characteristics of the pavement. In the aforementioned TxDOT study, microsurfacing was shown to perform most efficiently at reducing bleeding and increasing Pavement Condition Index (*17*). Similarly to Freeman et al., Temple et al. (*63*) found microsurfacing produced a higher PCI and maintained it longer than chip sealing. Conventional thin asphaltic concrete overlays are expensive and often do not perform well in harsh environments. Also, chip seals, in addition to their performance limitations, are often associated with windshield breakage and increased noise, while microsurfacing does not suffer from either of these limitations to the same degree (*36*).

Microsurfacing allows for rapid opening of roadways to traffic, often within 1 hour or less of its application under a range of conditions (*27*). Reports of a great reduction in ride roughness support microsurfacing's immediate benefits (*46*), while additional benefits are seen over time as microsurfacing effectively addresses rutting, increases ride quality, and has a significant service life (*41*). Labi et al. (*41*) found that the superiority of microsurfacing in terms of cost is most evident when treatment life is the measure of effectiveness, and least evident when increased pavement condition is used compared to thin HMA overlays. This further strengthens the fact that the benefits seen with microsurfacing appreciate over time when compared to alternative treatments. Microsurfacing is aesthetically pleasing to people as it restores a black appearance to roadways (*66*). Microsurfacing requires no adjustment of curb lines, manholes, guide rails or bridge clearances due to its thin lift height (*54*).

Additional benefits from microsurfacing can be seen when indirect cost-savings are extracted from the literature. Reincke et al. (*54*) pointed out that the problem of broken windshields from loose aggregate occurring with other maintenance treatments doesn't happen with microsurfacing, thereby limiting costly claims after a project. When describing the safety benefits observed on roads that received microsurfacing treatments, Erwin and Tighe (*15*) also mentioned the financial ramifications of microsurfacing's reduction of automobile crashes, which cost the United States $164 billion in 2008.

Overall, literature appears to demonstrate that microsurfacing provides the best balance of effectiveness, cost, number of deficiencies for which it addresses, and potential for future development of any preventative maintenance treatment.

Factors Contributing to Success

While some limitations of microsurfacing are debated, there is no doubt that an ideal set of conditions for successful application of the treatment exists. In order to limit qualifying every statement with a note about whether agreement is unanimous on the following suggestions, this section should be considered more as a best-practices guide which need not apply when applying microsurfacing in unusual, debated or extreme scenarios. In this section, recommendations will be stated as fact, but the reader should understand there may be researchers that could take exception to certain suggestions in light of the aforementioned debates.

Factors that contribute to the successful use of microsurfacing are well documented. Research suggests that the distribution of the sub-No. 200 (75 micron) fraction is critical to control the reaction rate in microsurfacing emulsions (*56*). Due to the fast-set of microsurfacing, aggregate characteristics influence quality much more than in conventional slurry seals (*24*). Hixon and Ooten (*26*) reported that applications of microsurfacing in layers of 1.1-1.5" (25.4-38.1 mm) exhibit flushing, rerut, and crack more than lower profile lifts and, therefore, recommend filling deep ruts in two passes.

Critical components to ensure the success of a microsurfacing project include a comprehensive mix design process, quality materials, and the use of a knowledgeable and experienced contractor (*36*). Olsen (*47*) also reported that workmanship is a key factor in the effectiveness of microsurfacing treatments. Other studies have shown microsurfacing performance is strongly affected by workmanship and the condition of the pavement at the time of application is the most important factor contributing to success (*24, 31, 46, 60*). Pederson et al. (*49*) categorically stated that the quality of a finished microsurfacing project depends greatly on the skill of the operator and crew.

When used as a preventive maintenance treatment on pavements in relatively good condition, microsurfacing may last 7 to 10 years, although longer life times have been claimed (*65*). On average, however, the life expectancy of a microsurfacing treatment is 5 to 7 years (*57*). When applied in ruts, the life of the treatment is dependent on the stability of the microsurfacing, traffic level, and the condition of the underlying pavement (*42, 46*). The main mechanism of failure is wear in which the surface oxidizes and is abraded over time (*37*).

Microsurfacing should not be placed on highly deflecting surfaces, cracked surfaces, pavements with base failures, or on dirty or poorly prepared surfaces (resulting in delamination) (*3*). As is true of most PM treatments, microsurfacing is much more effective when used on non-interstate and flexible pavements as opposed to interstate and rigid pavements (*39*).

The body of scientific evidence reveals known limitations and benefits to microsurfacing, and certain factors contributing to the success of microsurfacing treatments. There is certainly a need, however, to further identify the techniques contractors have utilized which have led researchers to determine that workmanship is a crucial factor in determining the success of microsurfacing. Such understanding can only be obtained by interviewing contractors who have done the work both successfully and unsuccessfully, then isolating the key variables that create the two outcomes.

The Future of Microsurfacing

We are currently in a time when both economic and ecologic efficiency are hot-button issues receiving enormous attention in politics, the private sector and the media. With increasing demands on the world's infrastructure, it is imperative for decision makers to wisely utilize funds (*2, 50*) while also balancing the demands of citizens for environmental sensitivity. Figure 2-3 shows the environmental impact of microsurfacing compared to HMAs and even polymer modified HMAs.

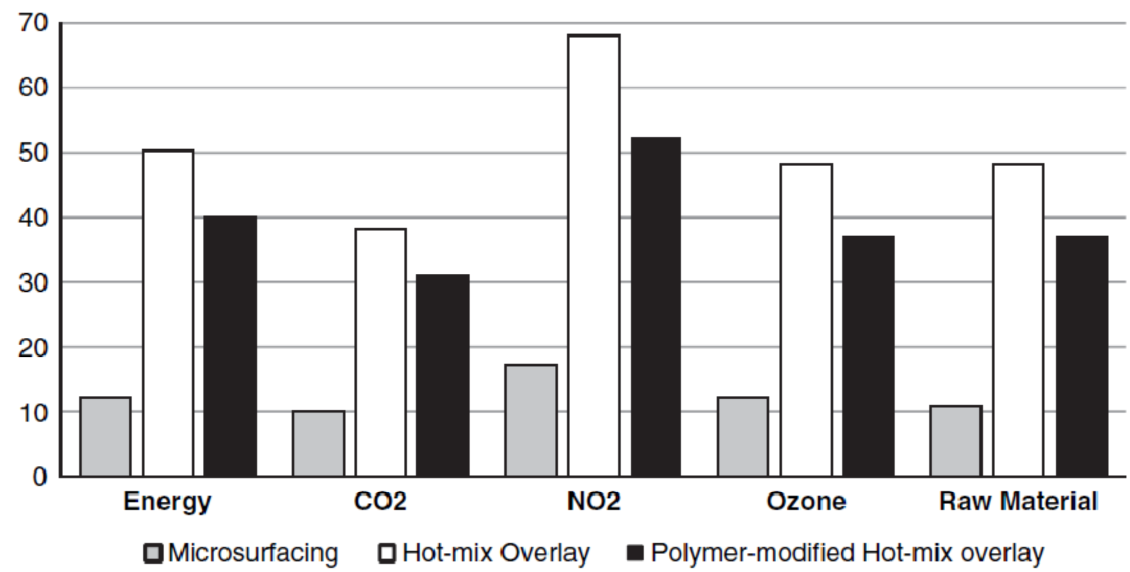

Figure 2-3. Comparative Environmental Impacts of Three Pavement Preservation and Maintenance Treatments. (*62*)

Of the preventative maintenance treatments that can effectively and efficiently prolong the service life of roadways, microsurfacing is best poised to meet the increasing demands placed upon such projects.

Much has been written on how to determine when microsurfacing should be applied to pavements in order to limit the application of treatments to pavements too far gone to benefit. The other key factor contributing to the success of microsurfacing is workmanship. Guides have been written (*31, 32*) outlining what good workmanship entails but there are still applications that are applied with poor workmanship. In a meeting on microsurfacing mix design procedures in 2004, (*16*), Glynn Holleran pointed out that the French requires a one-year warranty with their microsurfacing projects, and that instituting that requirement would be in the United States is one means of quality assurance. Would such a requirement address this key aspect of success and be affective in improving the workmanship on microsurfacing projects? Shober et al. (*58*) conducted a study and found that asphaltic concrete pavement that was warranted by the contractor had an international roughness index (IRI) that was 41% better, and a pavement distress index (PDI) that was 56% better, after three years than nonwarranted pavements. This makes a strong case that requiring warranties on all microsurfacing treatments should be common practice in order to improve the workmanship and, therefore, the success of these treatments.

Allan (*1*) stated one of the greatest challenges for our industry is to be able to meet the ever-changing environmental regulations. Cold applied-non-polluting maintenance products for road systems will definitely be used. The ISSA reports that microsurfacing emits ¼ the potential of HMA and 1/3 the potential of modified HMA with regards to kilograms of ethene, carbon dioxide, and kilograms of nitrogen dioxide when measured per lane mile (*30*). Sinha and Labi (*59*) similarly stated the impact of environmentally friendly PM treatments by pointing out the monetary costs of air pollution and the global agreements on air quality standards and air-quality legislation. Takamura et al. (*62*) concluded that a small improvement in durability of the microsurfacing would result in significant cost and ecological advantages, and that future improvements in microsurfacing technologies could lead to additional cost and environmental advantages. Along the same lines with regards to microsurfacing, Allan (*1*) predicts the possibilities for the inclusion of performance enhancing additives above and beyond those already available will greatly impact the equipment used in the future. One such study by Holleran and Reed (*28*) looked at improving the crack resistance of microsurfacing by increasing polymer content, as well as adding fibers to the binders. They found that while fibers do not help, certain polymers do increase flexibility and cracking resistance of microsurfacing, especially in association with crumb rubber asphalt. More studies need to be done on ways to make microsurfacing less susceptible to reflective cracking, effectively addressing one of the two factors that contribute most to failure of this treatment.

CHAPTER III:
MIX DESIGN METHOD AND MATERIAL SELECTION

NCHRP Synthesis 411 (*21*) describes microsurfacing deign as essentially a six step process:

(1) Identifying and characterizing the roads where a microsurfacing treatment is necessary.
(2) Selecting materials: emulsion, aggregate, mineral filler, additives, and water.
(3) Developing a job mix formula.
(4) Laboratory testing of the job mix formula.
(5) Developing application rates.
(6) Preparing construction documents based on steps 1 ~ 5.

Steps 2, 3 and 4 will be dealt with in the current chapter of this report.

Through the NCHRP survey, 27 states responded to which formal mix design their microsurfacings were based on with the following frequencies:

- ISSA Design Method for Microsurfacing (*30*): ISSA A143 — 12 responses.
- ASTM Design Method for Slurry Seals: ASTM D 3910-98 — 3 responses.
- ASTM Design Method for Microsurfacing: ASTM D 6372-99a — 2 responses.
- Texas Transportation Institute Design Method for Microsurfacing (*68*): TTI 1289 — 1 response.

Texas is the only state that bases their microsurfacing mix design on TTI 1289. TTI 1289 was developed by the Texas Transportation Institute (TTI) in 1996 making it the oldest of the mix designs by a decade (*68*). From the survey in NCHRP 411 (*21*), 77% of respondents reported that they give the contractor the responsibility for the job mix formula. Questions from this study's survey revealed that TxDOT personnel are removed from the mix design process as well with 80% of respondents not knowing which company did their mix designs. TxDOT relies on contractors in Texas to supply the mix design for microsurfacing, who in turn receive their mix designs from the emulsion supplier. This parallels the state of practice in most other states as seen in the NCHRP study with, as the NCHRP authors said, microsurfacing projects "delivered as *de facto* performance contracts." As will be shown later, such practices shift the traditional QC/QA of microsurfacing toward higher contractor responsibility.

Once supplied with the mix design, only 40% TxDOT respondents to this study's survey reported that they sample and test each emulsion delivery to the project with 37.5% reporting not testing each emulsion and 23% uncertain as to whether the emulsion are tested or not. No correlation to higher rates of microsurfacing performance ratings could be made to those districts testing each emulsion delivery from the responses to this study's survey but the results do demonstrated a degree of non-involvement of TxDOT in the mix design process.

In the NCHRP report, Texas falls into the bottom group of states in reported satisfaction with microsurfacing. Table 3-1 shows the number of respondents reporting in each satisfaction level.

Table 3-1. Microsurfacing Performance Ratings from NCHRP Synthesis 411

Performance Rating	Excellent	Good	Fair	Poor	Very Poor
U.S.	1	20	4	0	0
Canada	1	7	0	0	0
Total	2	27	4	0	0

Texas is one of the four states reporting in the "fair" category. Of the other three states, one did not report on which design procedure was used, one reported relying on the contractor for the design procedure and one reported designs based on empirical evidence from experience. It is not determined that Texas' mix design is inadequate but since Texas is the only state with a formal mix design that also reports in the lowest category of satisfaction with microsurfacing, it may be worthwhile to consider reviewing the current mix design for potential improvements. Another option could be adopting ISSA A 143 or another of the newer and more popular mix designs.

When the same question of microsurfacing performance ratings was presented to TxDOT personnel in this study's survey, this study found the responses slightly different. While NCHRP saw Texas reporting a performance rating for microsurfacing of "fair", this research team received higher degree of satisfaction as shown in Table 3-2.

Table 3-2. Microsurfacing Performance Ratings from Current Study

Performance Rating	Excellent	Good	Fair	Poor	Very Poor
Percentage of TxDOT respondents	16%	76%	8%	0%	0%

Since the survey from this study recruited a larger sample size within Texas, it should be assumed that the results from this study are a more accurate reflection of the performance rating of microsurfacing within Texas. Microsurfacing appears to present as a more polarizing pavement treatment than most. As will be discussed later, this could stem from some high-profile problems experienced with cape seals in the late 1990s. Therefore, depending on who is sampled, responses could vary greatly due to the strong perceptions of this treatment on each side.

Microsurfacing mix design in Texas is covered in TxDOT Standard Specification Item 350. This specification requires a cationic polymer-modified asphalt, mineral aggregate, mineral filler, water and has room for other additives. Warranted microsurfacing in Texas is covered by Special Specification item 3150. Mix design procedure and tests are covered by Tex-240-F and include the mixing test, wet cohesion test and wet track abrasion test. The contractor provides TxDOT with a copy of the mix design which is subject to verification before approval. 75% of TxDOT personnel survey respondents say that current microsurfacing specifications are adequate to produce a quality product in Texas. This may provide a counter argument that a change in the formal design method in Texas is warranted since the performance ratings may be higher than the NCHRP survey would indicate. Not only do TxDOT personnel report high satisfaction rates of microsurfacing performance in Texas, they also report that TTI 1289 is sufficient.

All of the contractor respondents to this study's survey say that current specifications are adequate but the one emulsion supplier stated that higher performance mix design testing was needed. In reference to this, it was reported to the research team that the "mixing test" for microsurfacing specified in Tex-240-F seemed subjective and inadequate by a small number of personnel within TxDOT. The emulsion supplier reported that they are working on alternative tests but do not currently have viable substitutes.

From the 10% of respondents from TxDOT reporting inadequate microsurfacing specifications in Texas, comments on how to improve the specifications included "Need to adjust aggregate gradation requirements depending on the harshness of the aggregate used" and "Increase flexibility of material." The purpose of suggesting adjusting gradation requirements depending on harshness seeks to maintain excellent skid resistance in microsurfacing since friction loss is one of the defects that microsurfacing should correct. Increasing the flexibility of the material walks a fine line that many surface treatments do of trying to balance a durable wearing surface with the ability to absorb damage and "self-heal." In studies done by the Kansas Department of Transportation and the Minnesota Department of Transportation that will be discussed in Chapter VII of this report, it was determined that the use of a softer binder to produce a more flexible microsurfacing results in increased resistance to reflective cracking and better thermal deformation protection (*55*). The research includes the addition of a new additive developed by Road Science but since susceptibility to reflective cracking is a weakness of microsurfacing, it is worth monitoring developments in this area for potential improvements in the mix design.

MATERIALS SELECTION

Materials acceptance testing ensures that the materials proposed for use by the contractor meet the specification requirements. This testing may be done at district or Construction Division Laboratories and must be completed prior to commencement of work.

In Texas, the following tests are done to ensure quality of the ingredients.

Polymer-Modified Emulsified Asphalt Concrete

- Ensures that the polymer-modified asphalt concrete meets the specification requirements.
- Determines the percentage of polymer in the distillation residue by test method Tex-533-C or another analytical method approved by TxDOT.

Emulsions used for microsurfacing in Texas do not have a required test. The specific binder that is used for microsurfacings in Texas is Cationic Polymer-Modified Asphalt: CSS-1P (MNT 506). Texas is the only state from the NCHRP study that uses this binder with CSS-1hP the most commonly used binder nationwide. CSS-1hP is a similar but harder binder than the one Texas uses. Emulsions used in microsurfacing are unique due to the addition of latex polymers. The latex does not combine chemically with the asphalt, instead, the latex "melts" around the asphalt providing an integrated structure as seen in Figure 3-1.

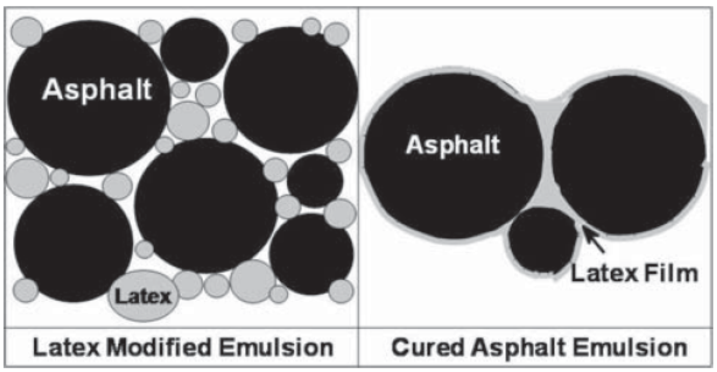

Figure 3-1. Emulsion with Latex in Dispersion after Breaking and Curing (*67*)

The addition of polymer additives to the microsurfacing mix improves stiffness and temperature susceptibility and improves adhesion and cohesion properties of the binder. Natural rubber latex is a commonly used polymer. Other polymers used include styrene butadiene rubber, styrene butadiene styrene and ethylene vinyl acetate. The amount and suitability of the polymers is determined by viscosity and softening point tests on asphalt cements. Table 3-3 shows the typical properties of microsurfacing emulsions.

Table 3-3. Typical Properties of Microsurfacing Emulsions (*32*)

Test	Typical Specification	Method
Residue	62% min.	AASHTO T59
Sieve Content	0.3% max.	AASHTO T59
Viscosity at 77°F (25°C)	15-90	AASHTO T59
Stability (1 day)	1% max.	ASTM D244
Storage Stability (5 days)	5% max.	ASTM D244
Residue Penetration at 77°F (25°C)	40-90	ASTM D244
Elastic Recovery	5%-60%	AASHTO T301
Softening Point	135°F (57°C) min.	ASTM D5
Distillation at 350°F (177°C)	62% min.	ASTM D6997
Polymer Content	3.0% min.	ASTM D6372

Aggregate

The mineral aggregate should:

- be composed of clean, tough, and durable particles of crushed trap rock, crushed granite, crushed sandstone, or other material approved by the engineer.
- be produced by crushing operations from a single source.

Table 3-4 shows the test methods used in Texas to ensure that aggregate specification requirements are met.

Table 3-4. Aggregate Testing Requirements (*74*)

Test Method	Description
Tex-203-F	Sand equivalent. Performed on the gradation to be used on the project.
Tex-411-A	Maximum weight loss when subjected to five cycles of conditioning using magnesium sulfate solution. Performed on the gradation to be used on the project.
Tex-438-A	Polish value test. Performed on the parent rock.
Tex-200-F, Part II	Washed sieve analysis gradation requirements.

For comparison, NCHRP Synthesis 411 reported the general aggregate requirements as seen in Table 3-5 below.

Table 3-5. General Aggregate Properties and Aggregate Requirements (*32*)

Test	Microsurfacing	Test Number and Purpose
Sand Equivalent (min.)	65	ASTM D2419 Clay Content
Soundness (max.)	15%	ASTM C88 (using $NaSO_4$)
Abrasion Resistance	30% max.	AASHTO T96 Resistance to traffic
Crushed Particles	100%	ASTM D5821

Two different gradation specifications emerged from the NCHRP study as most commonly used, namely Type II and Type III. Table 3-6 shows the difference in the two gradations. Type II has a smaller aggregate distribution leading to less road noise whereas Type III has a greater macro texture resulting in better drainage but noisier roadways. Texas has a slightly different gradation specification as shown in Table 3-7.

Table 3-6. Microsurfacing Aggregate Gradations (*32*) and Usage Found in the NCHRP 411Survey

	Percentage Passing		
Sieve Size	**Type II**	**Type III**	**Stockpile Tolerance**
3/8 (9.5 mm)	100	100	------
# 4 (4.75 mm)	90-100	70-90	± 5%
# 8 (2.36 mm)	65-90	45-70	± 5%
# 16 (1.18 mm)	45-70	28-50	± 5%
# 30 (600 μm)	30-50	19-34	± 5%
# 50 (330 μm)	18-30	12-25	± 4%
# 100 (150 μm)	10-21	7-18	± 3%
# 200 (75 μm)	5-15	5-15	± 2%
	Survey Usage		Other Gradation
U.S.	16	11	6
Canada	2	7	1
Total	18	18	7
Content Analysis Total	7	6	8
Grand Total	25	24	15

Table 3-7. Aggregate Gradation Requirements from TEX-200-F, Part II (Washed)

Sieve Size	**Percent Passing**
½	100
3/8	99-100
#4	86-94
#8	45-65
#16	25-46
#30	15-35
#50	10-25
#100	7-18
#200	5-15

Texas specifications are in between Type II and Type III. The main benefit seen with a finer gradation appears to be lower road noise. When asked what the most common public-user complaint was about microsurfacings in Texas, only 3% of survey respondents said road noise with 74% reporting no user complaints. The only recommended changes to the gradation requirements came from the microsurfacing contractors in Texas to "raise the 3/8" on rutfill and remove the 3/8" on surface course", and "open up sieves similar to ISSA Type II to allow more coarse gradation for some projects. Also one contractor suggested TxDOT "allow ISSA Type III gradations to be used for coarser texture on skid resistance, rut fill and scratch courses." It appears that creating a separate gradation specification for scratch courses would be a beneficial change to the current microsurfacing requirements simply because the contractors who have the knowledge and experience with microsurfacing suggest such a change.

Mineral Filler

Mineral filler is used in microsurfacing as a "mixing aid allowing the mixing time to be extended and creating a creamy consistency that is easy to spread . . . hydroxyl ions counteract the emulsifier ions, resulting in a mix that breaks faster with a shorter curing time" (*21*).

Mineral filler for microsurfacing in Texas should be non-air-entrained Portland cement that is free of lumps or foreign matter and meets the requirements of Item 524 of the Texas Standard Specifications for Construction of Highways, Streets and Bridges (*75*). The only type of mineral filler reported by contractors as used in Texas was Portland cement. The types of mineral fillers found in the NCHRP study were more varied including: Portland cement, hydrated lime, limestone dust, crushed rock screenings, fly ash, kiln dust and baghouse fines.

Water

Water used for microsurfacing should simply be potable and free of harmful soluble salts. Contractors in Texas do not test the water unless it is drawn from a natural water source in which case the water is tested with the mix design. As long as potable water is used, sulfates or other impurities will not be a problem.

Other Additives

Additives to microsurfacing are used primarily to control break time. Since the specific additive is often part of a proprietary formula, emulsion suppliers select the appropriate compound and then submit the chemical composition, brand name, additive designation or other acceptable method of identification directly to TxDOT for verification of compatibility. In Texas, Ralumac or other break control additives are used ubiquitously but only one contractor reported using an additive in addition to a break control in the form of an anti-stripping agent. Nationwide, NCHRP found the following additives used: Aluminum sulfate crystals, ammonium sulfate, inorganic salts, liquid aluminum sulfate, amines, and anti-stripping agents.

MIXTURE DESIGN VERIFICATION

Once the contractor has provided the mix design for a microsurfacing in Texas, the materials to be used in that microsurfacing must be available to TxDOT to test. TxDOT performs the tests in Table 3-8 to verify the mix design meets the requirements.

Table 3-8. Mixture Design Testing Requirements for Texas

Test Method Tex-240-F, Part I	"Mixing Time Test"
Test Method Tex-240-F, Part II	"Modified Cup Flow Test"
Test Method Tex-240-F, Part III	"Wet Cohesion Test"
Test Method Tex-240-F, Part IV	"Wet Track Abrasion Test"

For reference, the typical test requirements for microsurfacing mix designs that are based on the International Slurry Surfacing Association's (ISSA) formal designs are included in Table 3-9. The wet cohesion and wet rack abrasion tests used by TxDOT are identical to those seen in ISSA's requirements. Texas uses Part I and II of Tex-240-F to determine the viscosity and break time of the mix.

Table 3-9. Typical Microsurfacing Mix Requirements (32)

Property	Test (ISSA)	Microsurfacing
Wet-Track Abrasion Loss (wear loss)	TB 100 (1 hour soak) (6 day soak)	50 g/SF (538 g/SM) max. 75 g/SF (807 g/SM) max.
Wet Cohesion (traffic time)	TB 139 (30 minutes) (60 minutes)	12 kg-cm min. 20 kg-cm min.
Wet Stripping (adhesion)	TB 114	Pass 90% Minimum
Classification Compatibility (integrity)	TB 144	11 Grade Points Minimum (AAA, BAA)
Excess Asphalt by LWT Sand Adhesion (excess binder)	TB 109	50 g/SF (538 g/SM) max.
Lateral Displacement (deformation)	TB 147	5% max.

LWT = loaded wheel tester.

MIX DESIGN DURING CONSTRUCTION

Mix design and material selection appears to be an important part of microsurfacing success. Because of the importance of correct mix ratios, 50 % of respondents to this study's survey said that the contractor should be allowed to adjust the water content of the mix design in order to compensate for weather, 12% said mineral filler and 27% said asphalt emulsion. 80% of respondents also said the contractor should be allowed to adjust for mix design to account for existing pavement surface conditions. This reflects understanding on the part of TxDOT personnel that on-site conditions affect the mix enough that a contractor must be allowed to change certain items to ensure a quality product.

When asked what a good contractor does, respondents to this study's survey reported that the contractor will be knowledgeable on mix design and how to alter it during placement for best results but will also communicate such changes to the TxDOT personnel on site. The communication of the changes is as crucial to TxDOT personnel as the actual changes are to the success of the project. Responses to factors that contribute to a contractor delivering a successful or unsuccessful microsurfacing project included the answer "material and mix design" with the third highest frequency behind construction practices and communication of knowledge. This parallels the overarching logic seen in this study that no quality of mix design will overcome poor project selection but that a good mix is an essential part of a quality microsurfacing. The authors of NCHRP Synthesis 411 said it well when they stated "Applying the perfectly designed job mix to a road that will not benefit from microsurfacing is a formula for failure."

It appears that the mix design is something that is complex enough and far enough removed from TxDOT personnel that they must rely on the contractor's expertise for the design. This level of dependence creates an obvious unease in TxDOT as shown by the numerous comments that a good contractor will work with and communicate to the TxDOT personnel onsite in order to achieve a successful product. TxDOT personnel clearly report a reliance on contractor knowledge but also a desire for contractors to bring them into the process through communication.

CONCLUSIONS

It is difficult to point to specific inadequacies in mix design or material specifications as major contributors to the success or failure of microsurfacing. Specifications could be altered to include higher performance mix design testing, gradation requirements depending on the harshness of the aggregate, or even completely changed to a new set of specifications and some improvement in microsurfacing performance may be seen as a result. However, for the most part, 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 conclusion stems from five times more respondents to the survey citing project selection as the most critical factor in successful microsurfacing projects than citing material selection or mix design. Three and one half the number of respondents reported contractor experience as the most critical factor than material selection or mix design.

NCHRP 411 (*21*) 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 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.

CHAPTER IV:
EQUIPMENT PRACTICES

In this chapter the researcher team reviewed literature, survey responses and reports of equipment practices from interviews that contribute to or detract from the quality of microsurfacings.

INTRODUCTION

A microsurfacing paving train usually consists of a self-propelled, continuous travel mixer with onboard storage that is continually replenished by specialized trucks. The trucks deliver aggregate in a dump bed or dump trailer with tanks on the side containing emulsion and water, both of which are offloaded simultaneously with the aggregate. All of the ingredients are stored separately on the mixer and combined at the back as they are delivered to the spreader box. A major benefit to such a system is the ability to replenish material stores while on the move, decreasing the number of stops and starts and therefore the number of transverse joints in the microsurfacing.

When rut filling is required, a special rut box may replace the normal spreader box, especially when the ruts are deep enough to require two passes. When two lifts are utilized, a rut box will be employed on the first pass to fill the ruts and create a level surface on which to apply the wearing course.

A single operator stands on an elevated platform over-looking the spreader and controls the speed of the train. The operator also controls the amount of additive to control break time and time to traffic opening as well as the amount of water in the mix to adjust viscosity, or workability. Adjusting the amount of water only affects the fluidity of the mix and does not affect the amount of asphalt on the aggregate.

Truck-mounted microsurfacing machines are available but are not preferred and do not meet TxDOT specifications. The main flaw of truck-mounted units is the inability to perform continuous paving which leads to more, and potentially poorer, transverse joints. This flaw presents in truck-mounted units since supply trucks do not replenish the onboard stores of materials on the fly as the self-propelled units do, forcing the truck mounted units to stop paving to replenish stores.

Figure 4-1. Self-Propelled Unit (Left) vs. Truck-Mounted Unit (Right).

EQUIPMENT PRACTICES

Survey questions aimed at understanding best practices for equipment saw TxDOT personnel reporting that they require computerized monitoring of the mixing ratios half of the time. There was no correlation to those districts reporting that they required computerized monitoring of mixing ratios and higher performance of their microsurfacings. This finding is most likely due to the fact that current computerized mixing on microsurfacing machines simply act as a counter and calculator to report mix ratios and does not adjust the ingredients at all. The operator on a computerized or non-computerized mixer makes the same adjustments and the process only differs in whether the operator makes the calculations of ingredient-amount ratios or the computer does.

Overall, equipment practices were a low-frequency response to contributors of microsurfacing successes from TxDOT personnel. However, the research team followed up with one TxDOT engineer that reported a contractor that "tried to perform work with equipment not adequate for the job." The engineer oversaw a contract that was awarded to a contractor without access to the usual continuous, self-propelled microsurfacing paving train. The engineer was concerned because the contractor was inexperienced in microsurfacing and was planning to use low tech equipment to apply the material. The contractor claimed he could meet the specifications without having the traditional micro laydown machine. Before work began the contractor defaulted on the contract but the incident left an impression on the engineer. Specifications currently state that a self-propelled microsurfacing machine be used to perform the work and should be adequate to prevent such attempts at meeting specifications with improper equipment. However, NCHRP Synthesis 411: Microsurfacing says that “it is critical that the construction equipment system be well defined and capable of controlling the construction means and methods critical to the performance of the product.” The same synthesis cites Begkamp (*7*) saying “to a great extent, the equipment used in the construction phase drives the quality and performance of microsurfacing during its service life.” It is important to educate TxDOT personnel on what types of equipment are acceptable to meet the microsurfacing specifications in Texas to prevent incidences such as the one described above.

Equipment practices saw much greater importance as a contributor to success given to it from the microsurfacing contractors that responded to the survey than from the TxDOT personnel. Three of the four responding contractors included equipment maintenance as a crucial characteristic of a good microsurfacing contractor. One contractor reported that the main trait of a good contractor was “extensive maintenance and upkeep of paver and spreader box.” This difference in responses is not surprising since TxDOT personnel are reporting from the agency perspective which, by and large, does not have intimate knowledge of the practices of microsurfacing contractors.

When it comes to equipment practices that are key to a successful microsurfacing, the NCHRP study concluded that the items in Table 4-1 are crucial.

Table 4-1. Keys to Microsurfacing Success

A clean spreader box
No leaks
Pulled smoothly and evenly
No vibration

For TxDOT, an interesting dilemma arises with regards to equipment practices. TxDOT utilizes method specifications for microsurfacing which specify the types of equipment to be used to meet the specifications. Other states are mixed with some using method specifications which detail the equipment to be used such as Georgia and others simply using performance specifications with the contractor free to accomplish them however he may (*21*). The correct approach may not be obvious since method specifications may prevent attempts by contractors to meet specifications without the necessary equipment but as seen in other parts of this study, contractors in Texas know much better how to construct successful microsurfacings than TxDOT. Due to the lack of experience with microsurfacing on the part of TxDOT, allowing the contractor the freedom to exercise their experience through the use of performance specifications may prove beneficial. Instead of TxDOT attempting to codify practices such as those in Table 4-1, it may be more practical to specify an end-product and then allow contractors to enforce Table 4-1 internally.

Another example of this is one TxDOT respondent to the survey who reported that a poor microsurfacing contractor "uses poorly maintained equipment." Maintenance of equipment is difficult to operationalize, how clean is clean? It is better to focus on the requirements of the end product which then creates a minimum level of performance the machine must exhibit and results in a *de facto* cleanliness specification. It is therefore important to educate TxDOT personnel on certain construction defects to watch for that can come from improperly maintained equipment. A few of the greatest defects can be drag marks in the fresh microsurfacing coming from a damaged or dirty rear strike off, "washboarding" from jerky pulling or vibrations or running edges from spreader box leaks.

One TxDOT respondent of the survey mentioned starting and stopping the travel of the paving train as a problem that contractors can introduce into a microsurfacing project. This most often refers to the use of a truck mounted machine that must stop to have its ingredients replenished, resulting in transverse joints every time the paving is stopped. TxDOT specifications call for a continuous flow machine which appears to be a step above most other DOTs in the United States which report they prefer continuous mixing units but accept both (*21*). If a contractor is starting and stopping frequently in Texas, the purpose of specifying a continuous flow mixing unit is frustrated and that contractors should be approached by TxDOT about the reasons for such construction practices.

All of the contractors reported calibrating equipment at the beginning of every job with one reporting matching the weigh bin and screener tickets with the micropaver production ticket on a daily basis. Another contractor reported that they sometimes calibrate at every location, not just every project. Answers on frequency of furnishing calibration certificate ranged from "every project" to "minimum once a year or each time they change aggregate source." TxDOT specifications do not set a frequency of calibration or a calibration certificate except for in Standard Specification Item 520 which states "Check all weighing and measuring equipment after each move and at least once every 6 months. Or when requested by the engineer." TxDOT has their own procedures detailed for verifying equipment meters. The ISSA Inspector's Manual for Slurry Systems (*7*) contains recommendations as well as procedures for calibrating microsurfacing equipment and sets the procedure for such checks and is commonly used by agencies in the U.S. NCHRP Synthesis 411 reported that respondents to their survey favored field calibration to certified laboratory calibration by a margin of 2 to 1. Calibration comes into play when dealing with application rates and payments based on units of quantity. Application rates will be dealt with in the next section under "Construction Practices."

CONCLUSION

In general, since Texas appears to have adequate specifications in the category of equipment practices, 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 and specifications on the finished product should force the contractor to rectify any such problems. As long as a contractor has the proper equipment called for in the specifications and keeps it calibrated, sufficient equipment practices should result. Until computerized machines actually adjust the mixing ratios automatically, the final product is much more affected by the experience and skill of the crew using that machine.

CHAPTER V:
CONSTRUCTION PRACTICES

In Task IV, the research team analyzed construction practices that contribute to success or failure of a microsurfacing.

Construction practices appeared close behind project selection in the survey as the most important factor in determining success of a microsurfacing. Interestingly, while construction practices were reported as the second most important factor, specifics of what practices are beneficial seem hard to pinpoint. It may be a case of a contractor either has it or they don't. Case in point, simply "uses good construction practices" was a common answer. Some of the specific traits of a good contractor that were reported in the survey include:

"Stop paving when weather conditions are not appropriate."

"Cares about building a quality job not just meeting the minimum specifications."

"Accepts low production at the start of a project until both the Contractor and the Engineer (TxDOT) are satisfied with the combination of materials, mix design, roadway conditions and application rates to assure a quality finished product."

"Monitor material consistency."

Two consistent responses to important construction practices that cite specifics and run throughout the survey are rate of application and not paving when the weather turns poor. Weather conditions are dealt with in TxDOT specifications and match the temperature requirements of 12 other states, the greatest amount of states for any given temperature specification range (*21*). TxDOT personnel responded to this study's survey regarding whether weather conditions during application affect the success of microsurfacing with 48% saying "greatly", 45% saying "somewhat" and 7.5% "Not at all." Olsen (*47*) reports that weather factors are often responsible for failure of a newly constructed microsurfacing. This is another area where TxDOT personnel may benefit from a class on microsurfacing.

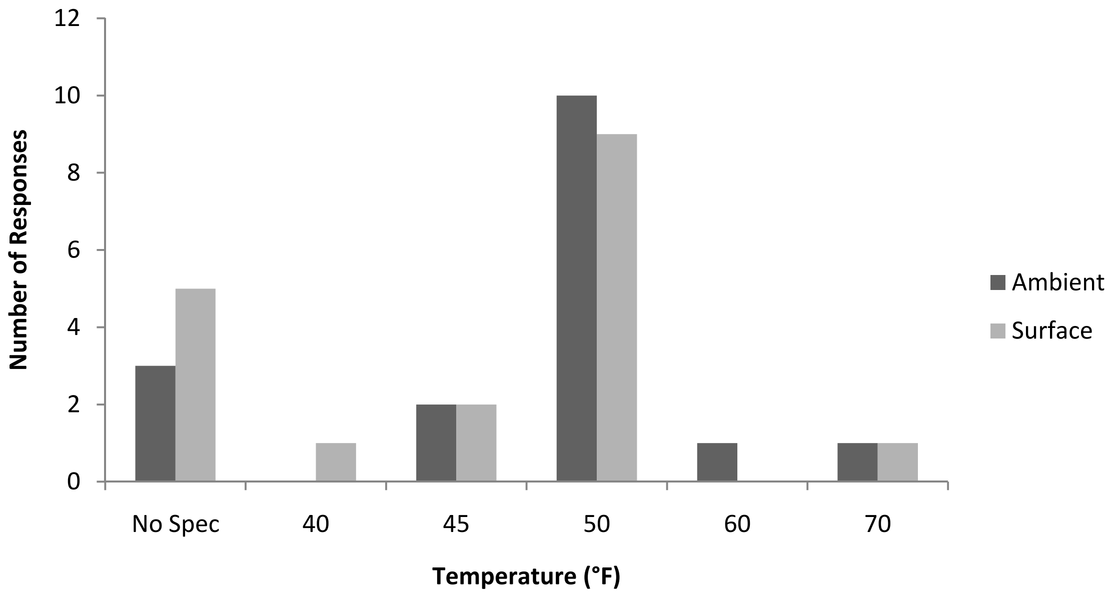

Figure 5-1. Summary of U.S. and Canadian Ambient Air and Surface Temperature Specifications.

Application rates are not included in TxDOT specifications yet interestingly enough the majority of personnel reporting these criteria as separating good contractors from bad ones also responded that microsurfacing specifications are adequate to produce a good product. Most likely such seeming disconnect in fact points to the difficulty in creating specifications for application rate and therefore the importance of a skilled contractor who will monitor and adjust for these factors appropriately. As seen in Table 5-1 below, suggested application rates vary considerably within a given application and differ from one application to the next. The rates should be established during the mix design and then monitored carefully by the contractor during construction.

Table 5-1. Suggested Application Rates (29)

Aggregate Type	Location	Suggested Application Rate per Pass
Type II	Urban and Residential Streets	10-20 lb/SY (5.4-10.8 kg/SM)
	Airport Runways	10-20 lb/SY (5.4-10.8 kg/SM)
	Scratch or Leveling Course	As required
Type III	Primary and Interstate Routes	15-30 lb/SY (8.1-16.3 kg/SM)
	Wheel Ruts	As required (see below)
	Scratch or Leveling Course	As required
Rut Depth		**Application Rate**
0.5-0.75 in. (12.7-19.1 mm)		20-30 lb/SY (10.8-16.3 kg/SM)
0.75-1.00 in. (19.1-25.4 mm)		25-35 lb/SY (13.6-19.0 kg/SM)
1.00-1.25 in. (25.4-31.75 mm)		28-38 lb/SY (15.2-20.6 kg/SM)
1.25-1.50 in. (31.75-38.1 mm)		32-40 lb/SY (17.4-21.7 kg/SM)

Along these lines, TxDOT inspectors and engineers have reported discomfort with the operator "adjusting knobs" on the microsurfacing machine while constructing microsurfacings because inspectors and engineers are not familiar with, and therefore unable to monitor or regulate, what the operator is doing. TxDOT personnel prefer explicit specifications and contractors that follow the specifications. The success of microsurfacing lies heavily in the experience and ability of the crewman which places TxDOT in a vulnerable position when the agency is used to specifications that must be followed and have been shown to produce good results. The knowledge deficit occurs because the crewman running the microsurfacing machine often has years of experience adjusting the speed, consistency and fluidity of the mix, experience that is very difficult to quantify and for anyone other than a microsurfacing crewman to obtain. Therefore, construction practices become a largely intangible factor and the discomfort of TxDOT personnel hard to remedy. Test strips can show the quality of work to be expected from a contractor and observation of the treatment in real time by inspectors can catch some flaws early enough to be hand-worked but in the end, the crew running the operation has great influence over the project outcome.

TxDOT specifications do not require a test strip for microsurfacing. No TxDOT personnel suggested that a test-strip is necessary but one respondent stated that a good contractor will "accept low production at the start of a project until both the Contractor and Engineer are satisfied with the combination of materials, mix design, roadway conditions and application rates." In essence this suggestion describes a form of test strip. NCHRP reports that 40% of DOTs specify test strips and the strips ranged in length from 500' to 1000'. Test strips are used to validate the calibrated machine is dispensing the correct amount of mix, to demonstrate the contractor's ability to properly construct transverse and longitudinal joints, to observe the texture of the final mix and to determine break and cure time (*21*). None of the reasons listed above were reported as significant problems in Texas microsurfacings in this study's survey except for application rates which, as discussed above, are difficult to specify.

CONSTRUCTION PRACTICES

Rolling

TxDOT specifications do not require rolling and in fact ISSA does not recommend rolling unless for airports and parking areas. NCHRP Synthesis 411 (*21*) suggests that the reasoning behind rolling microsurfacing can be contributed to the belief by some that rolling aids embedment and adhesion and may also accelerate the curing period. Whether or not such benefits result is unproven but no indications arose from either the literature review or survey that rolling should be added to microsurfacing specifications in Texas.

Scratch Coats

Scratch coats are used to fill wheel ruts that are greater than 3/8" deep 35% of the time in Texas according to the survey. The main purpose of scratch coats is to provide a level surface upon which the wearing course can be placed. In order to accomplish this, a steel strike off is used for scratch courses . As seen earlier, one contractor recommended allowing larger aggregate in the scratch coat but NCHRP concluded from their survey that "Scratch coat and full-width microsurfacing can use the same size aggregate with no apparent difference in performance." (*21*).

Pre-microsurfacing Road Preparation

Roads slated to receive a microsurfacing should be crack sealed prior to the microsurfacing. It is best to perform the crack sealing as far in advance of the microsurfacing as possible. This is especially important with microsurfacing because it will give traffic time to pack the seal into the crack. Microsurfacing is such a thin treatment that any seals left proud of the roadway will create a bump in the treatment surface. 72% of TxDOT respondents to the survey reported that in-house crews prep the roadway prior to receiving a microsurfacing and the length of time the preparation was performed before the microsurfacing construction varied from “min. 2 weeks” to “up to 1 year.” There was common expression from the respondents that the longer the better demonstrating that TxDOT understands the importance of performing the prep work well in advance of the microsurfacing but there were comments expressing regret that the prep work is sometimes performed shortly before the microsurfacing. Agency resources are a limiting factor in this regard but it may be beneficial to establish internal requirements of road prep timelines.

Contractor Communication

Overshadowing the aforementioned construction factors was one practice that, though it is unconventional to classify as a construction practice, received the greatest attention with 65% of survey respondents identifying it as crucial. This reported factor that most correlates to a good microsurfacing contractor is a contractor that knows which projects are suitable for microsurfacing and will communicate that knowledge to TxDOT personnel. From the survey, a strong conclusion can be made 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, and the highest level of knowledge of both of these factors belonging to the contractors, TxDOT is in a precarious position. Relying on contractors to inform TxDOT if the State has selected a project for microsurfacing that is not a proper application of the treatment 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 sees TxDOT requiring certification for contractors to encourage a contractor identify and communicate poor project selection. Option two sees TxDOT implementing 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 since their pocket books are tied to the performance of the project. Option three sees TxDOT developing much clearer guidelines on project selection criteria for microsurfacing and/or provide a course for TxDOT personnel to bring them up to speed on project selection. In fact, when asked what action would result in TxDOT using more microsurfacing, tied for the highest number of responses was "We (TxDOT) had additional training to better understand the process (of microsurfacing)." The first option leaves the responsibility in the hands of the contractors where it already lies. The second option has been shown 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 and with a course on microsurfacing already developed by TPP and TTI, should be relatively easy to implement. If TxDOT desires, project selection criteria could be determined and added to the course quite easily.

PROJECT SELECTION

Two examples of a system to assist in project selection are reproduced below from NCHRP Synthesis 411. With such models already in place, educating TxDOT personnel could be straight forward and efficient.

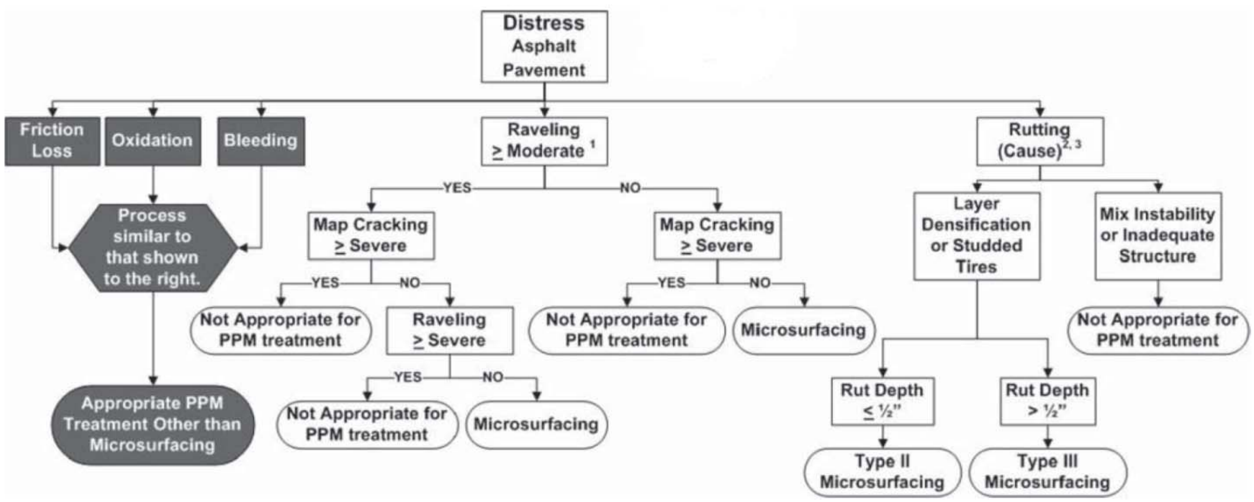

Figure 5-2. Conceptual Decision Tree for Asphalt Pavement Preservation and Maintenance Treatment Selection (*21, 25*)

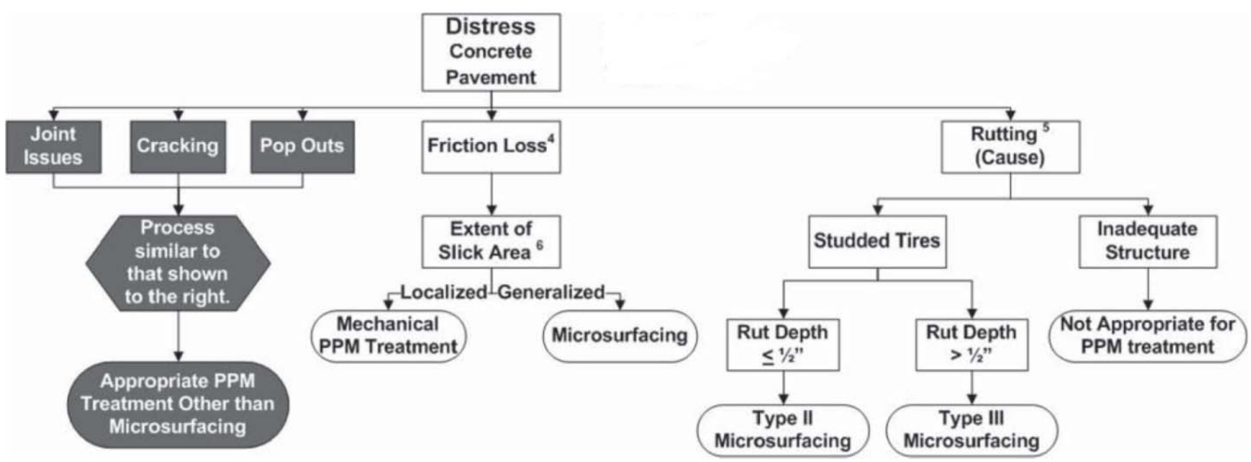

Figure 5-3. Conceptual Decision Tree for Concrete Pavement Preservation and Maintenance Treatment Selection (*3, 6, 21*)

Table 5-2 shows the respondent's answers to the NCHRP survey regarding selection logic for microsurfacing projects. In the NCHRP survey, Texas responded with the majority that the selection logic is based on providing a surface wearing course. When TxDOT personnel were asked to identify the reasons that they utilize microsurfacing in this study's survey, the top two answers were to fill wheel ruts and to stop bleeding on the surface. These two responses occurred more than twice as frequently as the next most common answers of improving ride characteristics of existing pavement and for routine pavement preservation. As seen from the table, Canadian DOT's utilize microsurfacing primarily as a rut filler whereas U.S. DOT's use microsurfacing primarily to provide a surface wearing course and to seal the surface (*21*). NCHRP Synthesis 411 concludes that since microsurfacing is one of the few pavement preservation and maintenance treatments that can restore the transverse profile of a roadway, that U.S. DOT's are not maximizing the potential benefits of microsurfacing as their Canadian counterparts are. From this study's survey, however, it appears that TxDOT personnel do understand the full potential of microsurfacing and are using it effectively.

Table 5-2. NCHRP Survey Responses for Microsurfacing Selecting Logic

Reason for Selecting Microsurfacing	Number of Responses		Reason for Selecting Microsurfacing	Number of Responses	
	U.S.	Canada		U.S.	Canada
Provide a Surface Wearing Course	9	0	Fill Surface Rutting	2	4
Prevent Water Infiltration	6	1	Improve Stripping Visibility	0	0
Oxidation	3	1	Distress (cracking)	1	0
Raveling	3	2	Improve Friction Resistance	1	0

Table 5-3 shows the NCHRP survey responses regarding factors used in the design of microsurfacings. Texas was the one state from the U.S. that answered in the "other" category, reporting that "it uses a combination of the distress score and ride score developed in its pavement management information system to provide input to the Texas Transportation Institute design method." (*21*).

Table 5-3. NCHRP Survey Responses for Factors Used in Design

Design Characterization Factor		U.S.	Canada
Qualitative (visual) factors		17	6
Roughness		9	3
Level of oxidation		5	0
Rutting		2	3
Other		1	1
Do not characterize existing conditions in the design process		4	0
Do you vary design based on urban vs. rural?	Yes	7	1
	No	15	7
	Do not know	6	0
If yes, what factors are used?	AADT	4	1
Number of ESALs		2	0
Proximity to urban areas		2	0
Proximity to rural areas		1	0

ESAL = equivalent single axle load.

CONCLUSIONS

Construction practices contain the most powerful contributors to the success of microsurfacing. Project selection, contractor experience and workmanship are consistently the frontrunners in the literature, data and discussion of crucial components for a microsurfacing project to perform well. However, none of the aforementioned factors are relevant if microsurfacing is an inadequate product so the question must be answered, “When microsurfacing is applied to the right project at the right time with good construction practices, is it a beneficial treatment?” The following chapter seeks to establish a framework with which to answer this question.

CHAPTER VI: PERFORMANCE MEASURES

In Task V, microsurfacing QC/QA guidelines were studied in order to investigate performance measures as well as to establish criteria for determining if a microsurfacing project was a success or failure over time. With several possible distresses and levels of severity affecting any one microsurfacing project, it is sometimes difficult to label the project as a success or failure on the whole. From the survey, literature review and site visits, the research team gathered data that will lead to a framework for assessing microsurfacing performance.

QC/QA OVERVIEW

NCHRP Synthesis 411 (*21*) states that field quality management in microsurfacing consists of the two main activities of sampling materials to ensure adequacy and then monitoring and correcting defects in workmanship. As seen earlier, the same synthesis reports that most DOT agencies, TxDOT included, rely heavily on the contractors to develop the job mix formula. Due to this shifting of design responsibility, QA responsibility also shifts to the contractor. This is true in Texas with contractor involvement in the QA process and contractor test results finding inclusion in the QA program.

As learned from the survey, the mix design always comes from the contractor in Texas, who in turn often receives it from the emulsion suppliers, and only 10.5% of TxDOT respondents said they use an independent laboratory to verify the mix design. 40% of TxDOT respondents report sampling and testing each emulsion delivery to the project. TxDOT does not require a test strip but 75% of contractors reported that they conduct a test strip prior to full production despite the lack of such requirement in the specifications. Such practices demonstrate the high involvement of the contractors in the QA process since they take it upon themselves to verify the mix design and construction procedures. TxDOT still retains inspection rights for field testing and laboratory testing but exercises them much more frequently in field testing. TxDOT course MNT 706 (*74*) contains an excellent chapter on construction quality check procedures for inspectors and engineers to use in the field. Since TxDOT has higher rates of field testing, it is recommended that personnel involved in the field testing attend the course mentioned above.

PERFORMANCE MEASURES

In defining or quantifying microsurfacing "quality" NCHRP 411 (*21*) summarized agency definitions from across the US. The resulting definitions were found:

- 19 agencies defined it as "meets expected performance life"
- 14 agencies defined it as "meets project specification requirements"
- 9 agencies defined it as "achieves desired friction/skid number"
- 8 agencies defined it as "qualitative measures-look, color, etc."
- 7 agencies defined it as "does not fail shortly after construction"
- 1 agency defined it as "meets texture standard (>0.6mm)"
- 1 agency defined it as "no maintenance expenditures over life."

Texas was recorded in the NCHRP survey as answering with the majority of agencies by defining success as "meets expected performance life." The question then arises "what is an appropriate expected service life?" From the literature and the NCHRP survey, the following table shows the services life expectations commonly reported for microsurfacings.

Table 6-1. Summary of Microsurfacing Service Life from the Literature and the NCHRP Survey

Source	Minimum Service Life	Maximum Service Life	Average Service Life
Bausano et al. (*5*)	6	7	6
Lyon and Persaud (*44*)	5	7	6
Smith and Beatty (*60*)	7	10	7
Watson and Jared (*66*)	5	7	6
Hicks et al. (*24*)	5	7	6
Labi et al. (*41*)	5	15	7
Temple et al. (*63*)	4	10	7
Chehovits and Galehouse (*12*)	2	5	3.5
Average Literature	**4.8**	**8.5**	**6**
U.S. Survey Respondents	1	15	6
Canadian Survey Respondents	3	9	7
Average of Survey Responses	**3.6**	**13**	**7**

As aforementioned, NCHRP defined a two tier activity for QC/QA of microsurfacing with the first being mix design. Since mix design verification was dealt with in Task II of this study, the second tier of QC/QA programming will be dealt with here. After a mix design is created, workmanship is the primary focus of QC/QA activities. The main areas of concern are longitudinal joints, transverse joints, edges and shoulders, uneven mixes and segregation, smoothness problems, damage caused by premature reopening to traffic, streaking and delaminating. Of these potential problems, the most common in Texas were as seen in Tables 6-2 and 6-3.

Table 6-2. Defects Seen in Texas Microsurfacings Immediately After Construction

Defect	Percentage of Respondents (%)
Crack reflection	19
Streaking	17
Surface texture variations	14
Delamination	13

Table 6-3. Defects Seen in Texas Microsurfacings 3 ~ 5 Years After Construction

Defect	Percentage of Respondents (%)
Crack reflection	27
Delamination	23
Raveling	11

It appears from these responses that the skill of contractors in Texas to construct joints and edges is adequate due to the lack of reporting these defects as significant problems. NCHRP Synthesis 411 reported the most common post-construction defects observed in microsurfacing nationwide as shown in Table 6-4.

Table 6-4. 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 of this topic is warranted.

When asked to rate factors most important to minimizing the aforementioned defects, NCHRP reported the answers in the following order of most important to least important:

- contractor experience
- selecting the right project
- construction procedure
- preconstruction road preparation
- better aggregates
- better binder

- design method
- QC/QA program

TxDOT personnel reported the factors in the following way, ordered most important to least important:

- contractor experience
- project selection
- workmanship
- mix design
- material quality
- proper application rate
- field construction procedures

The first three responses are identical to the national survey and strengthen the data gathered earlier in this project that says a difficult to quantify contribution from the contractor and project selection are far and away the two most important factors in determining microsurfacing success.

With respect to contributions to micro failures, NCHRP reported the following factors in order of highest contributor to lowest:

- poor project selection
- improper application rate
- dirty or dusty aggregate/gradation issues
- improper ambient and/or surface temperatures
- improper binder viscosity
- improper binder temperature
- improper surface preparation
- weather
- field construction procedures
- snow plow damage.

TxDOT personnel reported similar results with contractor experience and project selection falling at the top. Improper application rate would fall under the workmanship category and therefore under the contractor's responsibility. This further demonstrates the importance of experienced microsurfacing contractors in preventing poor applications of the treatment.

WARRANTIES

Texas has a warranted microsurfacing specification in Special Specification 3150. 3150 calls for a 2 year warranty from the contractor based on the performance requirements seen in Table 6-5.

Table 6-5. Warranty Performance Requirements for Texas Microsurfacings

Performance Characteristic	Requirement
Flushing, % max.	5
Skid Resistance, SN50S, avg. min.	25
Delamination, % max.	2
Weathering/Raveling, % max.	5
Rutting, in., max	3/8

In Texas only 26% of respondents to the survey said they use the warranted microsurfacings. From the survey, type of contract (warranty/non-warranty) did not present as a crucial contributor to the success of a microsurfacing project nor did it appear as a high response to the question of what actions would cause a district to use more microsurfacing. The NCHRP study produced the following table summarizing selected DOT warranty programs.

Table 6-6. Summary of Warranties Reported in the NCHRP Survey

Agency	Warranty Length	Nature of Microsurfacing Warranty	Microsurfacing Performance Rating from Survey
Indiana	3 years	Friction, raveling, rutting	Fair
Louisiana	1 year	Material and workmanship	Good
New Hampshire	1 year	Surface defects	Excellent
Nevada	2 years	Standard construction warranty	Good
New York	1 year	Delamination, snowplow damage, flushing, and raveling > 2.0 SY	Good
Ohio	2 years	Bleeding/flushing, surface loss, raveling, rutting, and maintenance bond	Good
Oklahoma	1 year	Standard construction warranty	Fair
Texas	2 years	Rutting, flushing, and raveling	Fair
Alberta	1 year	Adhesion (raveling)	Good
British Columbia	1 year	Standard construction warranty	Good
Manitoba	2 years	Performance specification includes warranty provision	Excellent
Nova Scotia	2 years	Standard construction warranty	Good
Ontario	2 years	Flushing, raveling	Good
Quebec	1 year	Standard construction warranty	Good
Saskatchewan	1 year	Standard construction warranty	Good

In the NCHRP synthesis, Ohio's warranty program for microsurfacing is singled out and a cost analysis study performed by Ohio DOT is reported on. The conclusion states that "microsurfacing projects with a warranty 32 had unit prices that were only 0.18% more than those without." Additionally, 69% of Ohio DOT personnel believed the addition of warranties to their microsurfacing contracts created improvement in the quality of their projects. Contractors in Ohio also reported changes in their perspectives including:

1. Quality conscious construction
2. Better workmanship
3. More design input.

The authors of the NCHRP Synthesis concluded that:

> The risk allocation changes when the contractor is allowed to have input to the design and that unit prices in Ohio did not skyrocket when warranties were introduced confirms the assertion that microsurfacing projects are good candidates for warranties because the contractor has more control over the design and construction process. This confirms the Ohio DOT warranty guidance directing engineers to carefully select "proper pavements" for warranted microsurfacing projects.

Similarly, in Texas, contractors have great control over the design and construction processes so Texas might benefit from more warranted microsurfacing projects. However, TxDOT personnel responding to the survey did not see to believe that increases in the use of warranties would result in greater performance of microsurfacings. It is appreciably difficult to select proper projects for microsurfacings as we have seen in the responses from the survey and the literature. To truly implement a successful warranty program careful selection of the project is crucial because inadequacies in the structural soundness of the underlying pavement may void the warranty. With the current lack of confidence seen in TxDOT regarding project selection and the importance of that factor to both the success of a non-warranted project and the strength of a warranty contract, training in project selection is highly recommended whether warranties are used more frequently or not.

CONCLUSIONS

In conclusion, contractor experience is vital to determining microsurfacing success. 38.5% of TxDOT personnel say that a certification program should be required of contractors in Texas. 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 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 to performance related specifications from the current method 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 DOT's is ubiquitous across the country as is seen in Table 6-7, a summary of General Contracting information from the NCHRP survey.

Lastly, project selection is the most important contributor to microsurfacing project success yet TxDOT personnel do not benefit from formal training on how to select appropriate microsurfacing projects and therefore report that assistance from contractors in project selection is sought. This makes a strong case for implementing a training class for TxDOT personnel that would help overcome this imbalance in knowledge.

Table 6-7. Summary of NCHRP Survey General Contracting Information

Question	U.S.	Canada	Total
Change in Annual Microsurfacing Program Volume?			
Virtually the Same Amount	5	3	8
Fluctuates ±20% Each Year	6	1	7
Fluctuates ±50% Each Year	1	1	2
Rarely Know How Much Each Year	9	1	10
No Knowledge	7	2	9
Typical Number of Bidders?			
1 to 3	25	7	32
4 to 6	2	1	3
7 to 9	1	0	1
Adequate Number of Qualified Bidders?			
Yes	12	2	14
No	14	6	20
No Opinion	2	0	2
Prequalified List of Eligible Bidders?			
Yes	11	0	11
No	14	8	22
Do Not Know	3	0	3
Required Training/Certification of Contractor Personnel?			
Yes	1	1	2
No	19	7	26
Do Not Know	8	0	8
Required Training/Certification of Agency Personnel?			
Yes	5	1	6
No	20	6	26
Do Not Know	3	1	4

CHAPTER VII:
MICROSURFACING SUCCESSES AND FAILURES

In Task VI, the research team compiled case studies on successful as well as unsuccessful microsurfacings from the literature, reports of microsurfacings from the surveys, site visits on four different sites in Texas and forensic studies of failures in Texas. Study and analysis of actual microsurfacing projects provides invaluable, real world experience that gives tangible data to compliment the theoretical concepts of much scientific literature. As this study has shown, TxDOT personnel are at a disadvantage with microsurfacing knowledge in the relationship with contractors. Microsurfacing contractors not only perform the work and provide the technical construction experience but also provide the microsurfacing designs. In order to move up the learning curve as fast as possible, case studies that reveal unique aspects of the treatment provide rich sources of knowledge.

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 ½ 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.

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.

US 281- Fort Worth:

<u>Description</u>:

- 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

<u>Performance</u>:

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

<u>Other Observations</u>:

- 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).

<u>Conclusions</u>:

- 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.

Waco SH 6

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.

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.

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. 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 wheelpaths 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 7-1 summarizes this information but for a more detailed treatment of this material, the class handbook is invaluable.

Table 7-1. Possible Construction Defects in Microsurfacings and Their Causes

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.

SITE VISITS

In the survey, the research team asked respondents to identify up to 3 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 7-2 summarizes the sites and detailed discussion may be found below.

Table 7-2. Summary of Site Visits

District	Road	Date completed	Summary
Abilene	US 180 from the Jones/Shackelford county line east to SH 351/US 180 interchange	August 2009	Performing well after almost 2 years. Little to no visible distress.
Abilene	LP 322 at Abilene from EN 10th St. to Lytle Creek	August 2007	Southbound lanes performing well after almost 4 years. Little to no distress beyond crack sealing. Northbound lanes receiving in place repairs at time of site visit.
Paris	FM 121 from Gunter to Tioga	November 2010	Performing well after 5 months. Some tears in intersections which appeared to be early traffic damage. Micro was slightly soft. Possibly due to lack of compaction on low average daily traffic (ADT) road.
Dallas	US 287 in Ellis County from 0.7 mi S of FM 878 to 0.82 mi S of BU 287R	May 2007	Performing very well after four years. Minor distress at infrequent intervals.

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 ¼” deep, some minor streaking and good texture.

	Minor raveling in the wheelpath occurred in one 100 foot section.
	Overall a very good project with little to no distress.

LP 322 in Abilene District

<table>
<tr><td></td><td>Southbound lanes showing no rutting, good texture, well constructed edges and joints, with crack-sealing.</td></tr>
<tr><td>
</td><td>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.”</td></tr>
</table>

	Minor unsealed crack in Northbound lane.

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.

	Delamintation 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.
	Another example of raveling and delamination in an intersection.
	Also present in this project was high frequency, low amplitude corrugation as seen on the left of the top lane. Rough pavement underneath reflecting through or causing the rear strikeoff to "jump" is the most likely cause of this. Demonstrates importance of meeting the requirements in Table 4-1.

	Another shot of the corrugation.
	Damage to intersection most likely from early opening to traffic.
	Tear marks (bottom left) from power to rear tires damaging the microsurfacing. The microsurfacing was still slightly soft when visited 5-6 months after construction. Demonstrates importance of creating an adequate mix design to ensure proper curing.

US 287 in Dallas District

	No rutting over ¼”, 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.
	Another view of the reflective crack.
	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.

Site Visit Conclusions

The site visits ranged in age from 5 months to 4 years. Each site offered an example of microsurfacing performance. US 180 showed how well a microsurfacing can perform when applied to a structurally sound pavement at the right time. Bleeding at the end of the project showed the difficulty of starting and stopping paving and reinforced the need for a continuous paving machine to minimize this effect. LP 322 in Abilene showed how poorly even a well-constructed project will perform if 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 fine. 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 receives good performance ratings overall from TxDOT personnel. Lastly, US 287 in Dallas District is an excellent example of a microsurfacing project that 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 again that microsurfacing will not correct structural deficits in pavement.

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 personnel report that microsurfacing will address the following pavement distresses:

<u>Distress (% of respondents answering this way)</u>

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

The majority of TxDOT personnel report that microsurfacing will NOT address the following pavement distresses:

<u>Distress (% of respondents answering this way)</u>

- 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%**

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 seals and 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.

CHAPTER VIII: CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to provide a synthesis of the state of practice of microsurfacing in Texas as compared to the United States. Through a comprehensive review of literature, survey, interviews and site visits, the research team gathered the data that will now be used to draw conclusions and make recommendations. Where the available data is not sufficient to draw an adequate conclusion or warrant a recommendation, suggestions of further research will be made.

CONCLUSIONS

- 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.
- When applied to "the right road, at the right time, for the right distress" microsurfacing can be expected to provide an average of 7 years of service life.
- 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.
- Contractor experience is the second most important factor contributing to a successful microsurfacing project. Texas, like most DOT's, wish there were more contractors bidding on and performing microsurfacing in their state. This may improve if a set amount of microsurfacing was consistent year to year.
- 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 roles in QC/QA resulting in dependence on the contractor for many levels of microsurfacing knowledge.

RECOMMENDATIONS

- Offer a class on microsurfacing to TxDOT personnel. MNT 705 and MNT 706 are an excellent option until the Federal Highway Administration finishes their certification program at the national level.
- Utilize microsurfacing as early in the life cycle of a roadway as is justifiable in order to maximize benefit and cost savings.
- Consider adding a test strip requirement to the microsurfacing specifications in order to allow proper calibration and to check workmanship prior to full production.

SUGGESTED RESEARCH

- 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.
- In order to ensure microsurfacing is placed on the right pavement, 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.
- Utilization of some of the more common ISSA mix designs in Texas may warrant trials to determine if they produce a more successful product than the current design.
- Developing an *in situ* QA/QC test for microsurfacing would aid in inspection and acceptance of microsurfacing.

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APPENDIX A: SURVERY QUESTIONNAIRE FOR TXDOT ENGINEERS

1. Who does the microsurfacing mix design for the contractor?

☐ Ergon
☐ Road Science
☐ Don't know
☐ Other, Please Specify:

2. Do you use an independent laboratory to evaluate microsurfacing mix design?

☐ Yes
☐ No
☐ Don't know

3. Do you sample and test each emulsion delivery to the project?

☐ Yes
☐ No
☐ Don't know

4. After the mix design has been submitted and approved should the contractor be allowed to adjust any of the following to account for weather conditions? Check all that are permissible.

☐ Water
☐ Mineral filler
☐ Asphalt emulsion
☐ Application rate
☐ Speed of the laying operation
☐ Time until opening to traffic

5. Should the contractor be allowed to adjust the mix design to account for: Check all that are permissible.

☐ Weather
☐ Existing pavement surface condition
☐ Traffic conditions

6. Who has the authority to adjust the mix design to account for project specific field conditions? Check all that are permissible.

☐ The Engineer
☐ The Inspector
☐ District Lab Personnel
☐ The Contractor

7. Do you believe weather conditions during application affect the success of microsurfacing:

☐ Not at all
☐ Somewhat
☐ Greatly

8. Do you require computerized monitoring in the mixing equipment ratios?

☐ Yes
☐ No
☐ Don't know

9. Do you typically require a warranty with your microsurfacing projects?

☐ Yes
☐ No

If yes, do you believe it changes the results you get from the microsurfacing?

☐ Yes
☐ No

10. Do in house crews prep the roadways prior to receiving microsurfacing?

☐ Yes
☐ No

If yes, how far in advance? ______________________

11. In our district microsurfacing is used for the following reasons, check all that apply:

☐ Seal the pavement
☐ Cover old striping to provide uniform surface for new traffic pattern
☐ Stop bleeding on the existing surface
☐ Fill wheel ruts
☐ Provide additional structural support
☐ Routine pavement preservation
☐ Improve the ride characteristics of the existing pavement
☐ When the roadway carries more traffic than we would consider for a seal coat (chip seal).
☐ Simply to buy some time until a more permanent surface can be afforded

12. Do you use a PCI number to trigger you to use microsurfacing?

☐ Yes
☐ No

If yes, what is the range? ☐

13. How would you describe the level of distress on roads that generally receive a microsurfacing treatment?

☐ Severe
☐ Moderate
☐ Slight
☐ None
☐ Mixed

14. In our district we use a scratch or level up course of microsurfacing in addition to the surface course of microsurfacing when: Check all that apply.

☐ The existing pavement has wheel ruts greater than 3/8″ in depth
☐ The existing pavement has any rutting
☐ The existing pavement is flushed or bleeding
☐ The existing pavement has a variable surface texture
☐ The pavement carries higher traffic loadings
☐ The existing pavement needs additional structure support
☐ We are looking for extended service life from the microsurfacing treatment.
☐ We needed to improve the existing pavement ride

15. Should TxDOT require training and/or certification for crew members or contractor?

☐ Yes
☐ No
☐ Don't know

If yes, Who should be required to get the training/certification?
____

16. Rank the top 5 reasons for microsurfacing successes in order from greatest impact (1) to least impact (5).

____Contractor Experience
____Project Selection
____Material Quality
____Workmanship
____Mix Design
____Type of Contract (Warranty/Non-warranty)
____Weather
____Proper application rate
____Aggregate quality
____Aggregate gradation
____Vehicle speed control after the mixture is deposited
____Ability to control traffic
____Aggregate/binder compatibility
____Proper proportioning
____Proper surface preparation
____Field construction procedures
____Other, Please Specify:

17. Rank the top 5 reasons for microsurfacing failures in order from greatest impact (1) to least impact (5).

____Contractor Experience
____Project Selection
____Material Quality
____Workmanship
____Mix Design
____Type of Contract (Warranty/Non-warranty)
____Weather
____Improper application rate
____Dirty or dusty aggregate

____Aggregate gradation
____Vehicle speed control after the mixture is deposited
____Early open the traffic after the mixture is deposited
____Aggregate/binder compatibility
____Improper proportioning
____Improper surface preparation
____Field construction procedures
____Other, Please Specify:

18. Which factors are most critical in determining the life of your microsurfacing projects? Please indicate the top three in order of importance.

____Field construction procedures
____Original substrate surface quality
____Underlying pavement structure
____Maintenance funding
____Friction loss
____Traffic
____Cold climate considerations (freeze/thaw cycles, snowplowing, etc.)
____Other, Please Specify:

19. Which methods do you use to maintain your microsurfaced roads?

☐ Crack sealing
☐ Surface treatments (seal coat)
☐ Fog seal
☐ Additional applications of microsurfacing
☐ None
☐ I don’t know
☐ Other, Please Specify:

20. What common distresses are observed in your completed microsurfacing projects immediately after construction?

☐ Crack Reflection
☐ Streaking/Color Variations
☐ Raveling
☐ Delamination
☐ Corrugation/Poor Ride Quality
☐ Poor Transverse Joints

☐ Bleeding
☐ Poor Longitudinal Joints
☐ Potholes
☐ Surface Texture Variations
☐ Other, Please Specify:

21. What common distresses are observed in your completed microsurfacing projects 3-5 years after construction?

☐ Crack Reflection
☐ Streaking/Color Variations
☐ Raveling
☐ Delamination
☐ Corrugation/Poor Ride Quality
☐ Poor Transverse Joints
☐ Bleeding
☐ Poor Longitudinal Joints
☐ Potholes
☐ Surface Texture Variations
☐ Other, Please Specify:

22. What is the most common public-user complaint about microsurfacing?

☐ Loose stone
☐ Road noise
☐ Vehicle ride
☐ Appearance
☐ Do not get complaints
☐ Other, Please Specify:

23. How would you describe the pavement ride on a road immediately **before** receiving a new microsurfacing?

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Very Poor

24. How would you describe the pavement ride on the same road immediately **after** receiving a new microsurfacing?

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Very Poor

25. Our district would utilize microsurfacing more if: Please rank the top three.

___There were more contractors bidding the projects
___The contractors were somehow certified by TxDOT as truly qualified
___We (TxDOT) had additional training to better understand the process
___We were able to use the warranty clause for our projects
___We will not use microsurfacing because of past problems.

26. Which types of distress will microsurfacing correct?

Yes	No	
☐	☐	Fatigue Cracking
☐	☐	Reflection Cracking
☐	☐	Streaking/Color Variations
☐	☐	Raveling
☐	☐	Delamination
☐	☐	Corrugation/Poor Ride Quality
☐	☐	Poor Transverse Joints
☐	☐	Bleeding
☐	☐	Poor Longitudinal Joints
☐	☐	Potholes
☐	☐	Surface Texture Variations
☐	☐	Loss of Friction/Skid
☐	☐	Permeability
☐	☐	Rutting

☐ Other, Please Specify:

27. Are current microsurfacing specifications adequate to produce a quality product?

☐ Yes
☐ No
☐ Don't know

If no, how can they be improved?

____

28. We plan to use more microsurfacing in the future:

☐ Yes
☐ No
☐ Don't know

If yes or no, what are the reasons?

____

29. What does a *good* microsurfacing contractor do that is important?

____

30. What does a *poor* microsurfacing contractor do that is harmful?

____

Please identify up to three representative projects and evaluate their performance.

31. <u>Project 1</u>

a. Project name and Location:

b. Determine the overall level of success of this project

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Unsatisfactory

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success
(5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	Did you use it?	Level of success? (0 to 5)
Meets expected service life	☐ Yes ☐ No	
Does not fail shortly after construction	☐ Yes ☐ No	
Achieves desired friction/skid number	☐ Yes ☐ No	
Qualitative (subjective) measures—look, color, etc.	☐ Yes ☐ No	
Meets project specification	☐ Yes ☐ No	
Other, please specify:	☐ Yes ☐ No	

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress.
(Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of severity Immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	☐ Yes ☐ No		
Bleeding	☐ Yes ☐ No		
Corrugation	☐ Yes ☐ No		
Crack reflection	☐ Yes ☐ No		
Streaking	☐ Yes ☐ No		
Transverse joints	☐ Yes ☐ No		
Longitudinal Joints	☐ Yes ☐ No		
Other, please specify:	☐ Yes ☐ No		

32. <u>Project 2</u>

a. Project name and Location:

b. Determine the overall level of success of this project

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Unsatisfactory

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success
(5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	Did you use it?	Level of success? (0 to 5)
Meets expected service life	☐ Yes ☐ No	
Does not fail shortly after construction	☐ Yes ☐ No	
Achieves desired friction/skid number	☐ Yes ☐ No	
Qualitative (subjective) measures—look, color, etc.	☐ Yes ☐ No	
Meets project specification	☐ Yes ☐ No	
Other, please specify:	☐ Yes ☐ No	

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress.
(Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of severity Immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	☐ Yes ☐ No		
Bleeding	☐ Yes ☐ No		
Corrugation	☐ Yes ☐ No		
Crack reflection	☐ Yes ☐ No		
Streaking	☐ Yes ☐ No		
Transverse joints	☐ Yes ☐ No		
Longitudinal Joints	☐ Yes ☐ No		
Other, please specify:	☐ Yes ☐ No		

33. <u>Project 3</u>

a. Project name and Location:

b. Determine the overall level of success of this project

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Unsatisfactory

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success
(5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	Did you use it?	Level of success? (0 to 5)
Meets expected service life	☐ Yes ☐ No	
Does not fail shortly after construction	☐ Yes ☐ No	
Achieves desired friction/skid number	☐ Yes ☐ No	
Qualitative (subjective) measures—look, color, etc.	☐ Yes ☐ No	
Meets project specification	☐ Yes ☐ No	
Other, please specify:	☐ Yes ☐ No	

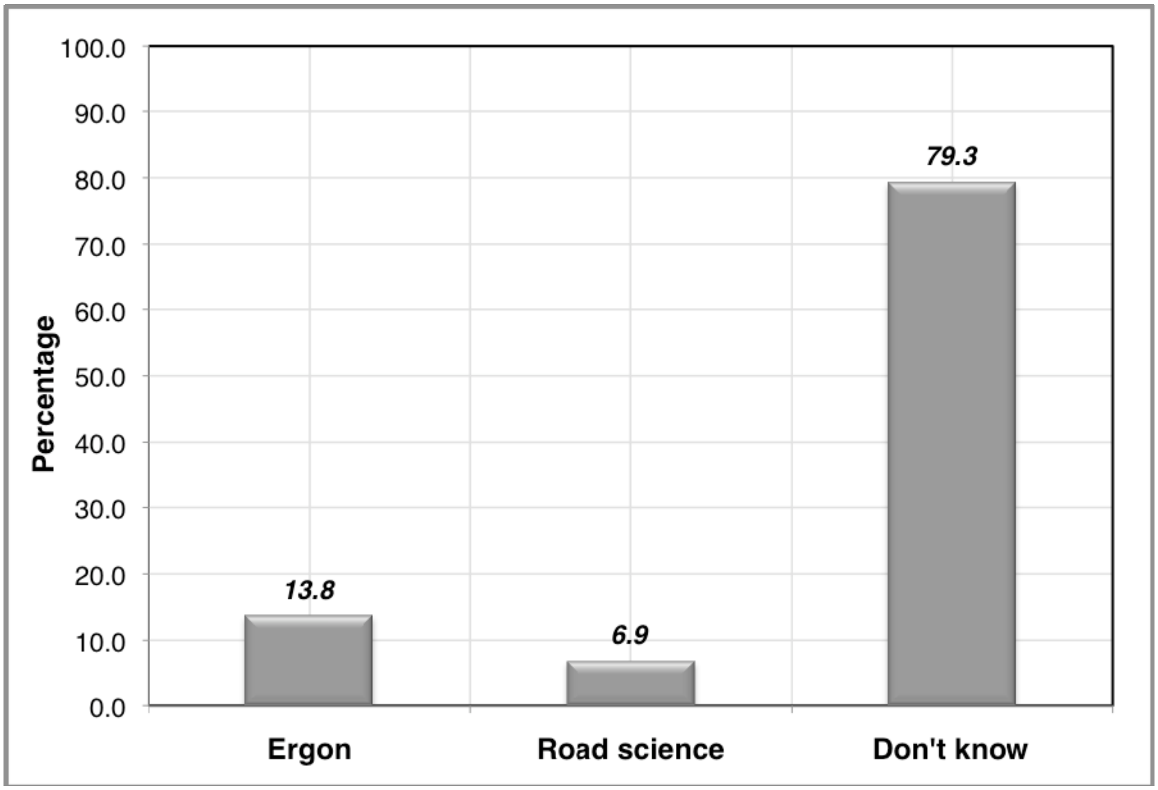
d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress.
(Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of severity Immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	☐ Yes ☐ No		
Bleeding	☐ Yes ☐ No		
Corrugation	☐ Yes ☐ No		
Crack reflection	☐ Yes ☐ No		
Streaking	☐ Yes ☐ No		
Transverse joints	☐ Yes ☐ No		
Longitudinal Joints	☐ Yes ☐ No		
Other, please specify:	☐ Yes ☐ No		

34. If there is anything that you would like to add that was not covered in this questionnaire which you feel would benefit this study, please write your comments below:

APPENDIX B: SUMMARY OF TXDOT ENGINEERS SURVEY RESULTS

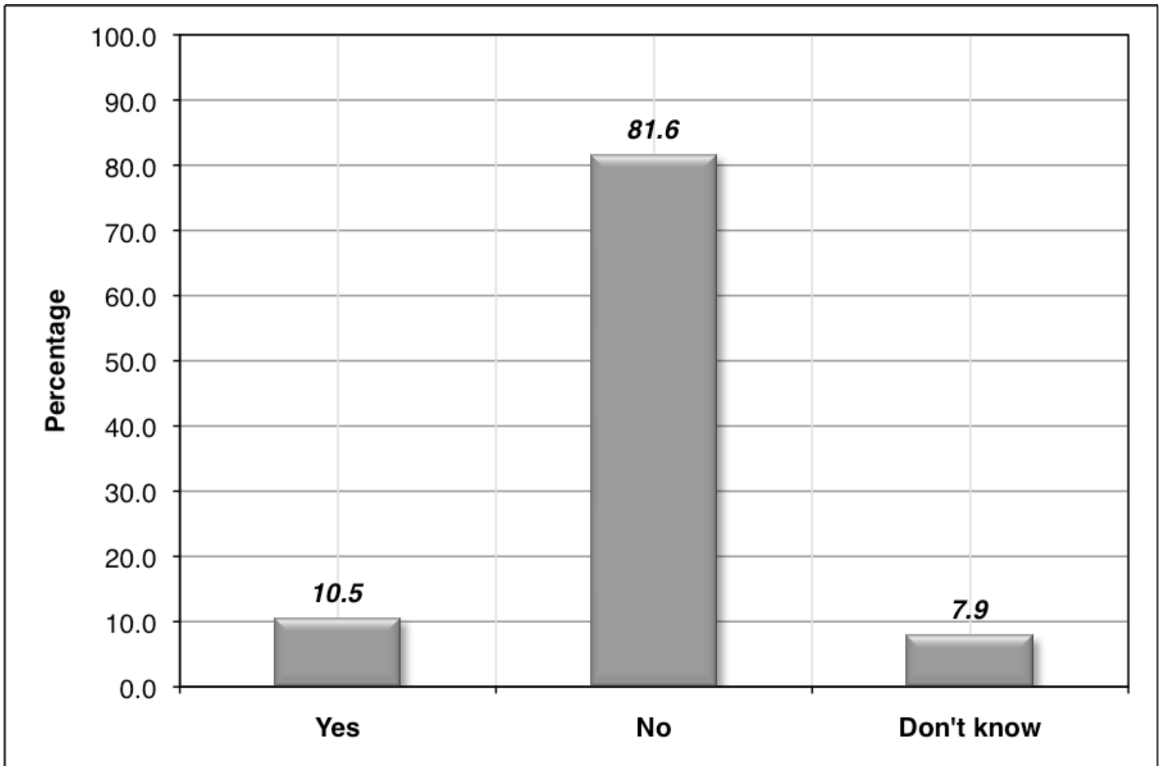
1. Who does the microsurfacing mix design for the contractor?



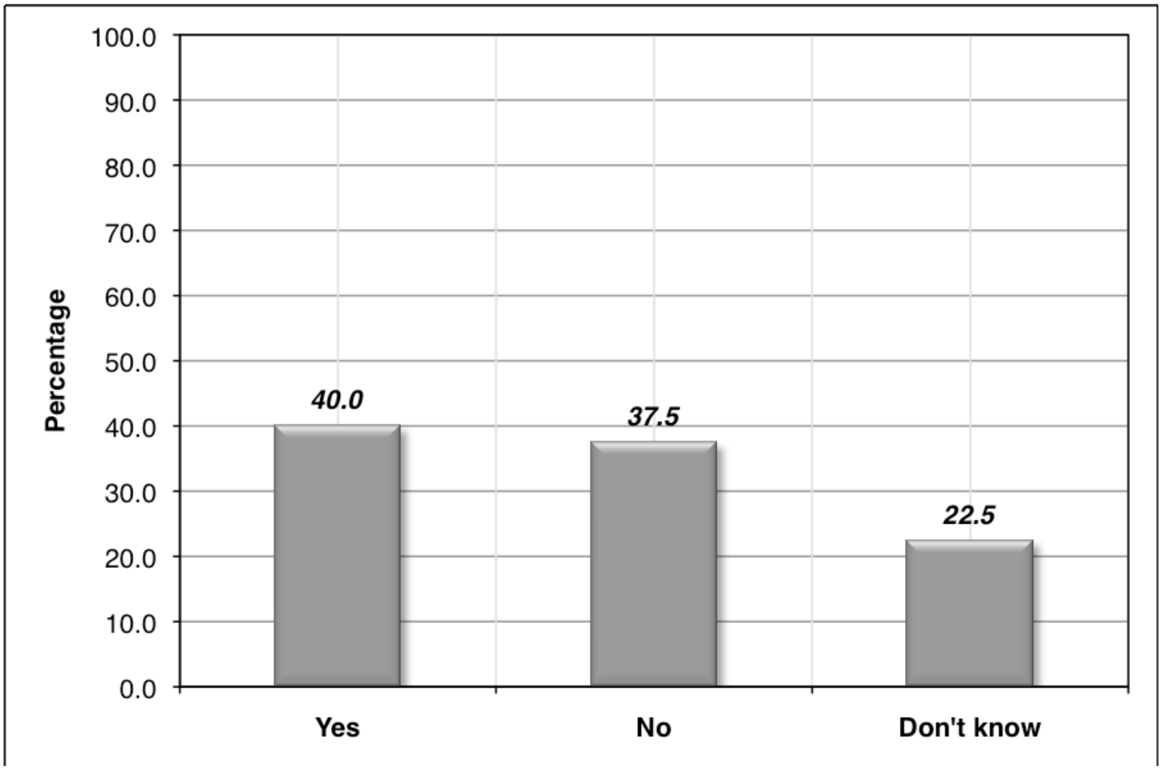
Other:

- Depends on contractor
- Private lab
- Third party engineer
- SEM materials
- Contractor submits it
- Contractor uses their emulsion supplier
- Depends on asphalt supplier
- Mix design is based on Spec. book requirements
- Depends on contractor
- Private lab
- Third party engineer

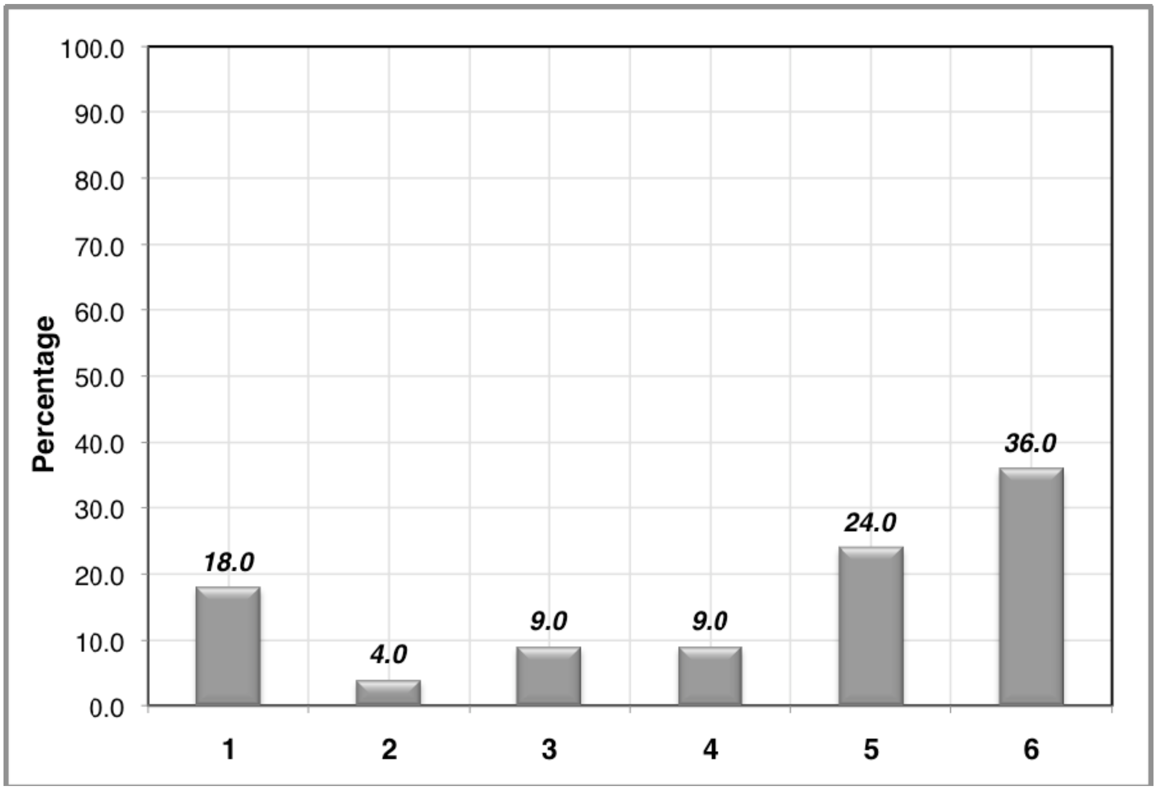
2. Do you use an independent laboratory to evaluate microsurfacing mix design?



3. Do you sample and test each emulsion delivery to the project?

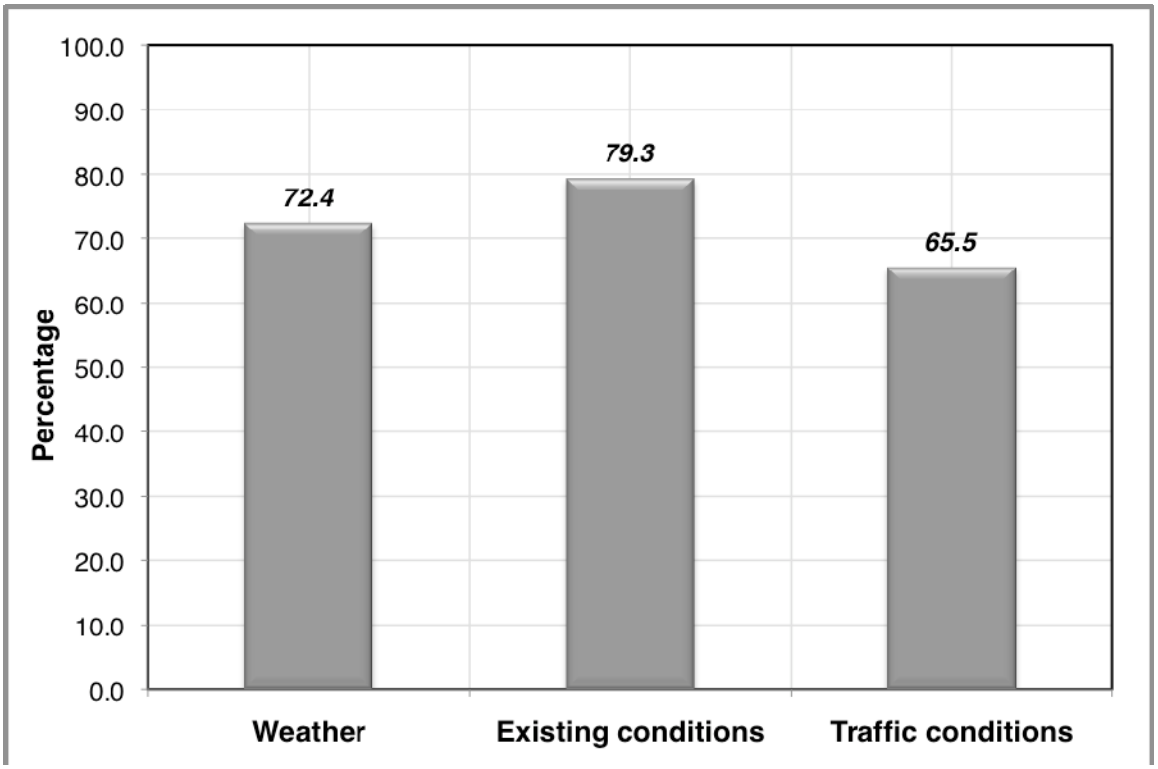


4. After the mix design has been submitted and approved should the contractor be allowed to adjust any of the following to account for weather conditions? Check all that are permissible.

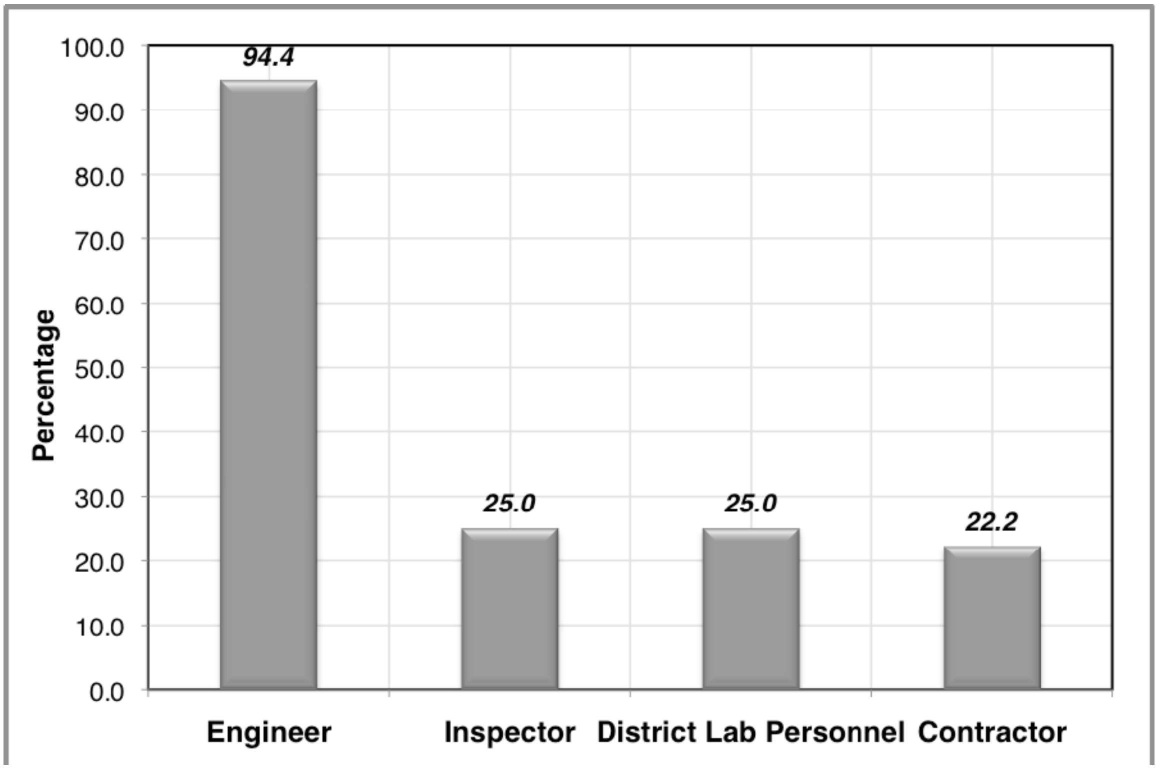


1. Water
2. Mineral filler
3. Asphalt emulsion
4. Application rate
5. Speed of the laying operation
6. Time until opening to traffic

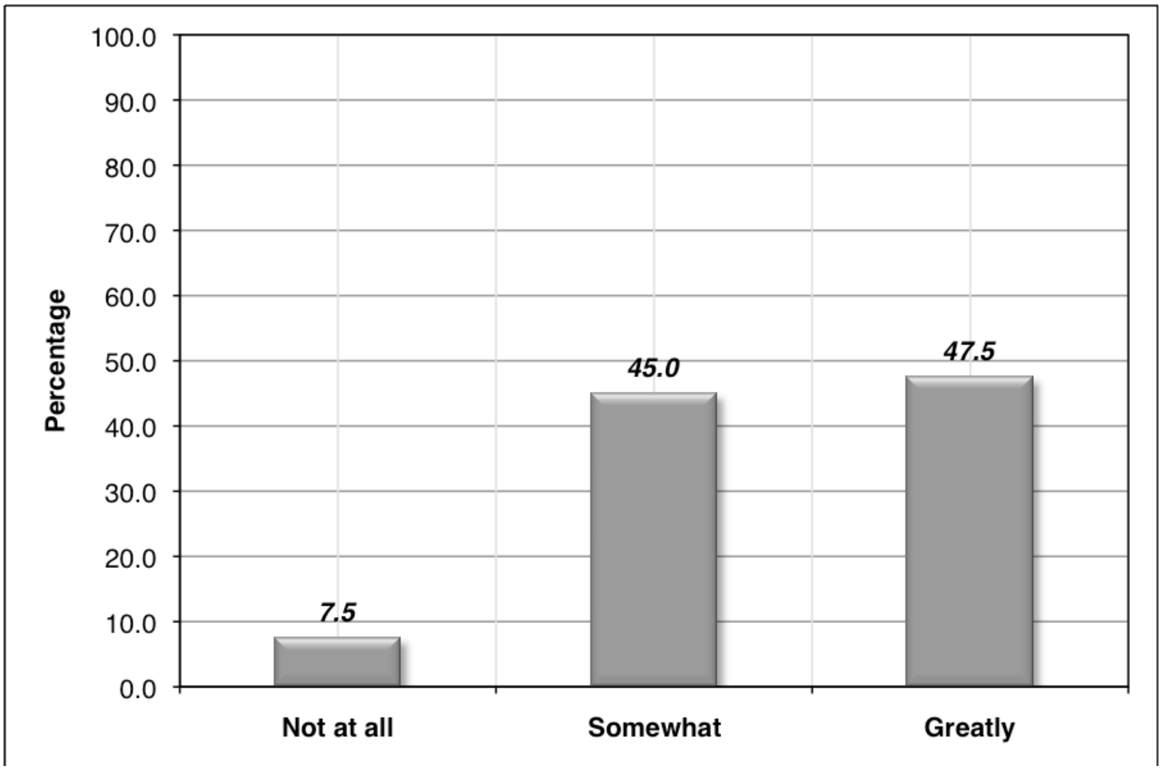
5. Should the contractor be allowed to adjust the mix design to account for: Check all that are permissible.



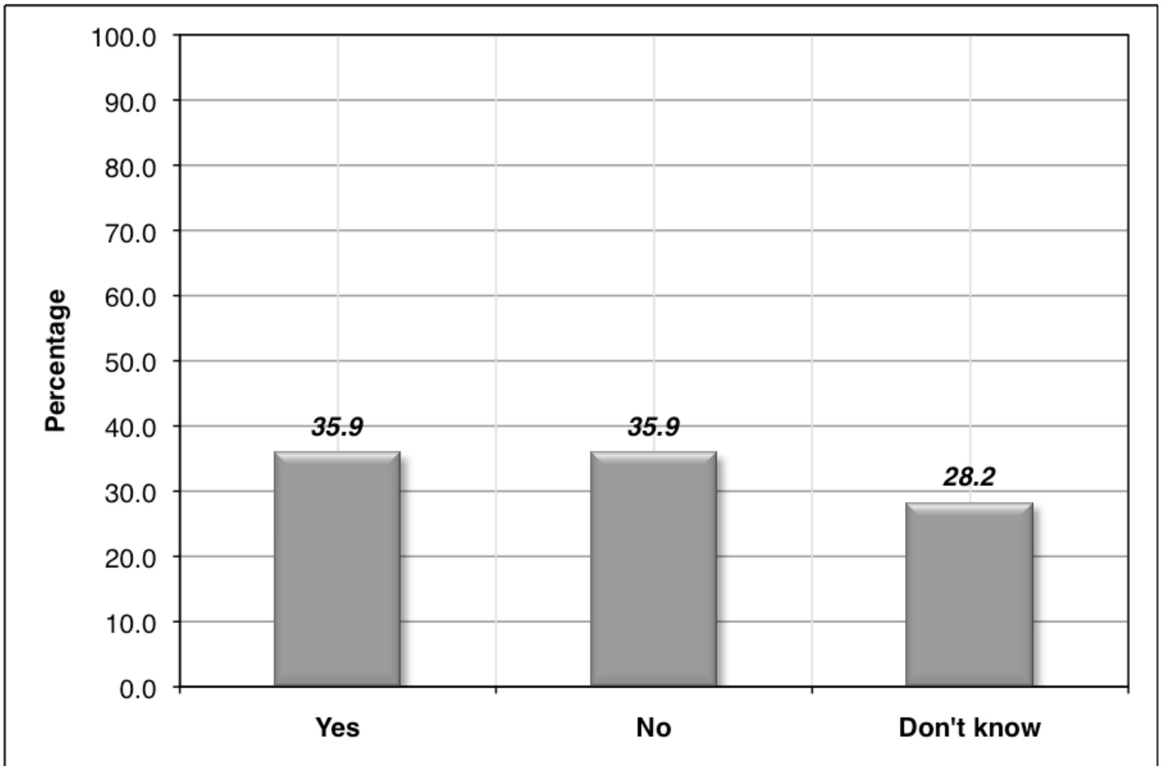
6. Who has the authority to adjust the mix design to account for project specific field conditions? Check all that are permissible.



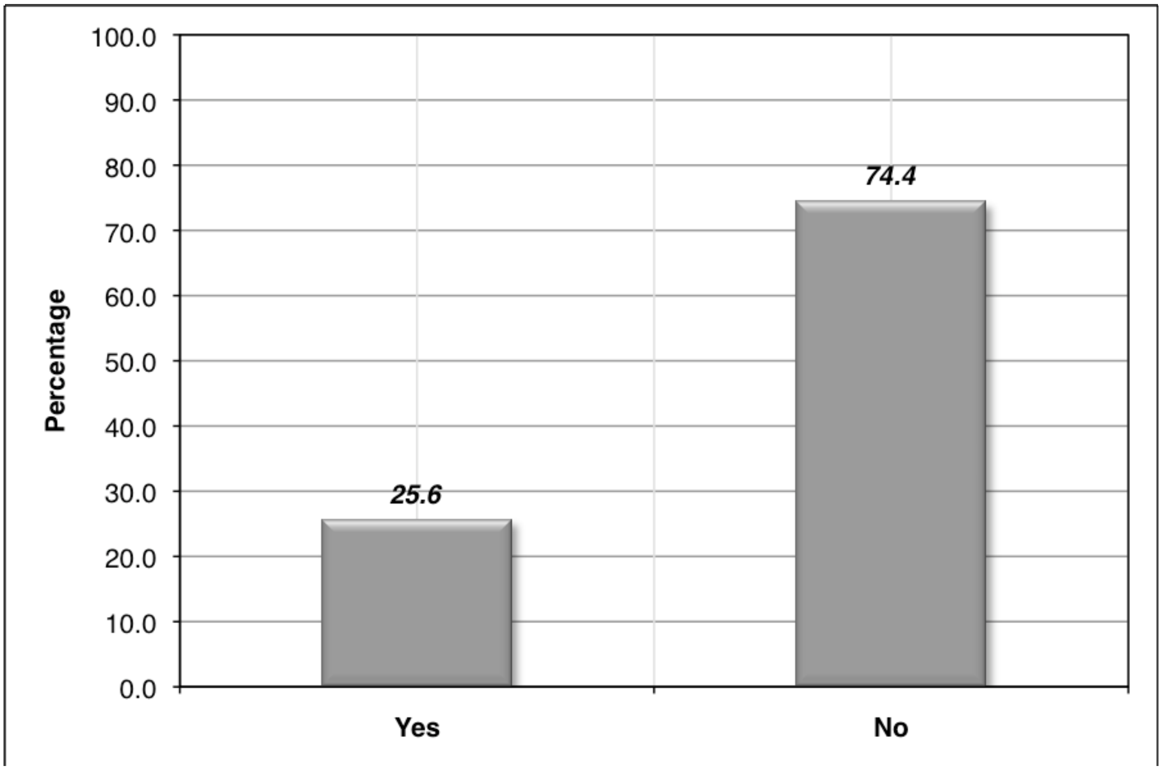
7. Do you believe weather conditions during application affect the success of microsurfacing:



8. Do you require computerized monitoring in the mixing equipment ratios?



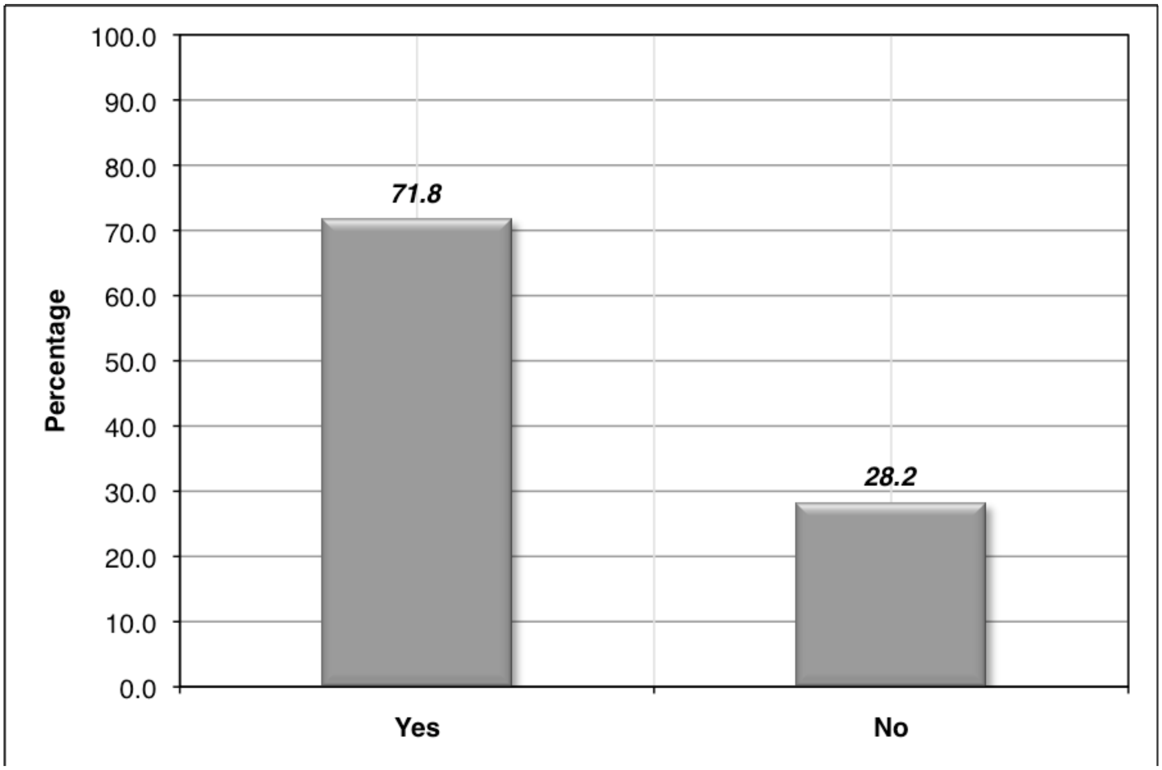
9. Do you typically require a warranty with your microsurfacing projects?



<u>If yes, do you believe it changes the results you get from the microsurfacing?</u>

- Yes, well at least it doesn't hurt
- Not certain
- Yes, the contractor seems to do a better job and give a better product as they do not want to come back
- No a higher price
- No significant improvement
- Somewhat
- I do, we have had warranty work done due to low skids

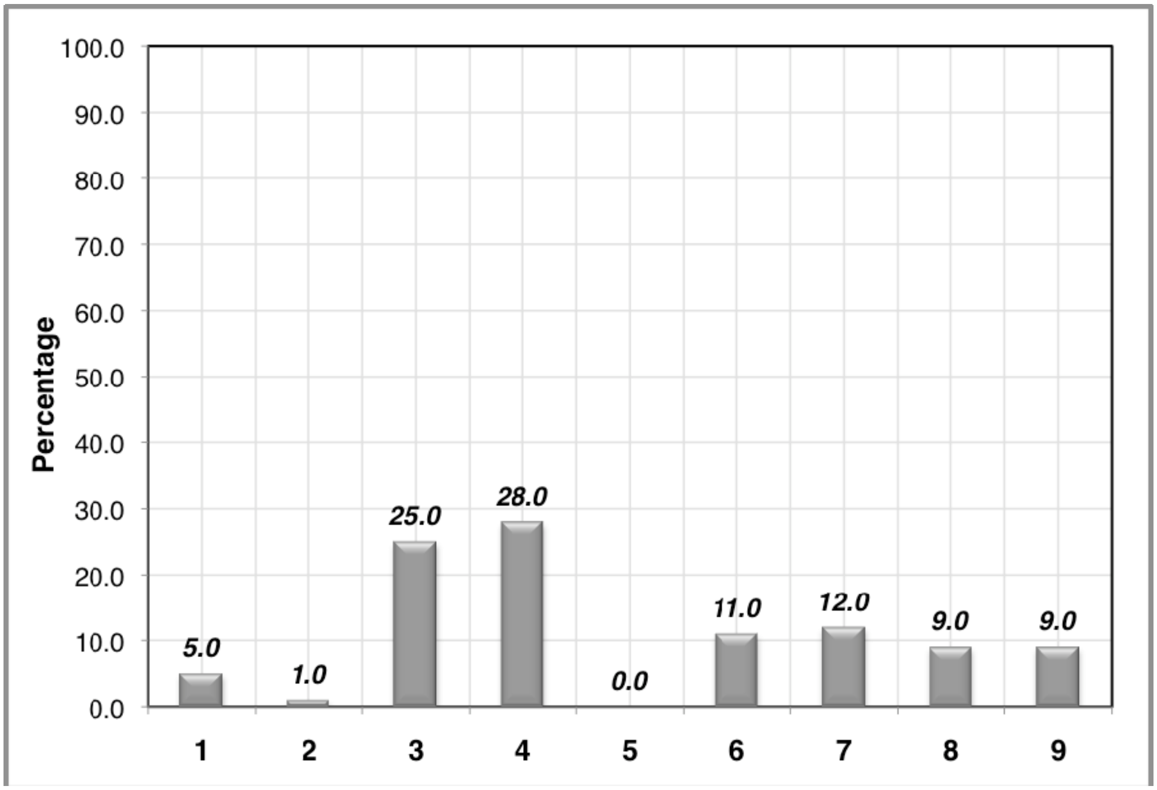
10. Do in house crews prep the roadways prior to receiving microsurfacing?



<u>If yes, how far in advance?</u>

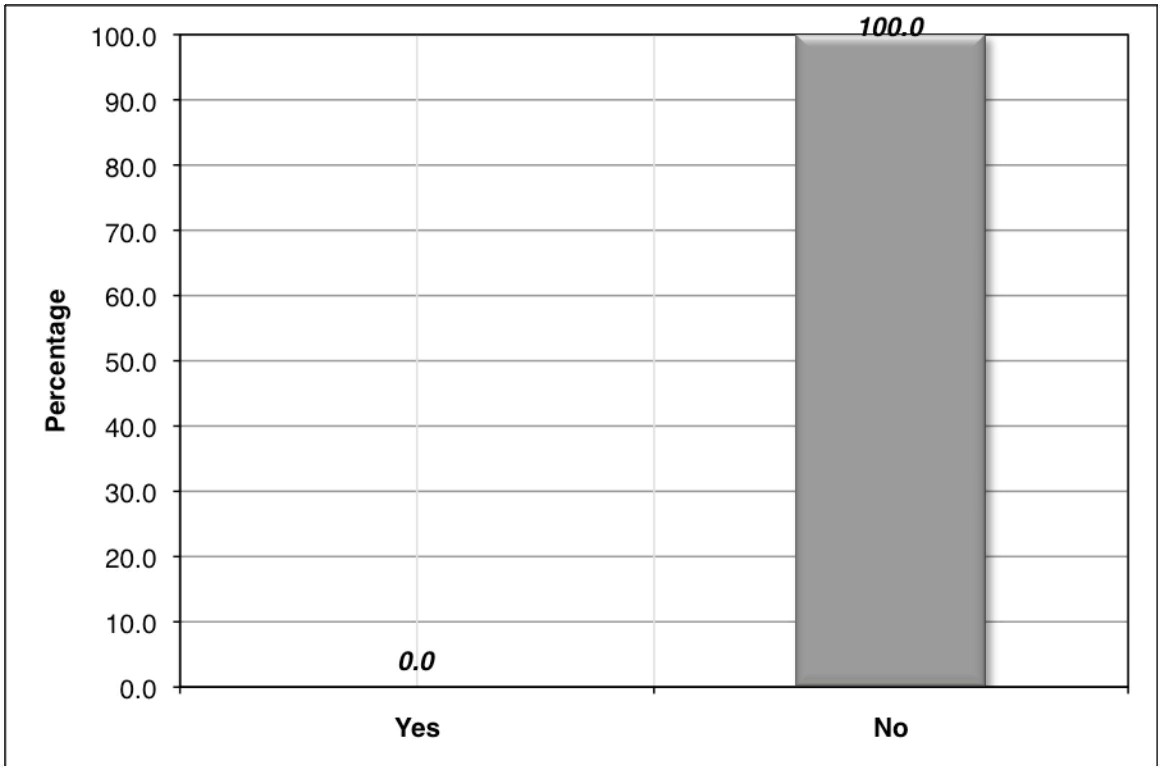
- Goal is several months
- As far in advance as possible, up to 1 year
- As much in advance as possible
- Preferably at least 6 months in advance
- 3 months
- Depends on requirements. Often just prior, unfortunately
- Within 6 months
- At least a month if possible
- 6 months preferable/3 months minimum
- Min 2 weeks
- 3 mo. To one year
- Depends on the type of prep (seal coat, sweep, blade grass)
- 3-6 months
- We have from as far as a year to two months ahead of time
- Should be done at least six months out
- Varies, however at least 6 months is best
- Six months if possible
- 1 year
- Repair any pavement distress

11. In our district microsurfacing is used for the following reasons, check all that apply:



1. Seal the pavement
2. Cover old striping to provide uniform surface for new traffic pattern
3. Stop bleeding on the existing surface
4. Fill wheel ruts
5. Provide additional structural support
6. Routine pavement preservation
7. Improve the ride characteristics of the existing pavement
8. When the roadway carries more traffic than we would consider for a seal coat (chip seal)
9. Simply to buy some time until a more permanent surface can be afforded

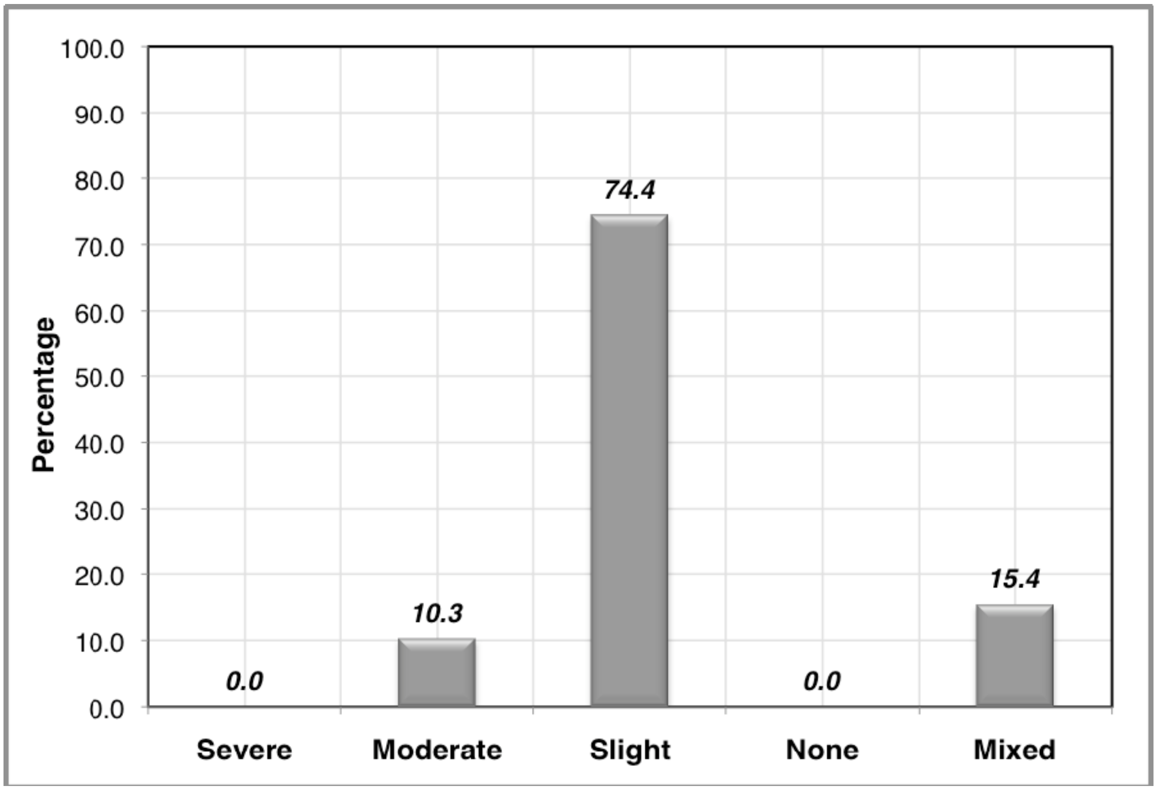
12. Do you use a PCI number to trigger you to use microsurfacing?



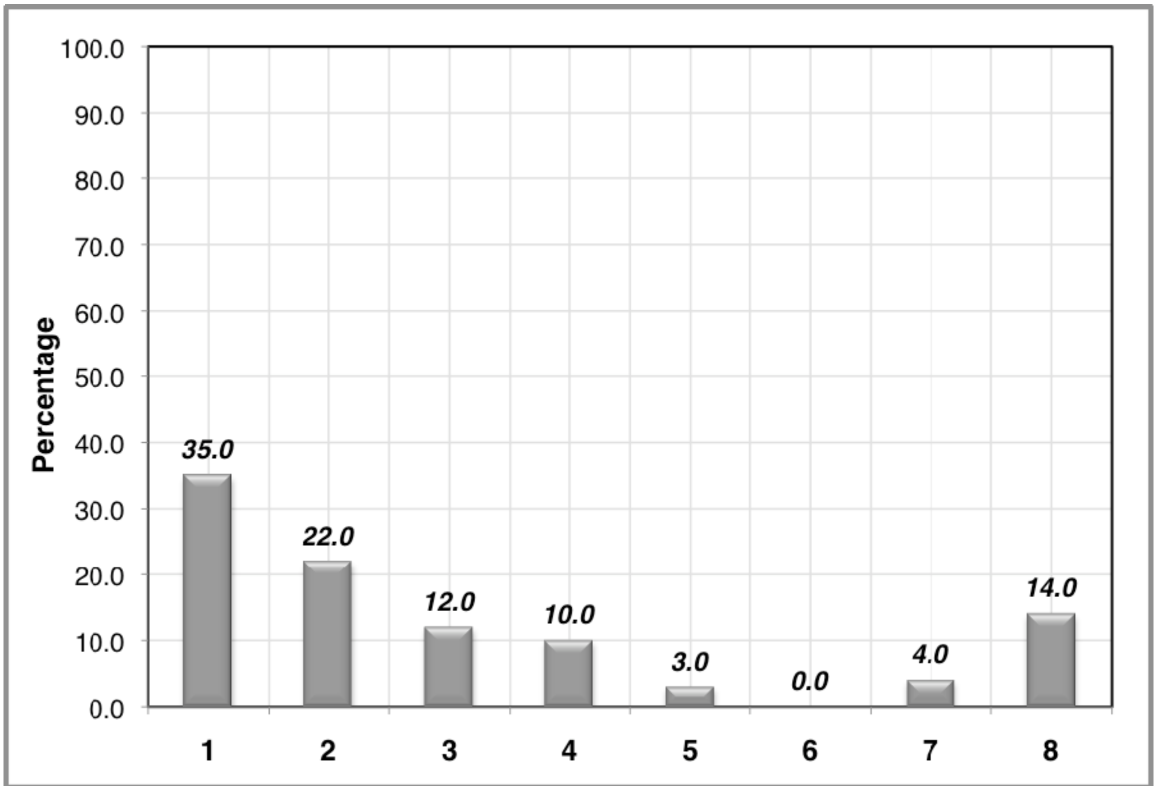
<u>If yes, what is the range?</u>

- Not sure
- I don't know what a PCI number is

13. How would you describe the level of distress on roads that generally receive a microsurfacing treatment?

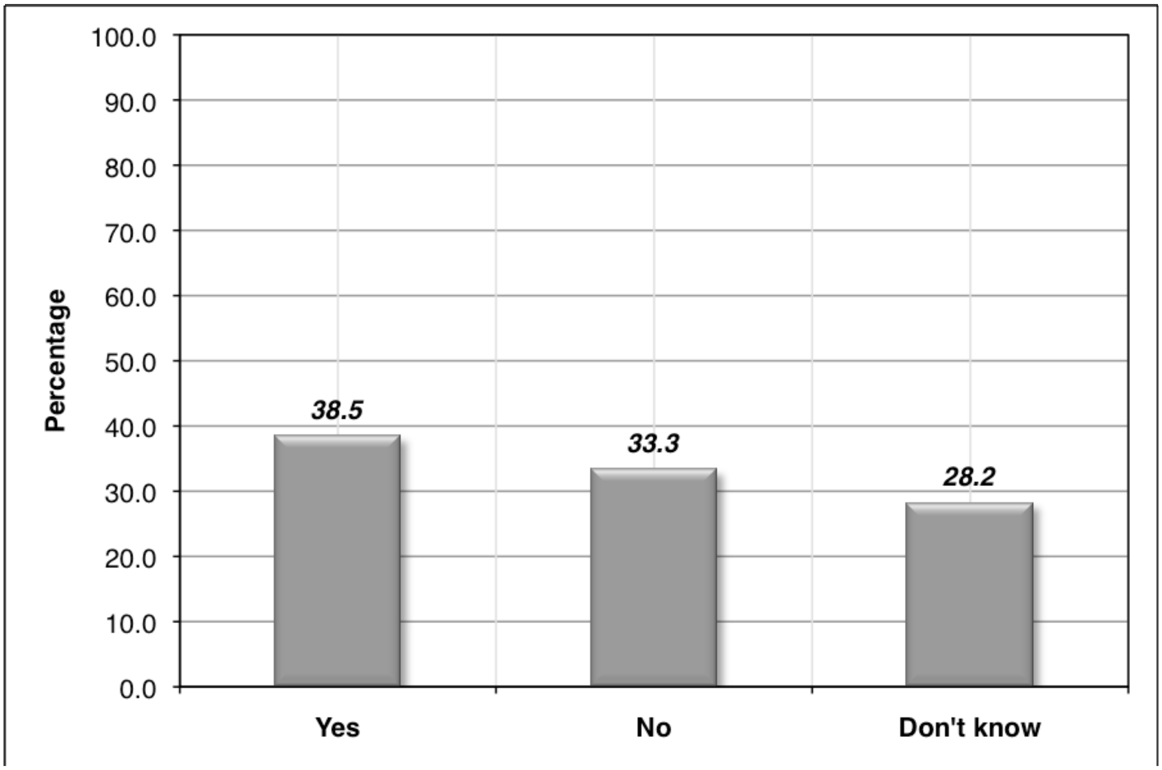


14. In our district we use a scratch or level up course of microsurfacing in addition to the surface course of microsurfacing when: Check all that apply.



1. The existing pavement has wheel ruts greater than 3/8” in depth
2. The existing pavement has any rutting
3. The existing pavement is flushed or bleeding
4. The existing pavement has a variable surface texture
5. The pavement carries higher traffic loadings
6. The existing pavement needs additional structure support
7. We are looking for extended service life from the microsurfacing treatment
8. We needed to improve the existing pavement ride

15. Should TxDOT require training and/or certification for crew members or contractor?



<u>If yes, who should be required to get the training/certification?</u>

- Inspector, pavement engineer, designers
- Contractor's responsible person (foreman and supt.)
- Paving foreman
- Lab personnel, mix production personnel, placement operators, contractor superintendent, TxDOT inspector
- Machine operator
- Inspector, contractors crew chief or PM
- Same as the hot mix certifications
- Superintendents and engineers
- TxDOT inspectors, contractor crews
- TxDOT and contractor

16. Rank the top 5 reasons for microsurfacing successes in order from greatest impact (1) to least impact (5).

	1	*2*	*3*	*4*	*5*	*Response Count*
Contractor experience	14 (40.0%)	10 (28.6%)	8 (22.9%)	1 (2.9%)	2 (5.7%)	35
Project selection	20 (69.0%)	2 (6.9%)	2 (6.9%)	3 (10.3%)	2 (6.9%)	29
Material quality	4 (17.4%)	12 (52.2%)	5 (21.7%)	1 (4.3%)	1 (4.3%)	23
Workmanship	6 (23.1%)	11 (42.3%)	3 (11.5%)	4 (15.4%)	2 (7.7%)	26
Mix design	4 (16.7%)	11 (45.8%)	5 (20.8%)	2 (8.3%)	2 (8.3%)	24
Type of contract (Warranty/Non-warranty)	0 (0.0%)	2 (16.7%)	5 (41.7%)	1 (8.3%)	4 (33.3%)	12
Weather	2 (9.5%)	8 (38.1%)	4 (19.0%)	5 (23.8%)	2 (9.5%)	21
Proper application rate	3 (13.6%)	6 (27.3%)	4 (18.2%)	7 (31.8%)	2 (9.1%)	22
Aggregate quality	2 (12.5%)	6 (37.5%)	4 (25.0%)	3 (18.8%)	1 (6.3%)	16
Aggregate gradation	2 (18.2%)	5 (45.5%)	3 (27.3%)	1 (9.1%)	0 (0.0%)	11
Vehicle speed control after the mix is deposited	2 (16.7%)	4 (33.3%)	4 (33.3%)	2 (16.7%)	0 (0.0%)	12
Ability to control traffic	3 (20.0%)	1 (6.7%)	5 (33.3%)	3 (20.0%)	3 (20.0%)	15
Aggregate/binder compatibility	3 (21.4%)	3 (21.4%)	6 (42.9%)	1 (7.1%)	1 (7.1%)	14
Proper proportioning	5 (26.3%)	5 (26.3%)	5 (26.3%)	3 (15.8%)	1 (5.3%)	19
Proper surface preparation	3 (17.6%)	5 (29.4%)	4 (23.5%)	3 (17.6%)	2 (11.8%)	17
Field construction procedures	4 (19.0%)	7 (33.3%)	3 (14.3%)	0 (0.0%)	7 (33.3%)	21

17. Rank the top 5 reasons for microsurfacing failures in order from greatest impact (1) to least impact (5).

	1	*2*	*3*	*4*	*5*	*Response Count*
Contractor experience	10 (31.3%)	9 (28.1%)	3 (9.4%)	4 (12.5%)	6 (18.8%)	32
Project selection	21 (67.7%)	3 (9.7%)	3 (9.7%)	2 (6.5%)	2 (6.5%)	31
Material quality	5 (27.8%)	6 (33.3%)	4 (22.2%)	3 (16.7%)	0 (0.0%)	18
Workmanship	5 (17.9%)	12 (42.9%)	5 (17.9%)	3 (10.7%)	3 (10.7%)	28
Mix design	2 (9.1%)	8 (36.4%)	9 (40.9%)	3 (13.6%)	0 (0.0%)	22
Type of contract (Warranty/Non-warranty)	0 (0.0%)	1 (7.1%)	4 (28.6%)	2 (14.3%)	7 (50.0%)	14
Weather	4 (19.0%)	5 (23.8%)	6 (28.6%)	3 (14.3%)	3 (14.3%)	21
Improper application rate	3 (15.0%)	3 (15.9%)	8 (40.0%)	5 (25.0%)	1 (5.0%)	20
Aggregate quality	4 (25.0%)	4 (25.0%)	6 (37.5%)	1 (6.3%)	1 (6.3%)	16
Aggregate gradation	0 (0.0%)	4 (33.3%)	7 (58.3%)	0 (0.0%)	1 (8.3%)	12
Vehicle speed control after the mix is deposited	1 (8.3%)	6 (50.0%)	4 (33.3%)	1 (8.3%)	0 (0.0%)	12
Early open the traffic after the mixture is deposited	1 (5.0%)	8 (40.0%)	5 (25.0%)	2 (10.0%)	4 (20.0%)	20
Aggregate/binder compatibility	2 (18.2%)	4 (36.4%)	4 (36.4%)	1 (9.1%)	0 (0.0%)	11
Improper proportioning	3 (17.6%)	5 (29.4%)	6 (35.3%)	2 (11.8%)	1 (5.9%)	17
Improper surface preparation	2 (11.8%)	5 (29.4%)	7 (41.2%)	2 (11.8%)	1 (5.9%)	17
Field construction procedures	5 (23.8%)	7 (33.3%)	3 (14.3%)	4 (19.0%)	2 (9.5%)	21

Other:

- Don't really know – do not have that much experience

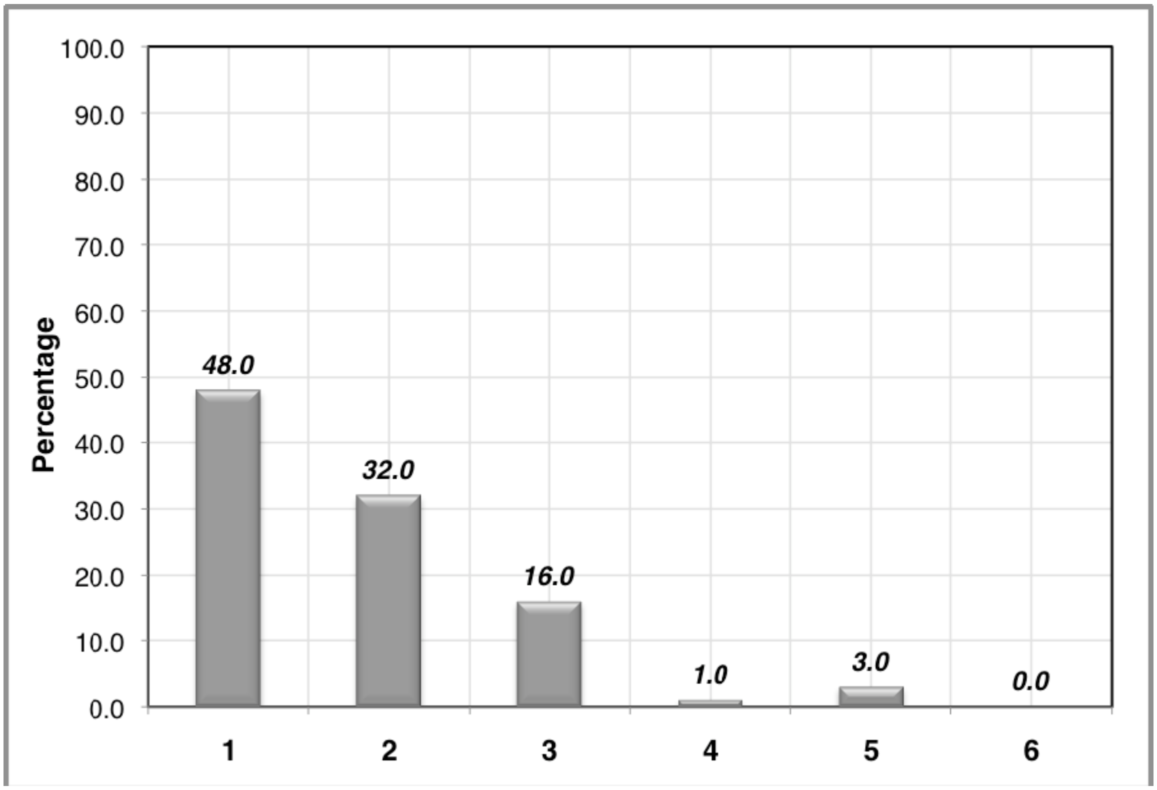
18. Which factors are most critical in determining the life of your microsurfacing projects? Please indicate the top three in order of importance.

	1	2	3	Response Count
Field construction procedures	8 (25.0%)	13 (40.6%)	11 (34.4%)	32
Original substrate surface quality	10 (43.5%)	7 (30.4%)	6 (26.1%)	23
Underlying pavement structure	25 (69.4%)	9 (25.0%)	2 (5.6%)	36
Maintenance funding	0 (0.0%)	1 (20.0%)	4 (80.0%)	5
Friction loss	0 (0.0%)	4 (80.0%)	1 (20.0%)	5
Traffic	3 (15.8%)	5 (26.3%)	11 (57.9%)	19
Cold climate considerations (Freeze/thaw cycles, snowplowing, etc.)	0 (0.0%)	4 (36.4%)	7 (63.6%)	11

Other:

- 2 Mix design

19. Which methods do you use to maintain your microsurfaced roads?

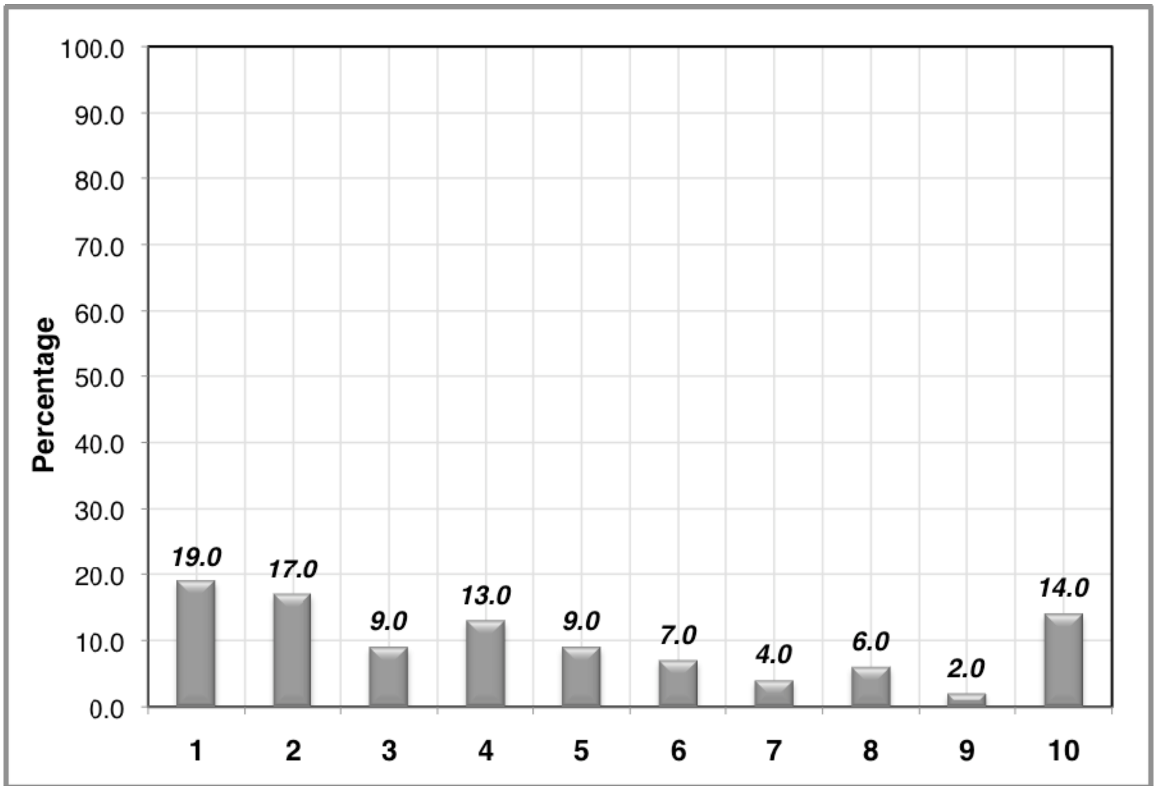


1. Crack sealing
2. Surface treatments (seal coat)
3. Fog seal
4. Additional applications of microsurfacing
5. None
6. I don't know

<u>Other:</u>

- Mill it off and use something better
- Strip seal

20. What common distresses are observed in your completed microsurfacing projects immediately after construction?

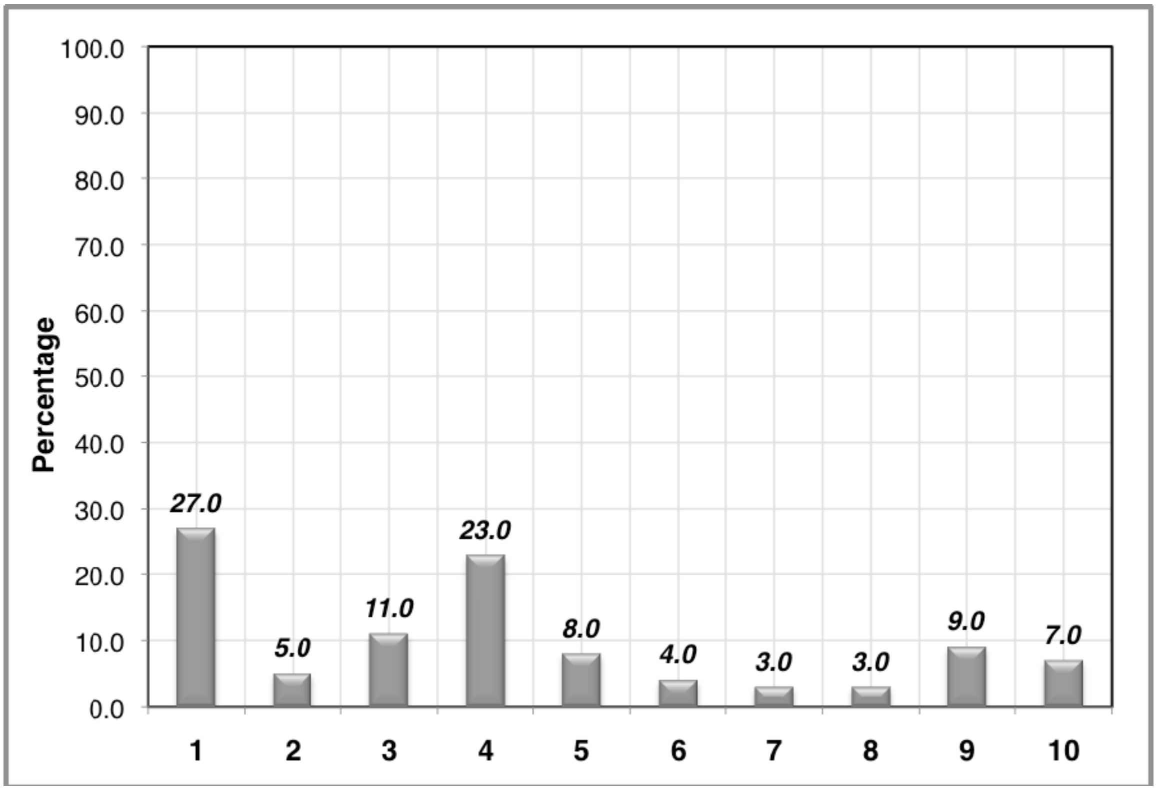


1. Crack reflection
2. Streaking/color variations
3. Raveling
4. Delamination
5. Corrugation/poor ride quality
6. Poor transverse joints
7. Bleeding
8. Poor longitudinal joints
9. Potholes
10. Surface texture variations

<u>Other</u>:

- Rutting
- Cracking of the micro

21. What common distresses are observed in your completed microsurfacing projects 3-5 years after construction?

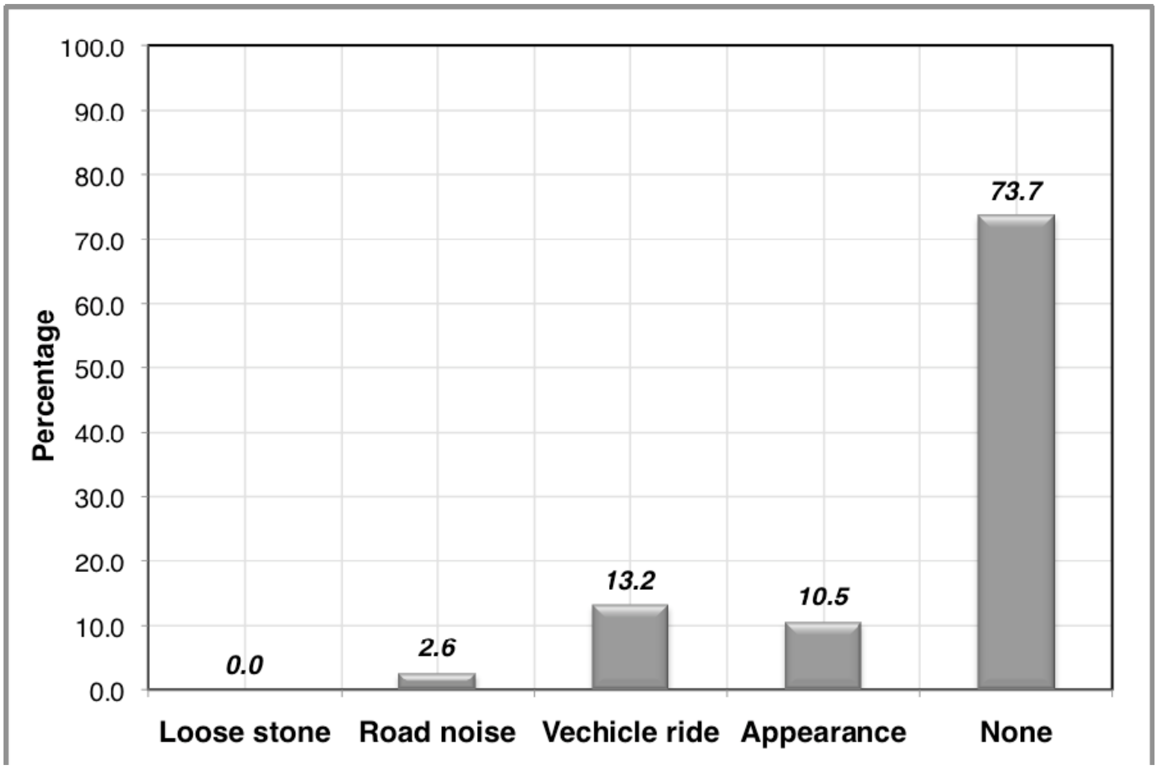


1. Crack reflection
2. Streaking/color variations
3. Raveling
4. Delamination
5. Corrugation/poor ride quality
6. Poor transverse joints
7. Bleeding
8. Poor longitudinal joints
9. Potholes
10. Surface texture variations

Other:

- Cracking
- Cracking of the micro

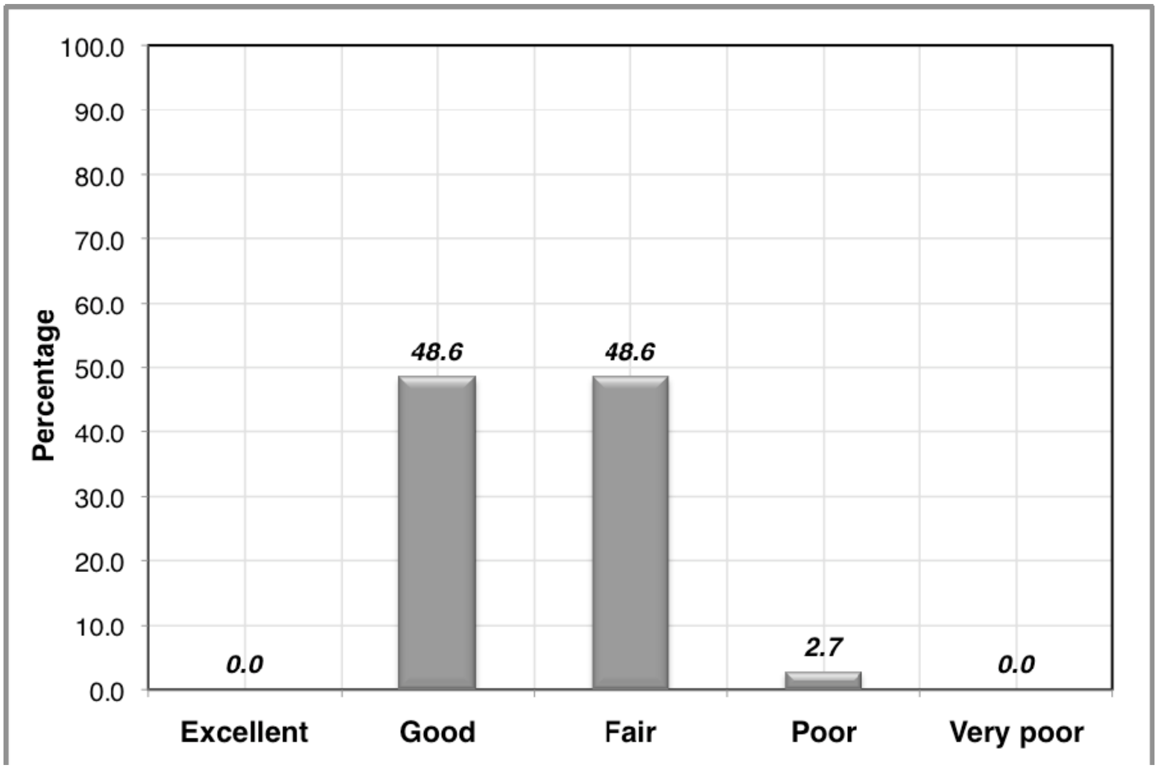
22. What is the most common public-user complaint about microsurfacing?



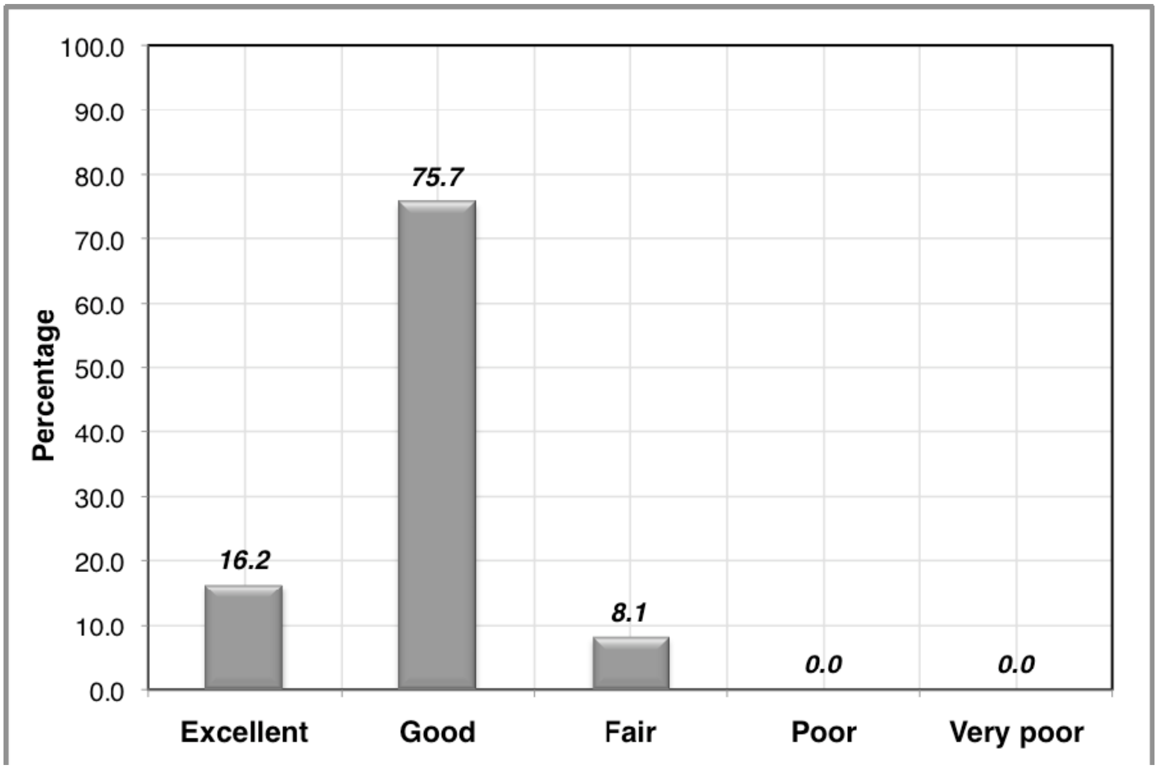
<u>Other:</u>

- Longitudinal joint lap too heavy, holds water

23. How would you describe the pavement ride on a road immediately **before** receiving a new microsurfacing?



24. How would you describe the pavement ride on the same road immediately **after** receiving a new microsurfacing?



25. Our district would utilize microsurfacing more if: Please rank the top three.

	1	2	3	Response Count
There were more contractors bidding the projects	5 (27.8%)	5 (27.8%)	8 (44.4%)	18
The contractors were certified by TxDOT as truly qualified	3 (17.6%)	10 (58.8%)	4 (23.5%)	17
We (TxDOT) had additional training to better understanding the process	6 (33.3%)	5 (27.8%)	7 (38.9%)	18
We were able to use a warranty clause	7 (58.3%)	1 (8.3%)	4 (33.3%)	12
We will not use microsurfacing because of past problems	6 (50.0%)	2 (16.7%)	4 (33.3%)	12

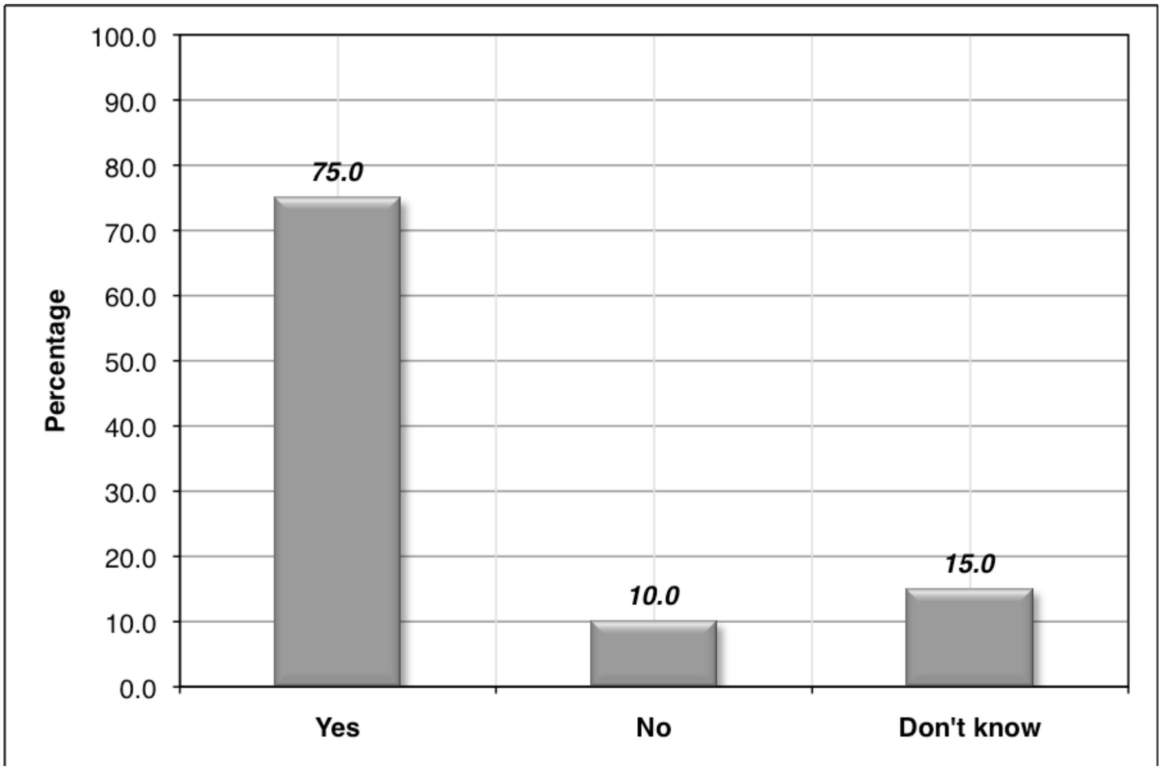
26. Which types of distress will microsurfacing correct?

	Yes	*No*	*Response Count*
Fatigue cracking	0 (0.0%)	34 (100.0%)	34
Reflection cracking	1 (2.9%)	33 (97.1%)	34
Streaking/color variations	28 (80.0%)	7 (20.0%)	35
Raveling	19 (57.6%)	14 (42.4%)	33
Delamination	2 (6.1%)	31 (93.9%)	33
Corrugation/poor ride quality	14 (40.0%)	21 (60.0%)	35
Poor transverse joints	8 (24.2%)	25 (75.8%)	33
Bleeding	35 (92.1%)	3 (7.9%)	38
Poor longitudinal joints	9 (27.3%)	24 (72.7%)	33
Potholes	1 (3.0%)	32 (97.0%)	33
Surface texture variations	32 (88.9%)	4 (11.1%)	36
Loss of friction/skid	38 (97.4%)	1 (2.6%)	39
Permeability	7 (20.6%)	27 (79.4%)	34
Rutting	35 (89.7%)	4 (10.3%)	39

Other, Please Specify:

- Have experienced an improvement in IRI values some 10 points better than sealed surface prior to micro
- Rutting-not necessarily, temp depending on cause
- Shallow rutting only
- Micro is a short term fix after awhile aloof the list will show up
- Minor rutting

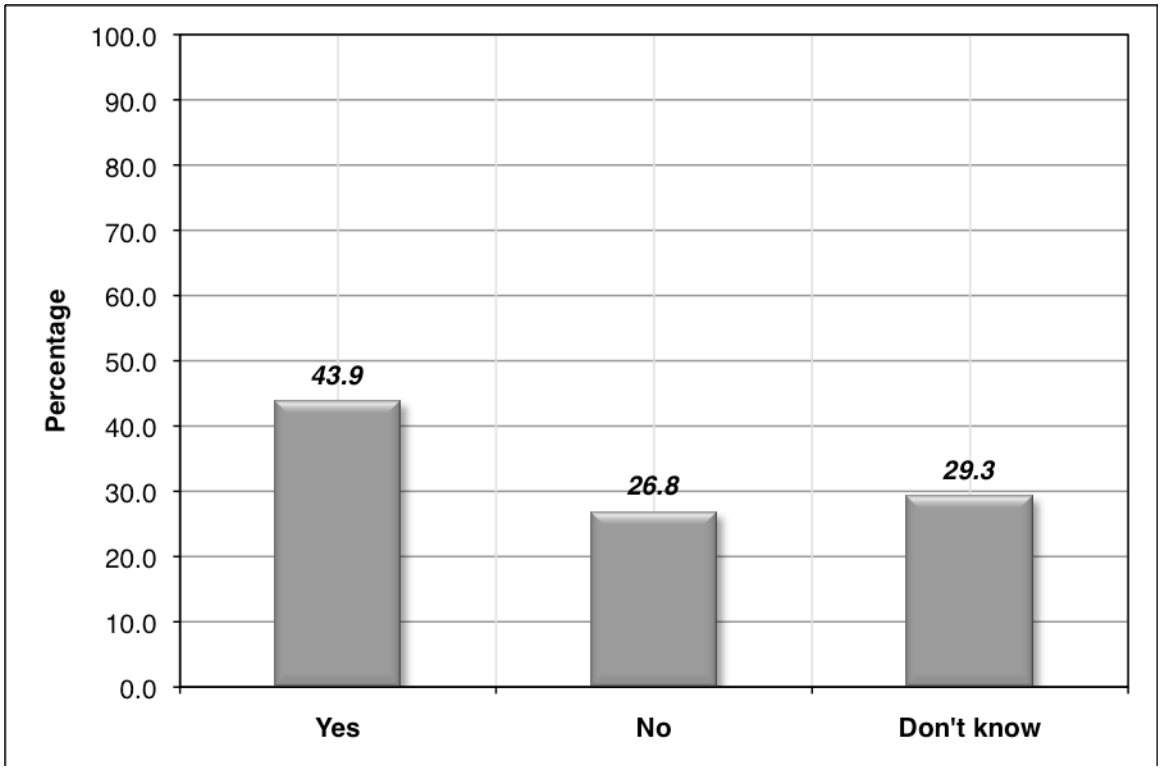
27. Are current microsurfacing specifications adequate to produce a quality product?



<u>If no, how can they be improved?</u>

- Need to adjust aggregate gradation requirements depending on the harshness of the aggregate used
- IRI readings must be at least 5% better than original
- Increase flexibility of material

28. We plan to use more microsurfacing in the future:



<u>If yes or no, what are the reasons?</u>

- Believe Micro has a valuable role in addressing conditions that it is designed for. Can make our maintenance dollar go farther when used properly
- We will use about the same amount or less due to a reduction in funding
- Limited use of HMAC allowed. Cost.
- Not suitable for use where pavement has distress
- Problems getting a good looking quality product out of the contractor. Problems with drag marks. Problems with joints that meet spec but look bad ride bad and hold water
- We will use it on projects suitable for micro. The limited use of micro -surfacing is due to the very narrow band of pavement conditions/ distress levels that warrant its use.
- We've had a number of poor jobs with even the best micro-surfacing contractors. Our dollars will be better spent elsewhere.
- I think we will continue to make sound decisions on appropriate PM and rehab scopes for our projects, which will not result in a significant change in the frequency of utilization of microsurfacing.
- Works good on the proper road and conditions such as filling ruts and skid.
- To extend the life of existing surface in unban areas subjected to heavy turning traffic with minor rutting or aged pavement.
- Improve ride
- Future use will be for low volume roadways. Recent experiences with use on high volume roadways have been poor.

- Poor performance. Mostly reveling and spalling. Too shallow to effectively patch without producing a poor ride.
- Will stay at same level
- Due to budget issue, seal coat is a cheaper option
- Immediate and pervasive delaminating within 3 weeks of project completion. Two times.
- It fulfills a need
- We believe it is an economical way to remove shallow rutting, stop bleeding, restore skids and keep from stacking seal coats on higher volume roadways.
- To improve skid and fill in minor rutting.

29. What does a *good* microsurfacing contractor do that is important?

- Help with evaluation of roadway sections.
- They take care of business and stand behind their product. They are willing to recommend when not to use their product as well as when it is a good fit.
- Provides a good mix design and uses good construction procedures
- Stop paving when weather conditions are not appropriate. Assist in selecting appropriate projects that a microsurface will improve.
- Becomes familiar with the roadway and issue(s) trying to be corrected. Makes sure all employees are committed to providing a quality product. Emphasis on doing it right the first time.
- Proper mix design and application.
- Work deliberately.
- Cares about building a quality job not just meeting the minimum specifications.
- A good contractor knows his product and has a crew that is proficient in applying it. He needs to explain the limitations to the customer and be willing to offer suggestions on how to get the best project for the dollar.
- Accepts low production at the start of a project until both the Contractor and the Engineer (TxDOT) are satisfied with the combination of materials, mix design, roadway conditions and application rates to assure a quality finished product.
- Repairs rutting problems on existing roads. Makes sure that roads that have been micro-surfaced have a better ride than before work was done.
- Watch the weather, good application rate
- Bring experience
- Controls materials, mix production and placement with competence and consistency among all key staff
- Uses good field construction techniques. Microsurfacing can get messy really fast and look terrible
- Takes pride in his workmanship and the finished product
- Communicates with the TxDOT Inspector on application rate and road conditions
- Concerned about quality and pride on the job
- Good workmanship and providing a nice looking job
- To make sure that the product will serve it's intended purpose.
- Knows what he is doing
- Understands the process and has technical experts within the company that consult during construction
- Attentive to comments from owner representatives and all contractor representatives have a quality mindset.
- Communicate with the engineer
- Knowledgeable of product and process and willing to share that information.
- Quits when it rains.
  Advises state of bad project selections.
- Consistent quality
- Care about the quality of their work.
- Monitor material consistency.
  Provide input on viable candidate projects during project selection.

30. What does a *poor* microsurfacing contractor do that is harmful?

- Poor workmanship and material quality control
- Tries to perform work with equipment not adequate for the job. In it strictly for the money and not the quality
- May provide a poor mix design and uses poor construction procedures.
- Paves too fast and leaves streaks and poor ride. Poor proportioning.
- Sloppy workmanship. Need to understand cheap bid does not mean TxDOT wants cheap work
- Improper mix design and poor application.
- Hurry
- Doesn't care about what the project looks like or how it rides or holds water along a joint as long as it meets specs and the contractor gets paid.
- Does not pay attention to detail and quality control. This leads to an unsightly and poor quality project.
- Tries to push high production rates at the expense of quality before establishing the appropriate relationship between the combinations of materials mix design, roadway conditions and application rates.
- Leaves the road with a worse ride than before.
- Start and stop, put it all down in one pass
- Provide a poor product because they can
- May not control materials, mix production and placement or any one of the three with competence and consistency among all key staff
- Sloppy work and does not care about looks or quality
- Blow and go to get to the next paying job.
- No communication and places the product on a surface that is not ready for it
- Have no exp. personal on the job
- Poor aesthetics, poor performance issues (equipment maintenance, joints, etc.)
- Unable to perform the best job for the project.
- Does not know what he is doing
- Push the limits of the paving season
- Lack of attention to details and quality. Unresponsive to comments from owner rep
- Cheat on asphalt content
- Sub par materials, lack of good workmanship, unwilling to work with department
- Paves wet pavement.
  Paves any project selected
- Inconsistent product
- Poorly maintained equipment, inexperienced and untrained personnel.

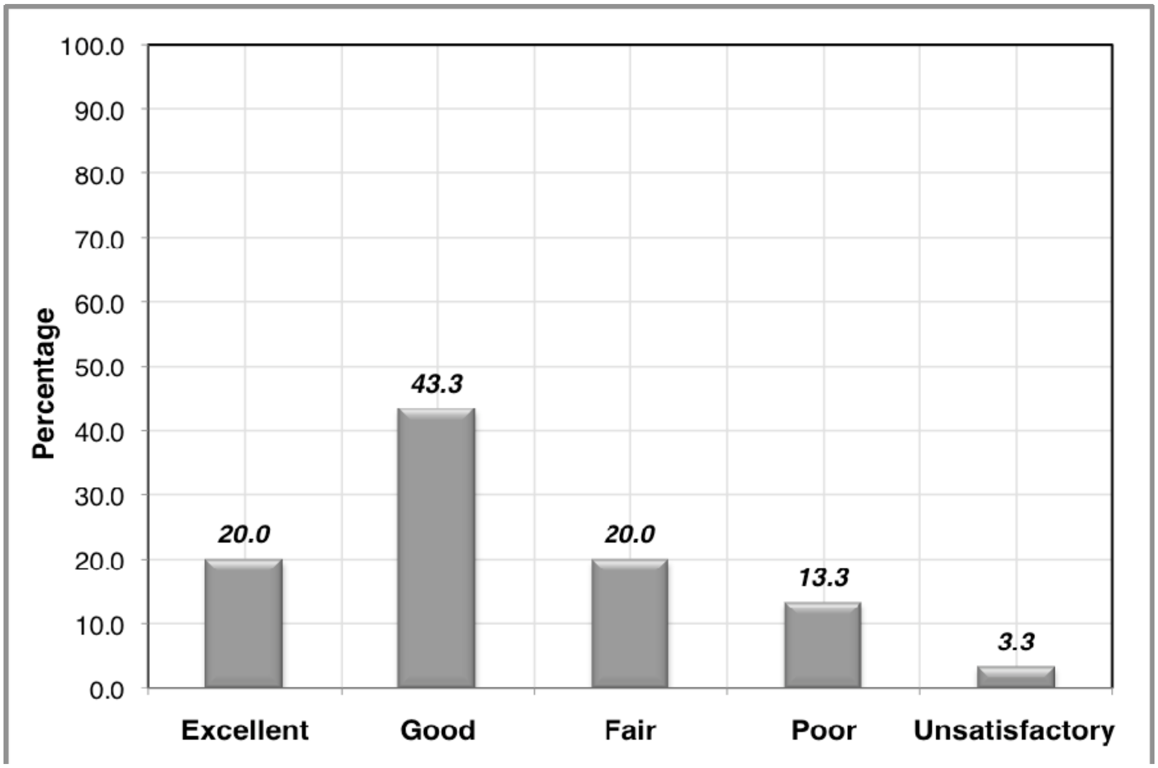
Please identify up to three representative projects and evaluate their performance.

31. <u>Project 1</u>

a. Project name and Location:

- SH 276 in Hunt county near Lake Tawaki. Had problems with a widening project that experienced bleeding due to the use of CRS1-P. Came in with a Change Order and place Micro. The finished product actually improved the cross slope on the newly widen section and eliminated the bleeding issue. Micro was placed in 2009 and is working well to this day.
- IH -35 San Bernardo - Laredo Texas
- US 180, Scurry Co. (Constructed in 2010)
- We have not used micro-surfacing in several years. Past projects were poor.
- Baylor County on US 183 from Seymour to Throckmorton County Line.
- IH-10 Sutton Co
- On RM 853 from FM 2288 to US 67 in San Angelo, Texas
- IH 30 Mt. Pleasant From: Franklin Co. Line to Sulphur River
- Any district 13 micro jobs since the mid 80's
- SH 12 in NE Collin county
- SH 43 South of IH 20
- US 287
- North Loop 289
- LP 322 from IH 20 to Lytle Creek in Taylor County
- CSJ: 0610-06-071 IH30 from 0.1 Mi W of Spur86 to 0.3 Mi W of Spur74
- SH 95, Bell County
- US 287 Waxahachie Bypass
- SH 63 in Jasper County
- US 84 Coleman Co
- IH 20 - Harrison county
- Not real sure it’s been several years since we have done a micro. The Counties were Mclennan and Coryell Waco District Wide Micro I think 2007 & 2008
- Several projects in 2003, 2004 in Brazos County
- None under current specifications.
- US 84 SH 16 US 183
- SH 121 in Bonham
- Summer 2010 district wide various
- Possibly 2 upcoming - I will have to see if they make it to letting
- SH 15 in Hansford County
- US 82 in Baylor County thru Seymour,
  SH 114 in Young County thru Olney US 81 in Montague County thru Bowie
- District wide project this year and the previous years
- US 287 Houston County

b. Determine the overall level of success of this project



c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success

	Excellent	*Good*	*Fair*	*Poor*	*Unsatis-factory*	*Did Not Use*
Meets expected service life	25.0%	32.1%	21.4%	3.6%	7.1%	10.7%
Does not fail shortly after construction	19.2%	42.3%	7.7%	3.8%	11.5%	15.4%
Achieves desired friction/skid number	34.5%	44.8%	13.8%	0.0%	0.0%	6.9%
Qualitative (subjective) measures-look, color, etc.	25.0%	35.7%	14.3%	10.7%	3.6%	10.7%
Meets project specification	22.2%	51.9%	22.2%	0.0%	0.0%	3.7%

Other:

- Stopped RC asphalt from bleeding back through for 7-8 years
- Still performing well after about 5 years
- Ride was not corrected. IRI numbers were no better after construction than before
- Ride quality – fair
- Warranty project

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress.
(Non-existent=0, Low=1, Medium=2, High=3)

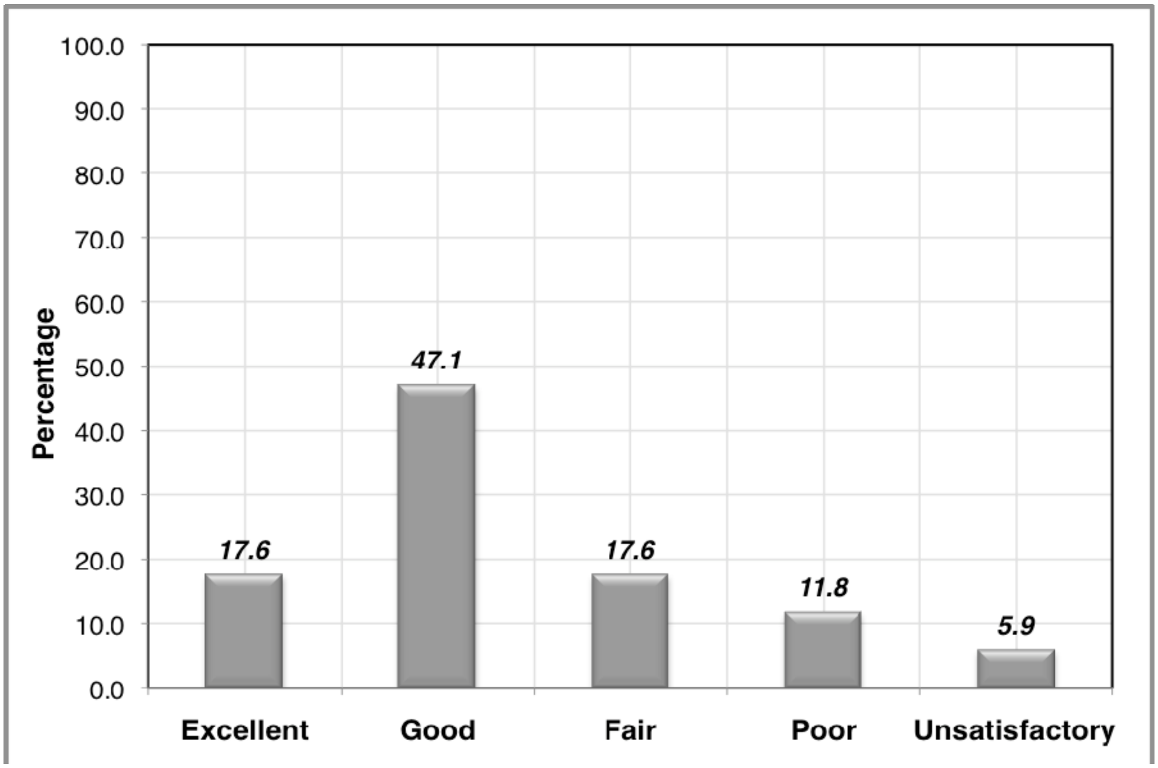
	Nonexistent	Low	Medium	High
Raveling	68.0%	24.0%	4.0%	4.0%
Bleeding	76.9%	19.2%	0.0%	3.8%
Corrugation	56.0%	32.0%	12.0%	0.0%
Crack reflection	40.0%	36.0%	20.0%	4.0%
Streaking	28.0%	44.0%	24.0%	4.0%
Transverse joints	46.2%	38.5%	11.5%	3.8%
Longitudinal joints	44.0%	36.0%	20.0%	0.0%

32. <u>Project 2</u>

a. Project name and Location:

- US 377 - From Whitesboro south to county line
  Work completed in 1997
- We have not used micro-surfacing for several years.
  Same as before
- US 82 Baylor County through Seymour
- FM989 Texarkana
  from US 82 to US 59
- IH 20 throughout Harrison County
- Plainview I-27 Frontage Roads
- US 180 from Shackelfor/Jone County line to SH 351 in Shackelford County.
- SH 6 McLennan
- FM 2799 in Jasper County
- US 377 Brown Co
- SH 43 - Harrison county
- US 84
  US 183
  SH 16
- Summer 2009 district wide various
- Loop 335 in Randall County
- US 183 in Baylor County, from Seymour to Throckmorton Co
- District wide seal coat projects this and last three years
- US 59 Angelina Co

b. Determine the overall level of success of this project



c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success
(5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

	Excellent	Good	Fair	Poor	Unsatis-factory	Did Not Use
Meets expected service life	20.0%	46.7%	0.0%	6.7%	6.7%	20.0%
Does not fail shortly after construction	30.8%	30.8%	7.7%	7.7%	7.7%	15.4%
Achieves desired friction/skid number	43.8%	31.3%	12.5%	0.0%	0.0%	12.5%
Qualitative (subjective) measures-look, color, etc.	14.3%	57.1%	0.0%	7.1%	7.1%	14.3%
Meets project specification	21.4%	50.0%	14.3%	7.1%	0.0%	7.1%

Other:

- Project was to address severe rutting by pulling rut box through project. Micro was sealed the following summer and has performed well entire time.
- Material delaminated shortly after project completion. Pushed and shoved making the ride unacceptable and had to be removed
- Purpose of project was to correct ride. Project was corrugated throughout after construction. No improvement to IRI numbers.
- Representative of a very good candidate for micro. Very minor rutting excellent existing pavement condition and relatively low traffic volume, very minimal turning movements and ability to give the material adequate time to cure before letting traffic have it.
- None

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress.
(Non-existent=0, Low=1, Medium=2, High=3)

	Nonexistent	*Low*	*Medium*	*High*
Raveling	84.6%	15.4%	0.0%	0.0%
Bleeding	76.9%	23.1%	0.0%	0.0%
Corrugation	38.5%	38.5%	7.7%	15.4%
Crack reflection	53.8%	23.1%	23.1%	0.0%
Streaking	16.7%	58.3%	16.7%	8.3%
Transverse joints	42.9%	28.6%	28.6%	0.0%
Longitudinal joints	50.0%	28.6%	21.4%	0.0%

<u>Other:</u>

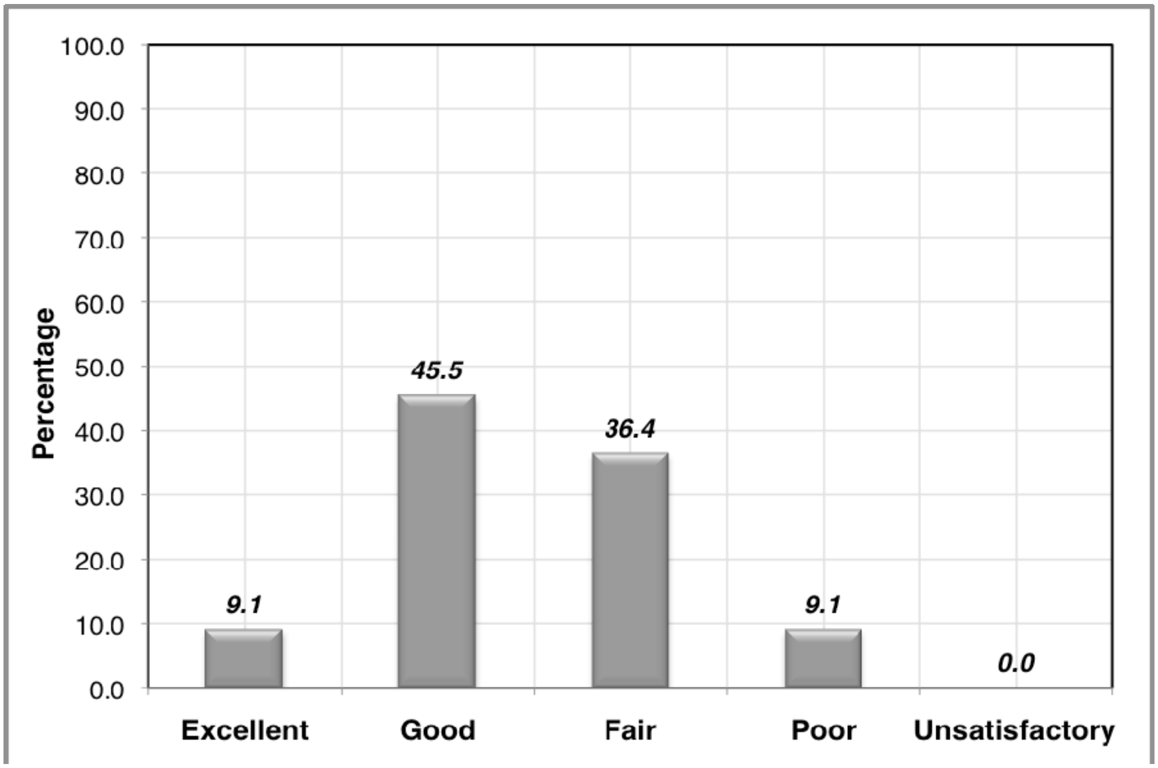
- This location is holding up well, only some minor cracking is occurring
- Use to fill ruts and seal the bleeding from previous OCST
- Cracking of micro
- None

33. <u>Project 3</u>

a. Project name and Location:

- FM 1417 and SH 56
  Work completed in 2001
- We have not used Micro-surfacing for several years.
  Same as before
- US 59 Carthage
  From US 59 North to US 79 East
- IH 20 East and West
- Spur 396, McLennan County
- US 69 in Tyler County
- US 59 - Cass
- Summer 2008 district wide various
- US 54 in Sherman County
- FM 51 in Cooke County, from IH 35 to FM 1306
- Same as before
- BU 69, Angelina Co

b. Determine the overall level of success of this project



c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success
(5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

	Excellent	Good	Fair	Poor	Unsatis-factory	Did Not Use
Meets expected service life	0.0%	63.6%	18.2%	18.2%	0.0%	0.0%
Does not fail shortly after construction	10.0%	50.0%	40.0%	0.0%	0.0%	0.0%
Achieves desired friction/skid number	27.3%	54.5%	18.2%	0.0%	0.0%	0.0%
Qualitative (subjective) measures-look, color, etc.	20.0%	40.0%	20.0%	10.0%	10.0%	0.0%
Meets project specification	10.0%	50.0%	10.0%	10.0%	10.0%	10.0%

<u>Other:</u>

- Fill ruts along wheel paths

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress.
(Non-existent=0, Low=1, Medium=2, High=3)

	Nonexistent	Low	Medium	High
Raveling	66.7%	22.2%	11.1%	0.0%
Bleeding	55.6%	33.3%	11.1%	0.0%
Corrugation	33.3%	66.7%	0.0%	0.0%
Crack reflection	50.0%	10.0%	20.0%	20.0%
Streaking	0.0%	66.7%	22.2%	11.1%
Transverse joints	33.3%	22.2%	22.2%	22.2%
Longitudinal joints	20.0%	30.0%	30.0%	20.0%

<u>Other:</u>

- Ruts re-appearing after a while. Temporary fix
- Cracking of micro

APPENDIX C: SURVERY QUESTIONNAIRE FOR CONTRACTORS

1. Which of the following mix design tests are performed on your projects for microsurfacing projects (select all)?

☐ ISSA A143
☐ ASTM D3910
☐ ASTM D6372
☐ TTI1289
☐ Other, Please Specify:

2. Are your mix designs done during the offseason/winter?

☐ Yes
☐ No

If “No”, are your mix designs done immediately prior to starting a project with material samples to be actually used on the project?

Please explain:

3. Who does your microsurfacing mix design?

☐ Ergon
☐ Road Science
☐ Don’t know
☐ Other, Please Specify:

4. Given the existing specified aggregate gradations shown in the table below, do you believe any change would be beneficial?

☐ Yes
☐ No

If "Yes",
what change would be beneficial?

Aggregate Gradation Requirements
Tex-200-F, Part II (Washed)

Sieve Size	Cumulative % Retained
1/2 in.	0
3/8 in.	0–1
#4	6–14
#8	35–55
#16	54–75
#30	65–85
#50	75–90
#100	82–93
#200	85–95

5. How do you select the binder type for microsurfacing jobs?

☐ Local climate
☐ Traffic volume or ESALs
☐ Weather conditions in which seal will be applied
☐ Identified during design
☐ Compatibility with aggregate
☐ Past experience
☐ Other, Please Specify:

6. Given the existing binder specifications, do you believe any changes to the specifications would be beneficial?

☐ Yes
☐ No

If "Yes", what changes would be beneficial?

7. Do you use modifiers with your base asphalt or binder for microsurfacing projects?

☐ Yes
☐ No

If “Yes”, what modifiers are used for microsurfacing projects? Check all that apply.

☐ Polymers
☐ Latex Additives
☐ Anti-stripping agents
☐ Styrene Butadiene Rubber (SBR)
☐ SBR—Polyisoprene
☐ SBR—Thermoplastic Elastomers
☐ Other, Please Specify:

8. What is the break control additive that you use?

____

9. Do you ever change break control additives?

☐ Yes
☐ No

If “Yes”, why?

10. What percentage of residual asphalt is normally specified in your Job-Mix Formula (JMF) proportions for microsurfacing projects?

☐ below 6%
☐ 6.0 to 7.0% (including 6.0%)
☐ 7.0 to 8.0% (including 7.0%)
☐ 8.0 to 9.0% (including 8.0% and 9.0%)
☐ higher than 9.0%

11. What percentage of mineral filler (hydraulic cement or hydrated lime) do you normally use in Job-Mix Formula (JMF) proportions for microsurfacing projects?

☐ below 0.5%
☐ 0.5 to 1.0% (including 0.5%)
☐ 1.0 to 1.5% (including 1.0%)
☐ 1.5 to 2.0% (including 1.5%)
☐ 2.0 to 2.5% (including 2.0%)
☐ 2.5 to 3.0% (including 2.5% and 3.0%)
☐ higher than 3.0%

12. What type of mineral filler do you most commonly use for microsurfacing projects?

☐ Portland cement
☐ Hydraulic lime
☐ Fly ash
☐ Limestone dust
☐ Crushed rock screenings
☐ Cement kiln dust (CKD)
☐ Baghouse fines
☐ Other, Please Specify:

13. What type of other additives do you use for microsurfacing projects?

☐ Aluminum sulfate crystals
☐ Ammonium sulfate
☐ Inorganic salts
☐ Liquid aluminum sulfate
☐ Amines
☐ Anti-stripping agents
☐ Other, Please Specify:

14. When you adjust residual binder content of the mix, how much of an adjustment is made for:

High traffic:____

Scratch/Level-up course:_______________________________

Rut filling:____

Temperature extremes:_________________________________

Existing bleeding or flushed pavement:____________________

15. Which type of mixing equipment calibration practices do you use?
(mark all options that apply, include frequency if known)

☐ Field calibration
How often?

☐ Our company furnishes a calibration certificate
How often?

☐ Other:
How often?

☐ No calibration
☐ Don't know

16. Does TxDOT request a construction of a test strip before full production microsurfacing?

☐ Yes
☐ No, and we do not construct a testing strip before full production
☐ No, but we do construct a testing strip before full production

17. Do you use a specific length or length range when building a test strip?

☐ Yes, we build a fixed length test strip.
Please specify length (or length range):

☐ Yes, but the strip length varies in each project
☐ No

18. Do you construct the test strip at night when the project is being done at night?

☐ Yes
☐ No

19. Do you ever roll microsurfacing?

When:

How:

20. Prior to microsurfacing, should tack coat be utilized?

When:

Type of material:

Application rate:

21. Do you have any comments concerning the specified requirement for pre-wetting/fogging the pavement with water prior to microsurfacing?

Comments:

22. Do you believe weather conditions during application affect the success of microsurfacing:

☐ Not at all
☐ Somewhat
☐ Greatly

23. Should the existing temperature requirements for microsurfacing be changed?

How:

Why:

24. Do you check and record weather conditions such as temperature, relative humidity, wind velocity, and precipitation daily?

☐ Yes
☐ No

25. In which months do you typically apply microsurfacing?

____

26. Do you require training and/or certification for crew members?

☐ Yes
☐ No

If “Yes”, what type of training or certification?

27. What do you typically do for your internal quality assurance on microsurfacing projects?

☐ What is required by job specifications
☐ Other: Please explain.

28. Does it matter if you change brands of mineral filler during a project?

☐ Yes
☐ No
☐ Don’t know

29. Do you check the quality of the water source used for a microsurfacing project?

☐ Yes
☐ No

If “Yes”, how?

30. When testing and accepting the aggregate for specification compliance, where is the acceptance test conducted?

☐ The pit/source
☐ The stockpile
☐ While transferring into the nurse units
☐ Just before it enters the microsurfacing paver mixing chamber
☐ Don’t know

31. Do you feel TxDOT is adequately qualified to inspect microsurfacing projects?

☐ Yes
☐ No

32. How would you describe the level of distress on roads that generally receive a microsurfacing treatment?

☐ Severe
☐ Moderate
☐ Slight
☐ None
☐ Mixed

33. What types of microsurfacing application methods have you performed?

☐ Full lane width
☐ Scratch coat
☐ Rut filling
☐ Hand-applied
☐ Other, Please Specify:

34. After the mix design has been submitted and approved should the contractor be allowed to adjust any of the following to account for weather conditions? Check all that are permissible.

☐ Water
☐ Mineral filler
☐ Asphalt emulsion
☐ Application rate
☐ Speed of the laying operation
☐ Time till opening to traffic

35. Should the contractor be allowed to adjust the mix design to account for:
Check all that are permissible.

☐ Weather
☐ Existing pavement surface condition
☐ Traffic conditions

36. Who has the authority to adjust the mix design to account for project specific field conditions? Check all that are permissible.

☐ The Engineer
☐ The Inspector

☐ District Lab Personnel
☐ The Contractor

37. Do you calibrate your mixing equipment (check all that apply):

☐ Annually
☐ Before each project
☐ When any material sources change
☐ After any machine maintenance

38. Beyond calibration of mixing and spreading equipment, do you perform any other field tests to check material application rates?

☐ Yes
☐ No

If “Yes”, what tests are done?

39. What tolerances are allowed for application rate and speed of microsurfacing?

____

40. What workmanship issues cause the most difficulties for your crews?

☐ Finished surface
☐ Construction joints
☐ Edges
☐ Ruts
☐ Other, Please Specify:

41. What is the typical time span between final spreading and opening to reduced speed traffic?

_______________Minutes/hours

42. What is the typical time span between final spreading and opening to full speed traffic?

_______________Minutes/hours

43. Which of the following treatments are performed post-microsurfacing?

☐ Sweeping
☐ Sanding
☐ Other, Please Specify:

44. If any of the above treatments are done, who conducts the treatments and when?

____

45. If sweeping is done, what kind of broom is used?

____

46. Rank the top 5 reasons for microsurfacing successes in order from greatest impact (1) to least impact (5).

____Contractor Experience
____Project Selection
____Material Quality
____Workmanship
____Mix Design
____Type of Contract (Warranty/Non-warranty)
____Weather
____Proper application rate
____Aggregate quality
____Aggregate gradation
____Vehicle speed control after the mixture is deposited
____Ability to control traffic
____Aggregate/binder compatibility
____Proper proportioning
____Proper surface preparation
____Field construction procedures
____Other, Please Specify:

47. Rank the top 5 reasons for microsurfacing failures in order from greatest impact (1) to least impact (5).

____Contractor Experience
____Project Selection
____Material Quality
____Workmanship
____Mix Design
____Type of Contract (Warranty/Non-warranty)
____Weather
____Improper application rate
____Dirty or dusty aggregate
____Aggregate gradation
____Vehicle speed control after the mixture is deposited
____Early open the traffic after the mixture is deposited
____Aggregate/binder compatibility
____Improper proportioning
____Improper surface preparation
____Field construction procedures
____Other, Please Specify:

48. Which factors are most critical in determining the *life* of your microsurfacing projects? Please indicate the top three in order of importance.

____Field construction procedures
____Original substrate surface quality
____Underlying pavement structure
____Maintenance funding
____Friction loss
____Traffic
____Cold climate considerations (freeze/thaw cycles, snowplowing, etc.)
____Other, Please Specify:

49. How would you describe the pavement ride on a road immediately before receiving a new microsurfacing?

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Very Poor

50. How would you describe the pavement ride on the same road immediately after receiving a new microsurfacing?

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Very Poor

51. Which types of distress will microsurfacing correct?

Yes	No	
☐	☐	Fatigue Cracking
☐	☐	Reflection Cracking
☐	☐	Streaking/Color Variations
☐	☐	Raveling
☐	☐	Delamination
☐	☐	Corrugation/Poor Ride Quality
☐	☐	Poor Transverse Joints
☐	☐	Bleeding
☐	☐	Poor Longitudinal Joints
☐	☐	Potholes
☐	☐	Surface Texture Variations
☐	☐	Loss of Friction/Skid
☐	☐	Permeability
☐	☐	Rutting

☐ Other, Please Specify:

52. Are current microsurfacing specifications adequate to produce a quality product?

☐ Yes
☐ No
☐ Don't know

If "No", how can they be improved?

53. What does a *good* microsurfacing contractor do that is important?

54. What does a *poor* microsurfacing contractor do that is harmful?

Please identify three representative projects and evaluate their performance.

55. <u>**Project 1**</u>

a. Project name and Location:

b. Determine the overall level of success of this project

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Unsatisfactory

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success (5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	Did you use it?	Level of success? (0 to 5)
Meets expected service life	☐ Yes ☐ No	
Does not fail shortly after construction	☐ Yes ☐ No	
Achieves desired friction/skid number	☐ Yes ☐ No	
Qualitative measures—look, color, etc.	☐ Yes ☐ No	
Meets project specification	☐ Yes ☐ No	
Other, please specify:	☐ Yes ☐ No	

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress. (Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of severity Immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	☐ Yes ☐ No		
Bleeding	☐ Yes ☐ No		
Corrugation	☐ Yes ☐ No		
Crack reflection	☐ Yes ☐ No		
Streaking	☐ Yes ☐ No		
Transverse joints	☐ Yes ☐ No		
Longitudinal Joints	☐ Yes ☐ No		
Other, please specify:	☐ Yes ☐ No		

56. **Project 2**

a. Project name and Location:

b. Determine the overall level of success of this project

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Unsatisfactory

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success (5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	Did you use it?	Level of success? (0 to 5)
Meets expected service life	☐ Yes ☐ No	
Does not fail shortly after construction	☐ Yes ☐ No	
Achieves desired friction/skid number	☐ Yes ☐ No	
Qualitative measures—look, color, etc.	☐ Yes ☐ No	
Meets project specification	☐ Yes ☐ No	
Other, please specify:	☐ Yes ☐ No	

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress. (Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of severity Immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	☐ Yes ☐ No		
Bleeding	☐ Yes ☐ No		
Corrugation	☐ Yes ☐ No		
Crack reflection	☐ Yes ☐ No		
Streaking	☐ Yes ☐ No		
Transverse joints	☐ Yes ☐ No		
Longitudinal Joints	☐ Yes ☐ No		
Other, please specify:	☐ Yes ☐ No		

57. Project 3

a. Project name and Location:

b. Determine the overall level of success of this project

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Unsatisfactory

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success (5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	Did you use it?	Level of success? (0 to 5)
Meets expected service life	☐ Yes ☐ No	
Does not fail shortly after construction	☐ Yes ☐ No	
Achieves desired friction/skid number	☐ Yes ☐ No	
Qualitative measures—look, color, etc.	☐ Yes ☐ No	
Meets project specification	☐ Yes ☐ No	
Other, please specify:	☐ Yes ☐ No	

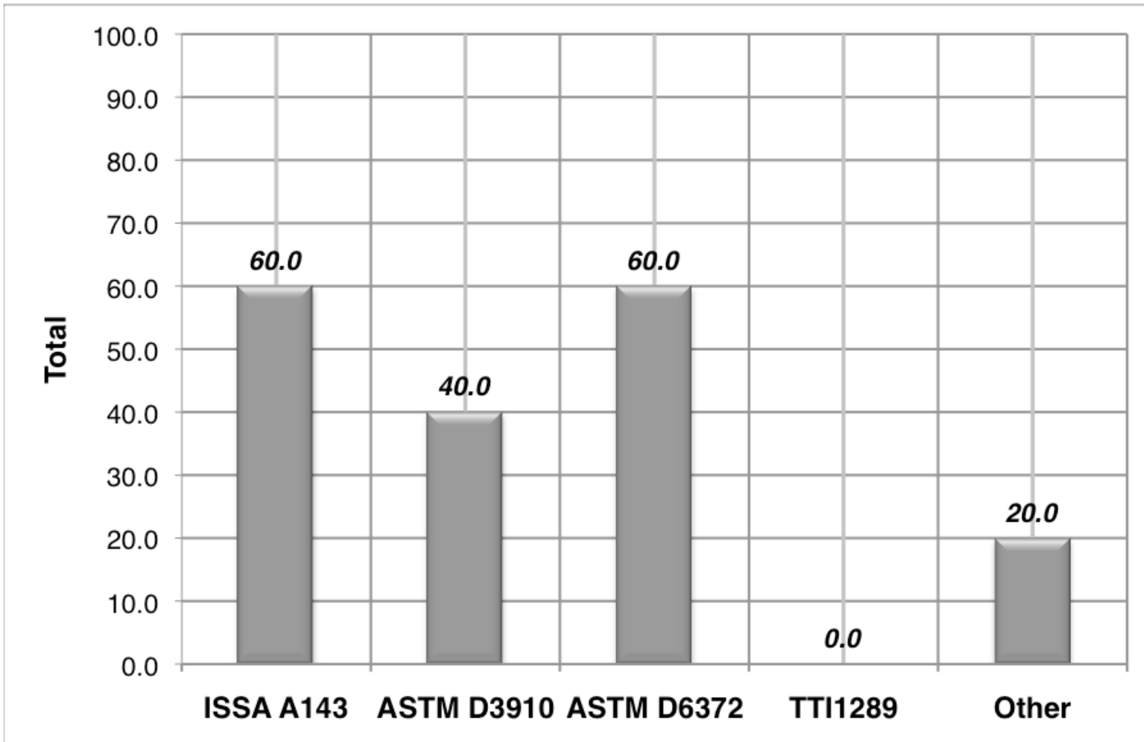
d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress. (Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of severity Immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	☐ Yes ☐ No		
Bleeding	☐ Yes ☐ No		
Corrugation	☐ Yes ☐ No		
Crack reflection	☐ Yes ☐ No		
Streaking	☐ Yes ☐ No		
Transverse joints	☐ Yes ☐ No		
Longitudinal Joints	☐ Yes ☐ No		
Other, please specify:	☐ Yes ☐ No		

58. If there is anything that you would like to add that was not covered in this questionnaire which you feel would benefit this study, please write your comments below:

APPENDIX D: SUMMARY OF CONTRACTORS SURVEY RESULTS

1. Which of the following mix design tests are performed on your projects for microsurfacing projects (select all)?

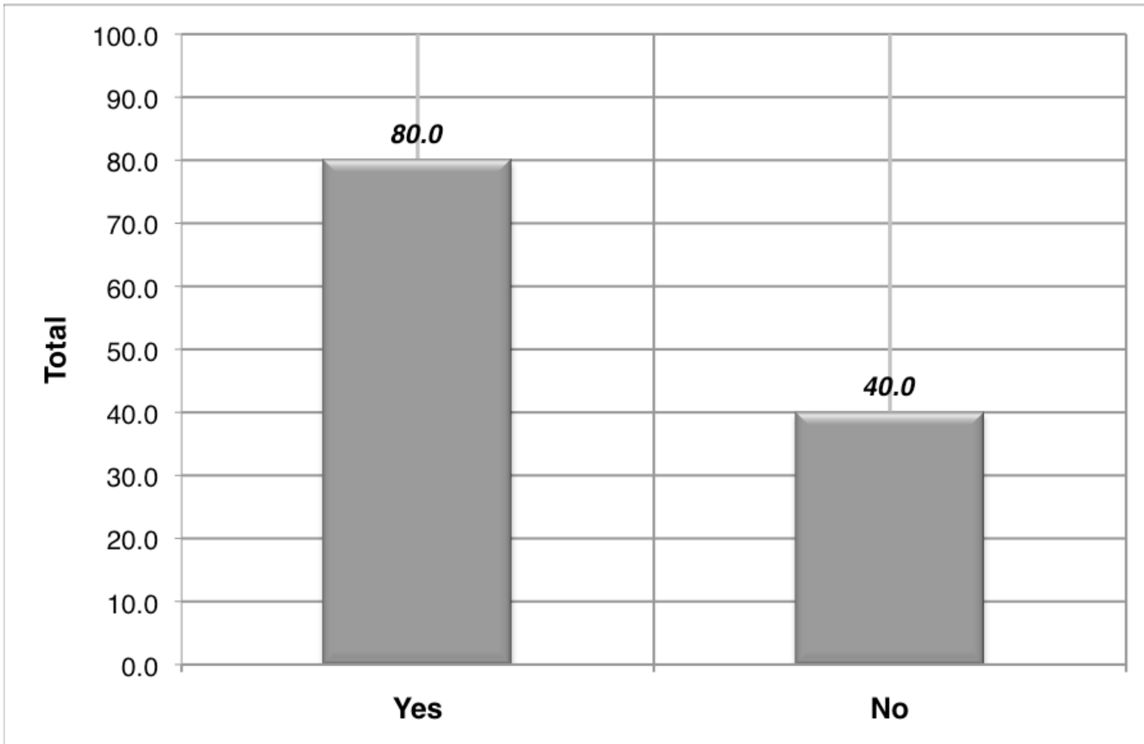


Other, Please Specify:

- Tex-240-F

- ASTM D2419
  ASTM D244
  ISSA TB109
  ISSA TB147
  ISSA TB144

2. Are your mix designs done during the offseason/winter?



<u>If "No", are your mix designs done immediately prior to starting a project with material samples to be actually used on the project?</u>

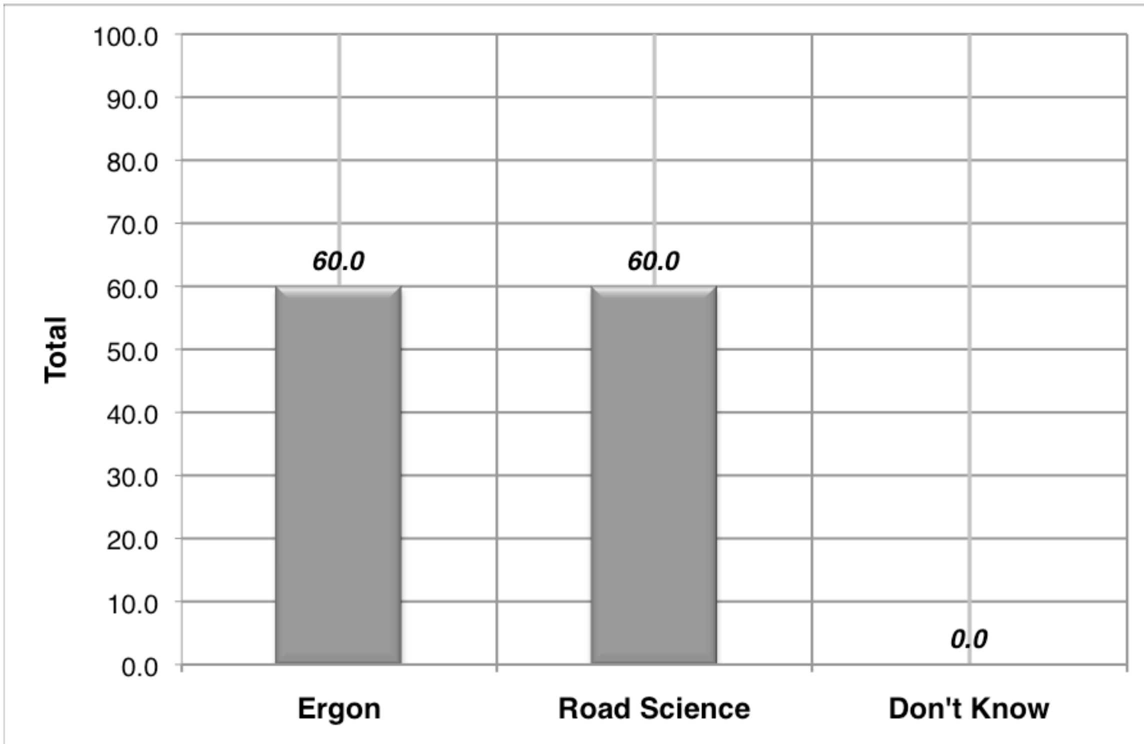
<u>Please explain:</u>

- The material's that are made just for Microsurfacing that sit all winter we will get as many of those mix designs done during the winter months, and we follow that up with a 1 point check before the project starts. The rest of the project mix designs are completed just before the project starts.

- Some mix designs are performed during off-season in preparation for early start-up and then just before projects during season.

- Occasionally they are conducted "just in time". We do like to use stockpiled materials whenever we can.

3. Who does your microsurfacing mix design?



Other, Please Specify:

- Garco Testing

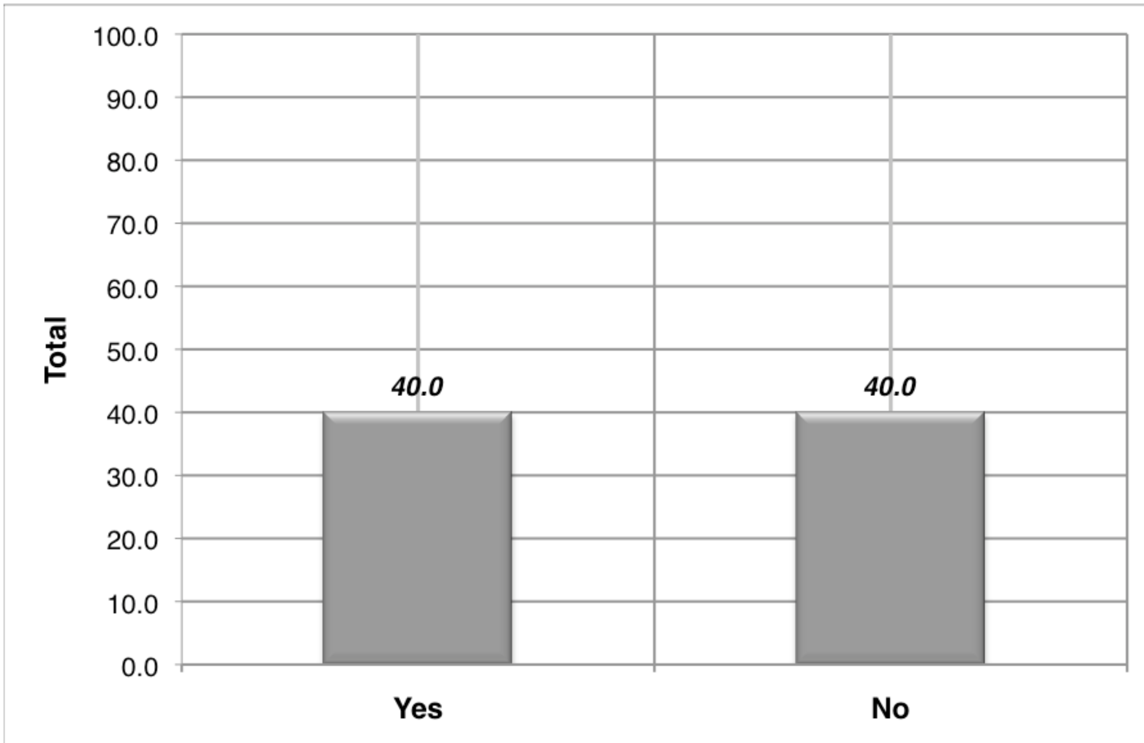
- Holly Asphalt, usually done by whichever emulsion provider is selected

- Licensees perform in-house designs through their laboratories

- Local emulsion supplier

- Our emulsion supplier does the mix design and we have historically used Ergon as our primary supplier for asphalt emulsion.

4. Given the existing specified aggregate gradations shown in the table below, do you believe any change would be beneficial?



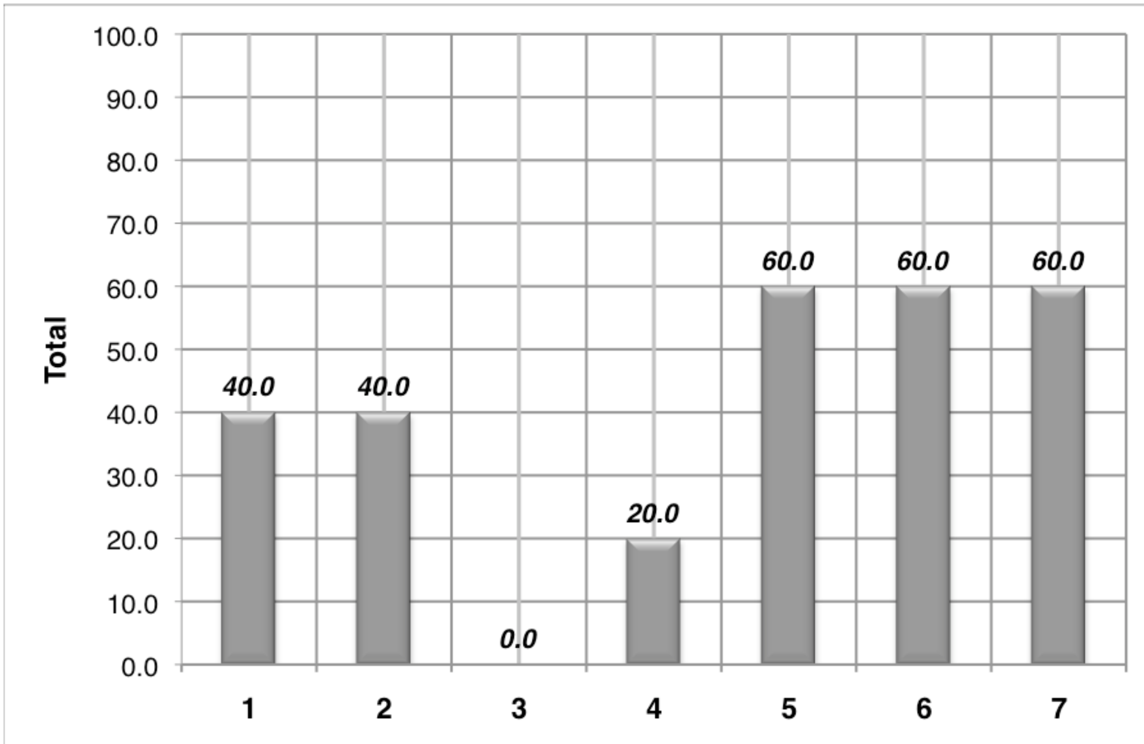
<u>If "Yes", what change would be beneficial?</u>

- Question depends on what kind of surface texture the agency is looking for? A coarse gradation would give more skid resistance. A fine gradation would give a quite riding surface.

- Raise the 3/8" % on rutfill and levelup, and remove the 3/8" % on surface course.

- Open up sieves similar to ISSA Type II to allow more coarser gradation for some projects. Also allow ISSA Type III gradations to be used for coarser texture on skid resistance, rut fill and scratch courses

5. How do you select the binder type for microsurfacing jobs?



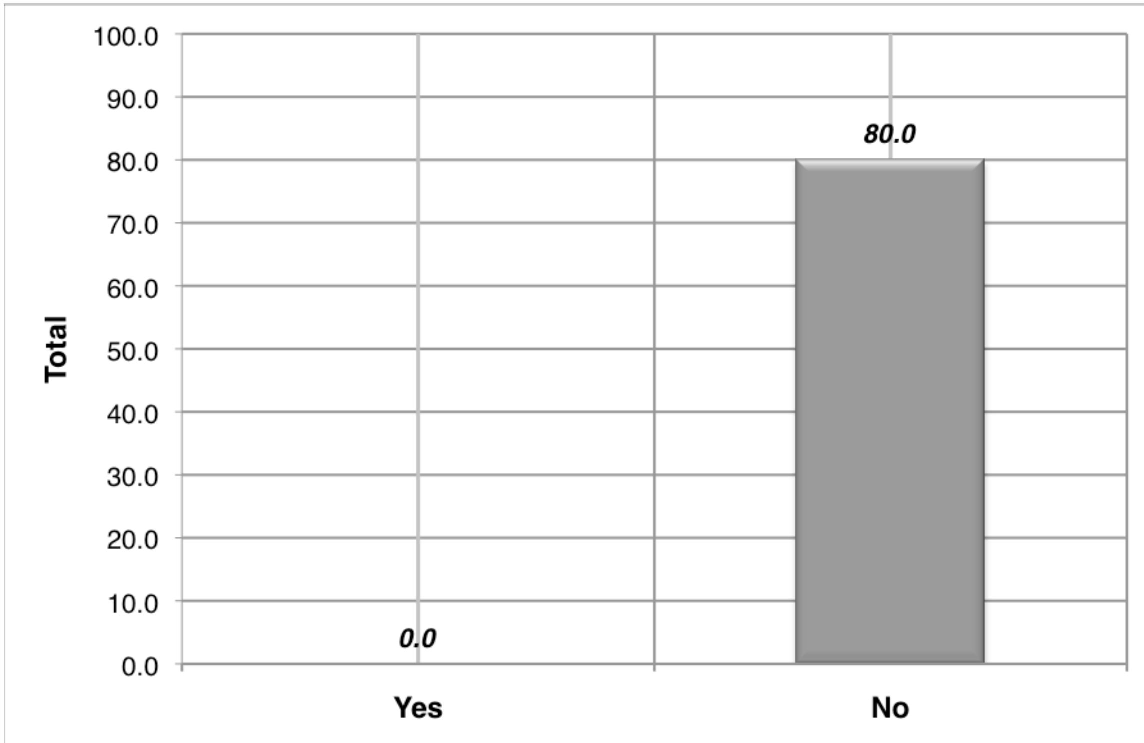
1. Local climate
2. Traffic volume or ESALs
3. Weather conditions in which seal will be applied
4. Identified during design
5. Compatibility with aggregate
6. Past experience
7. Other, Please Specify:

- Lowest Emulsion price on bidday.

- Has always been selected by the emulsion provider

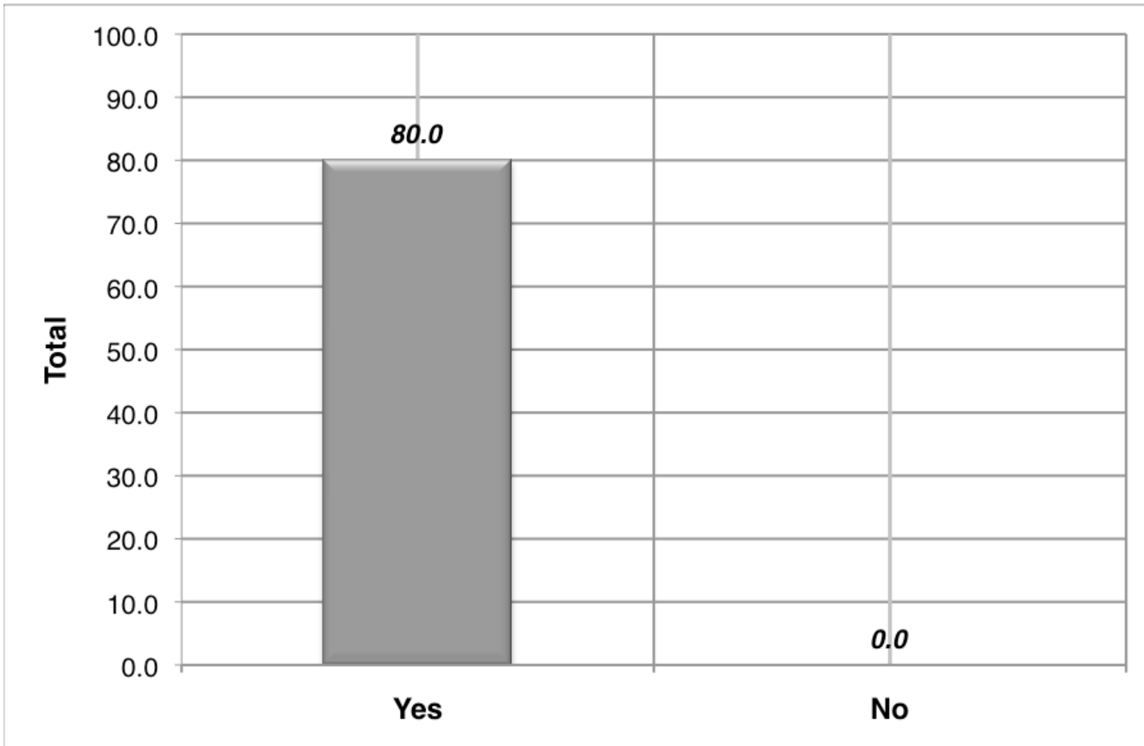
- SHRP grading for regional climate situation

6. Given the existing binder specifications, do you believe any changes to the specifications would be beneficial?



<u>If “Yes”, what changes would be beneficial?</u>

7. Do you use modifiers with your base asphalt or binder for microsurfacing projects?



If "Yes", what modifiers are used for microsurfacing projects? Check all that apply.

Polymers (4)

Latex Additives (4)

Anti-stripping agents (1)

Styrene Butadiene Rubber (SBR) (3)

SBR—Polyisoprene

SBR—Thermoplastic Elastomers

Other, Please Specify:

- Depends on the specifications

8. What is the break control additive that you use?

- MQK, IM diluted

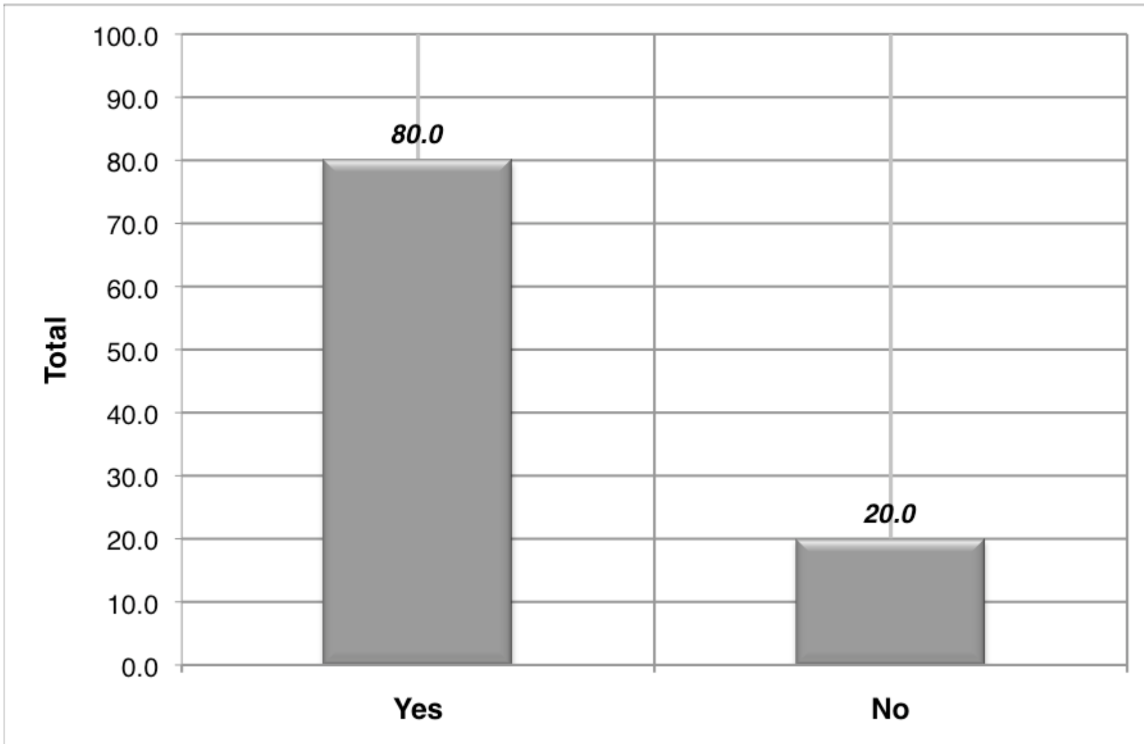
- Peral-Rolumac

- Road Science, LLC Ralumac® Field Additive

- Perel & Corsicana Chemical

- E Break Additive
(We typically use the emulsifier which is used in the microsurfacing emulsion supplied by our emulsion producer)

9. Do you ever change break control additives?



<u>If "Yes", why?</u>

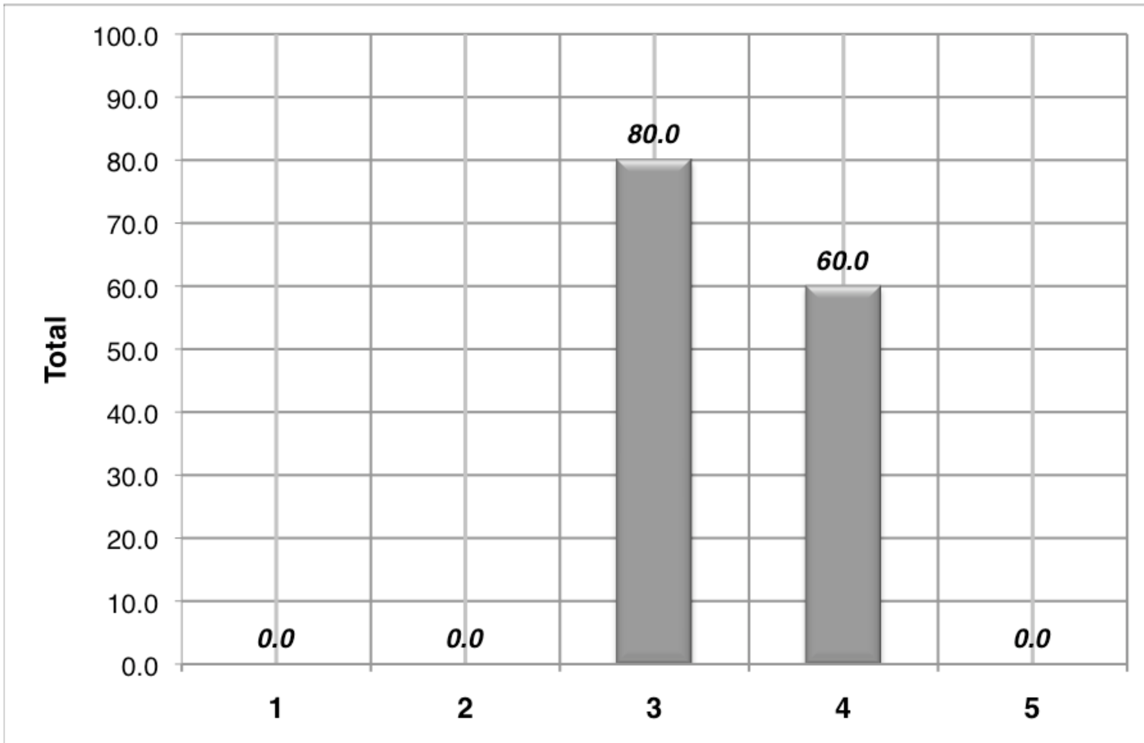
- Each binder supplier will have their own break control additive.

- Peral used with Roadscience, and not with Ergon

- Different emulsion suppliers use different systems

- We use what is recommended and supplied by our emulsion supplier, so any change would be due to their recommendation, or because of a change in supplier for the job in question.

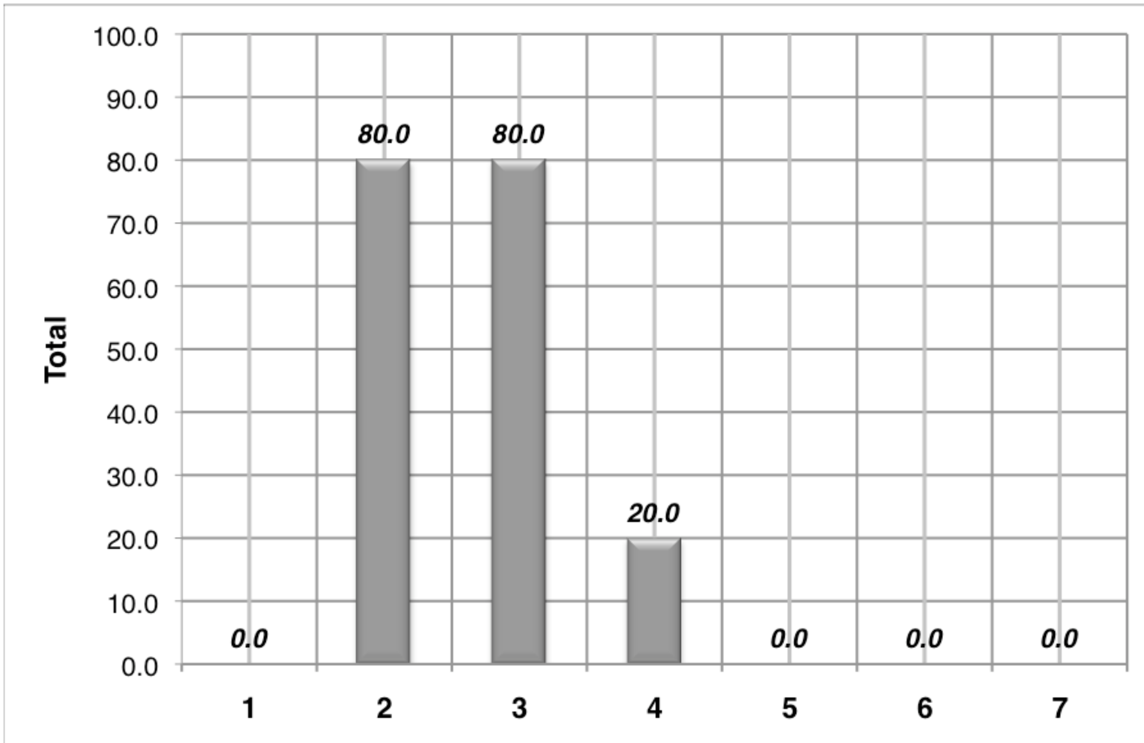
10. What percentage of residual asphalt is normally specified in your Job-Mix Formula (JMF) proportions for microsurfacing projects?



1. below 6%
2. 6.0 to 7.0% (including 6.0%)
3. 7.0 to 8.0% (including 7.0%)
4. 8.0 to 9.0% (including 8.0% and 9.0%)
5. higher than 9.0%

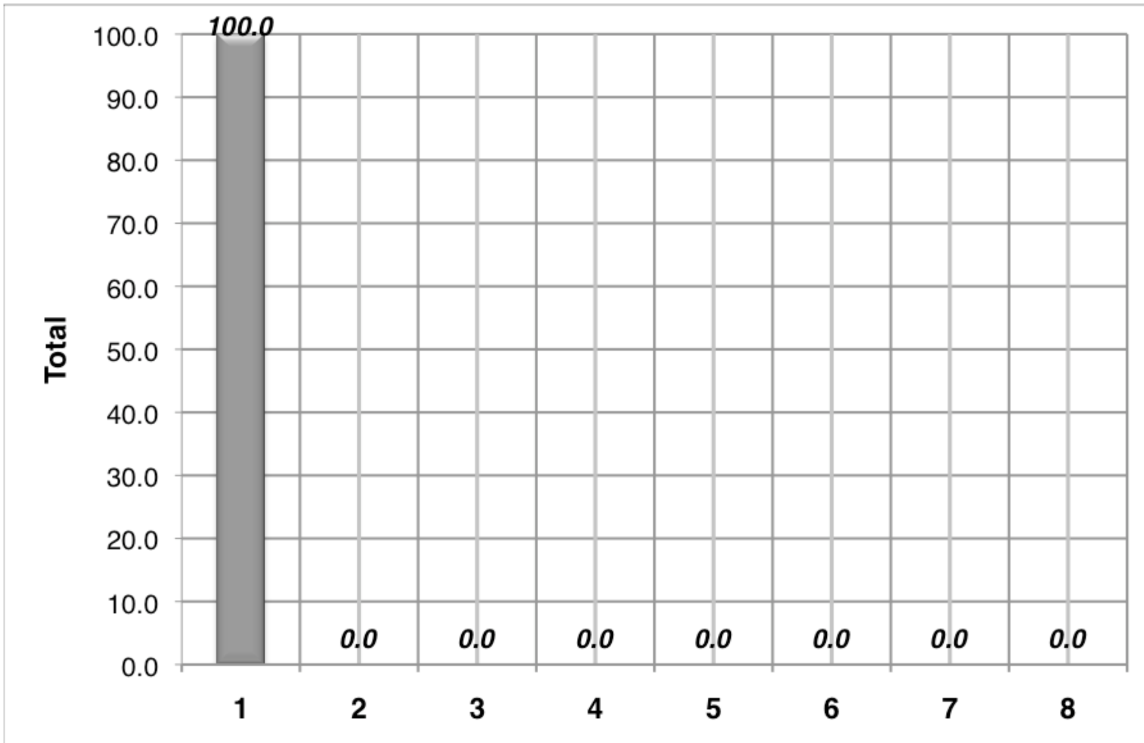
- This depends on aggregate quality and gradation.

11. What percentage of mineral filler (hydraulic cement or hydrated lime) do you normally use in Job-Mix Formula (JMF) proportions for microsurfacing projects?



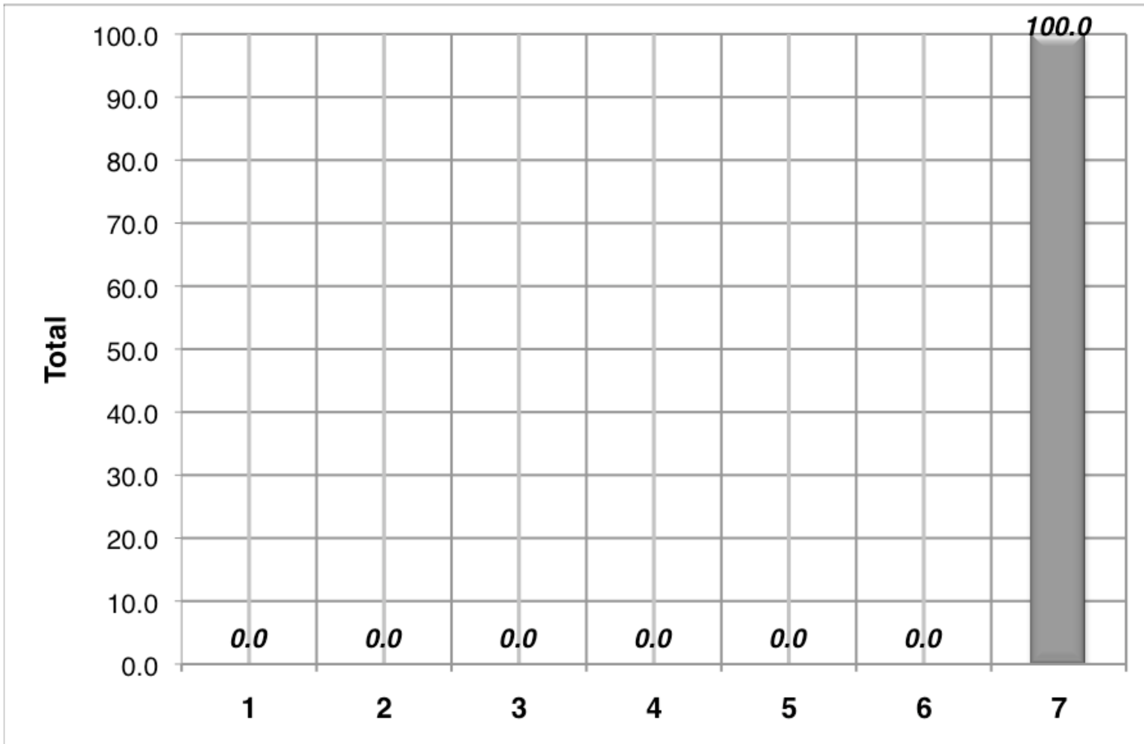
1. below 0.5%
2. 0.5 to 1.0% (including 0.5%)
3. .0 to 1.5% (including 1.0%)
4. 1.5 to 2.0% (including 1.5%)
5. 2.0 to 2.5% (including 2.0%)
6. 2.5 to 3.0% (including 2.5% and 3.0%)
7. higher than 3.0%

12. What type of mineral filler do you most commonly use for microsurfacing projects?



1. Portland cement
2. Hydraulic lime
3. Fly ash
4. Limestone dust
5. Crushed rock screenings
6. Cement kiln dust (CKD)
7. Baghouse fines
8. Other, Please Specify:

13. What type of other additives do you use for microsurfacing projects?



1. Aluminum sulfate crystals
2. Ammonium sulfate
3. Inorganic salts
4. Liquid aluminum sulfate
5. Amines
6. Anti-stripping agents
7. Other, Please Specify:

- None

- None

- We use various additives that stay confidential for our unique chemistry

- None

- Break additive

14. When you adjust residual binder content of the mix, how much of an adjustment is made for:

<u>High traffic:</u>

N/A
+/- 0.25%
N/A
0.5%

<u>Scratch/Level-up course:</u>

0.65
None
0.5%
-0.5%

<u>Rut filling:</u>

0.65
+/- 0.5%
0.5%
-0.5% to -1.0%

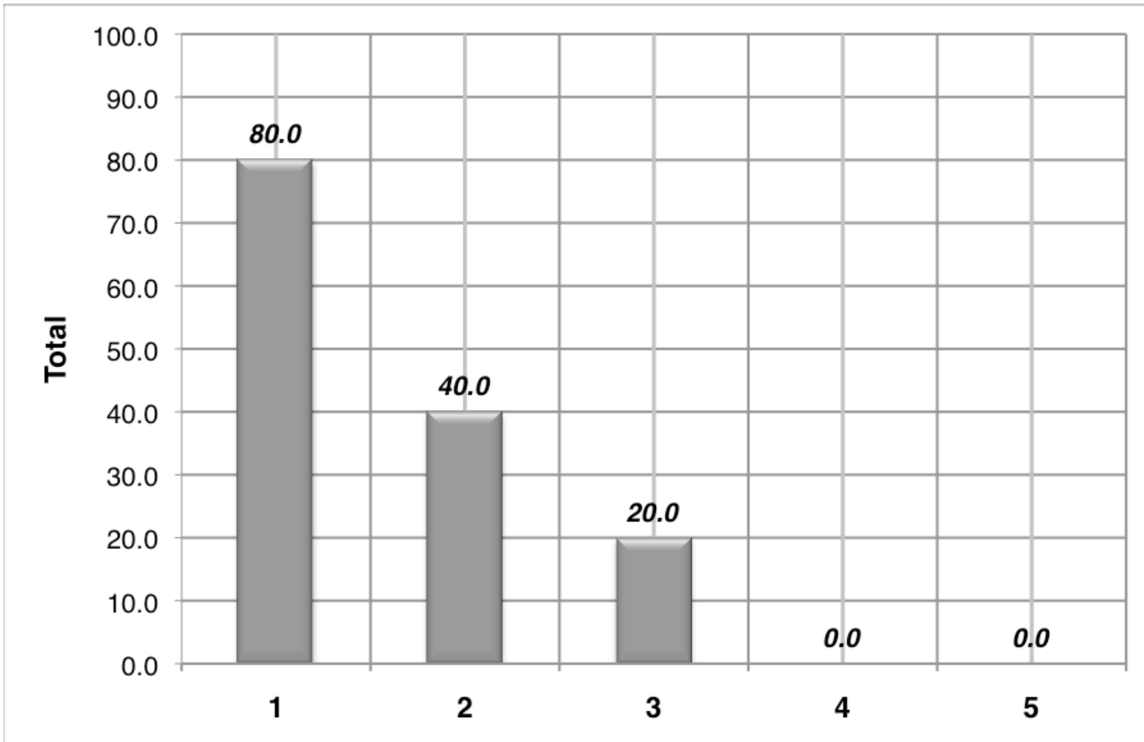
<u>Temperature extremes:</u>

N/A
N/A
N/A
-0.5%

<u>Existing bleeding or flushed pavement:</u>

0.65
-0.5%
0.5%
-0.5% to -1.0%

15. Which type of mixing equipment calibration practices do you use?
(mark all options that apply, include frequency if known)



1. Field calibration

How often?

- The Weigh bin and screener tickets are matched up with the micropaver computer production ticket daily
- Every project, sometimes every location
- At the beginning of each project
- Generally on each new project

2. Our company furnishes a calibration certificate

How often?

- Minimun once a year or anytime we change aggregate sources or change any part of the aggregate belt.
- For each project

3. Other:

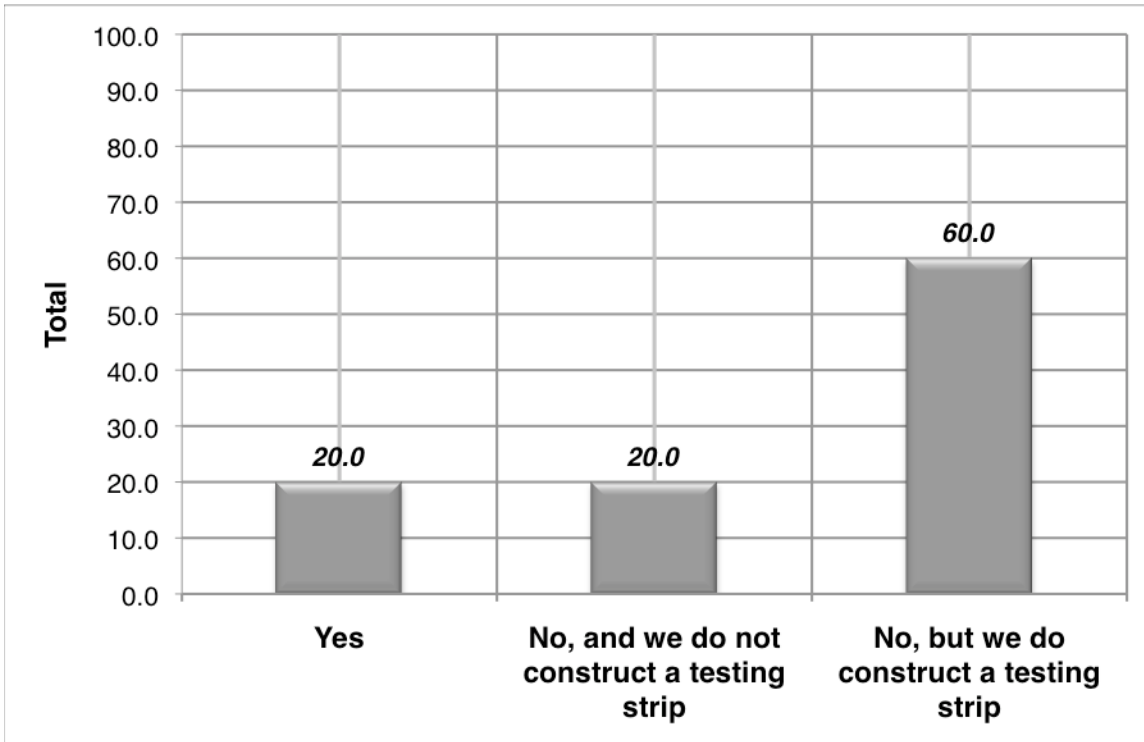
How often?

- Recommended before the start of each project or every 30 days

4. No calibration

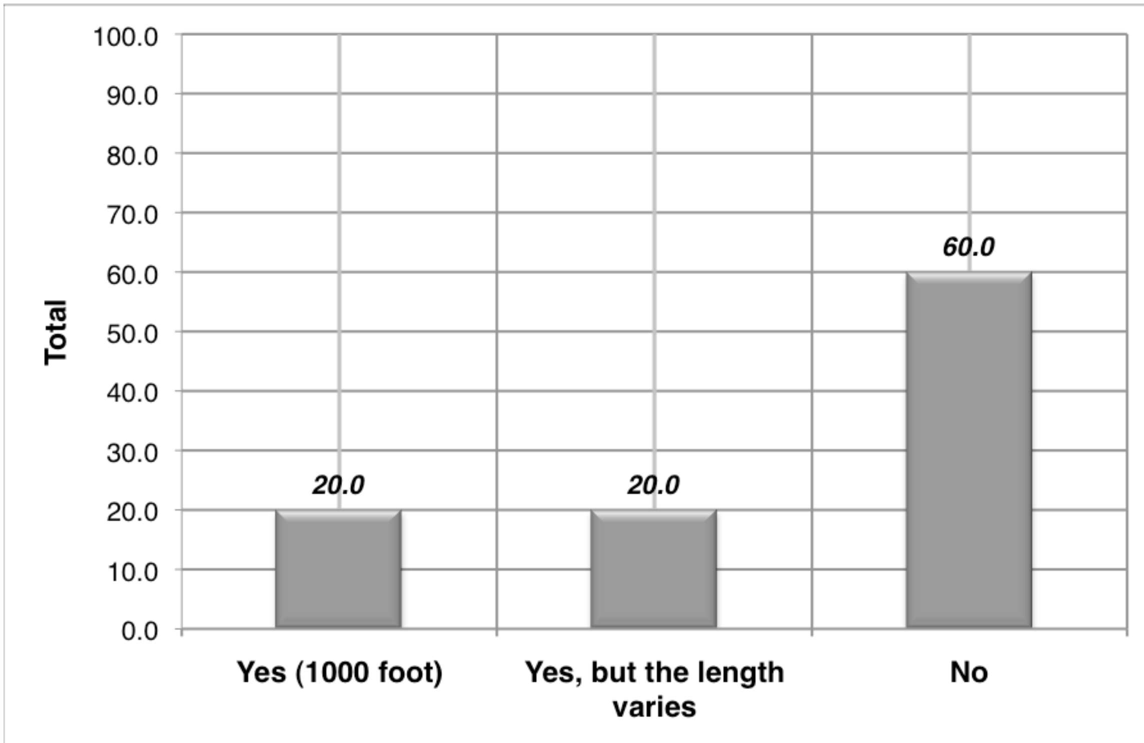
5. Don't know

16. Does TxDOT request a construction of a test strip before full production microsurfacing?

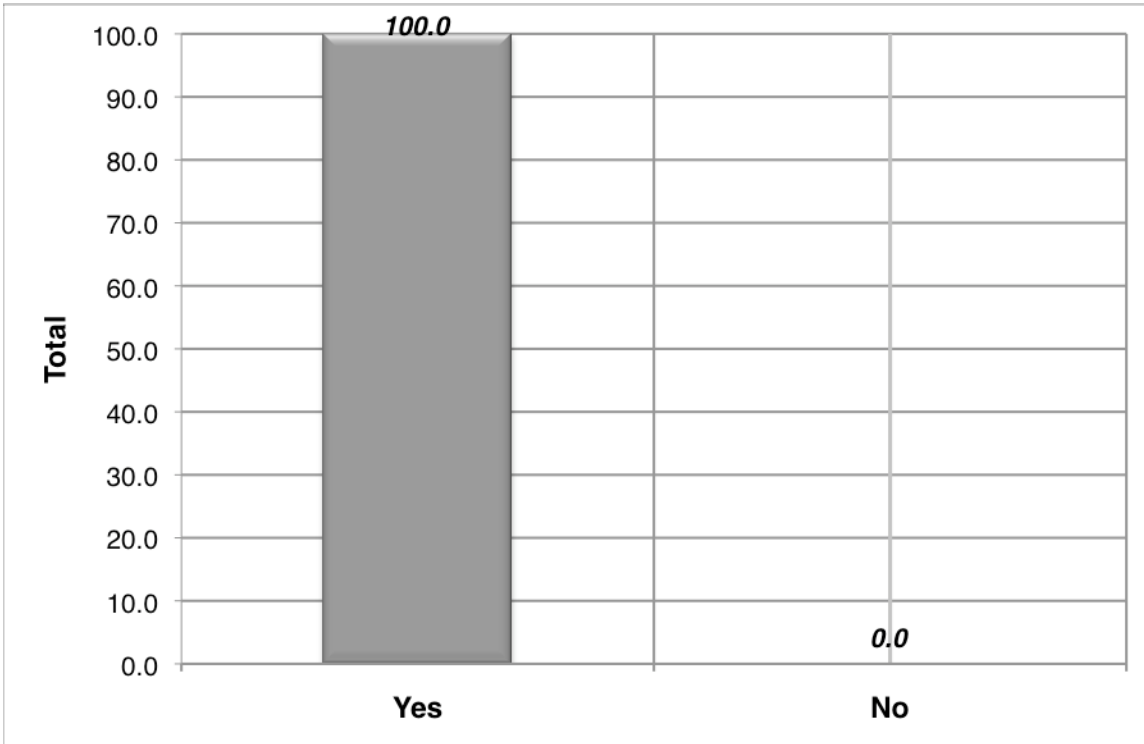


- Our first day or several hours of production are usually planned to be somewhat limited, and we consider it a test strip for demonstration of quality of workmanship, adherence to specifications, and example of expected application rate for the particular roadway.

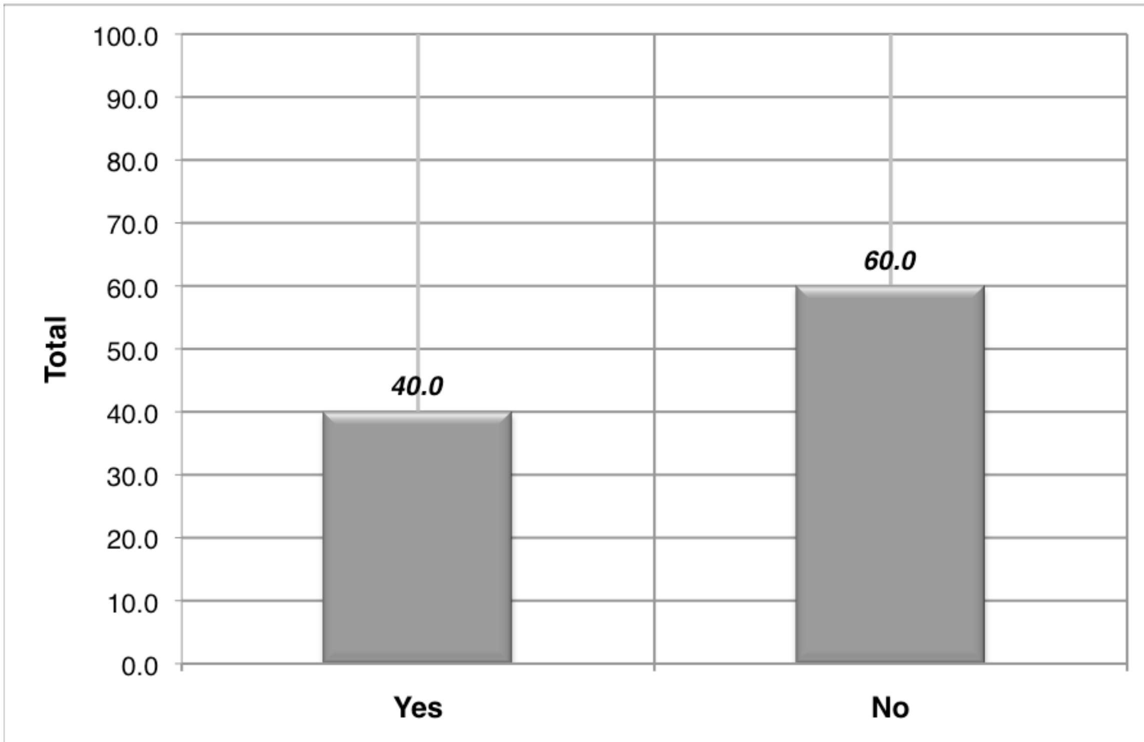
17. Do you use a specific length or length range when building a test strip?



18. Do you construct the test strip at night when the project is being done at night?



19. Do you ever roll microsurfacing?



<u>When:</u>

- When required by agencies like the FHWA.

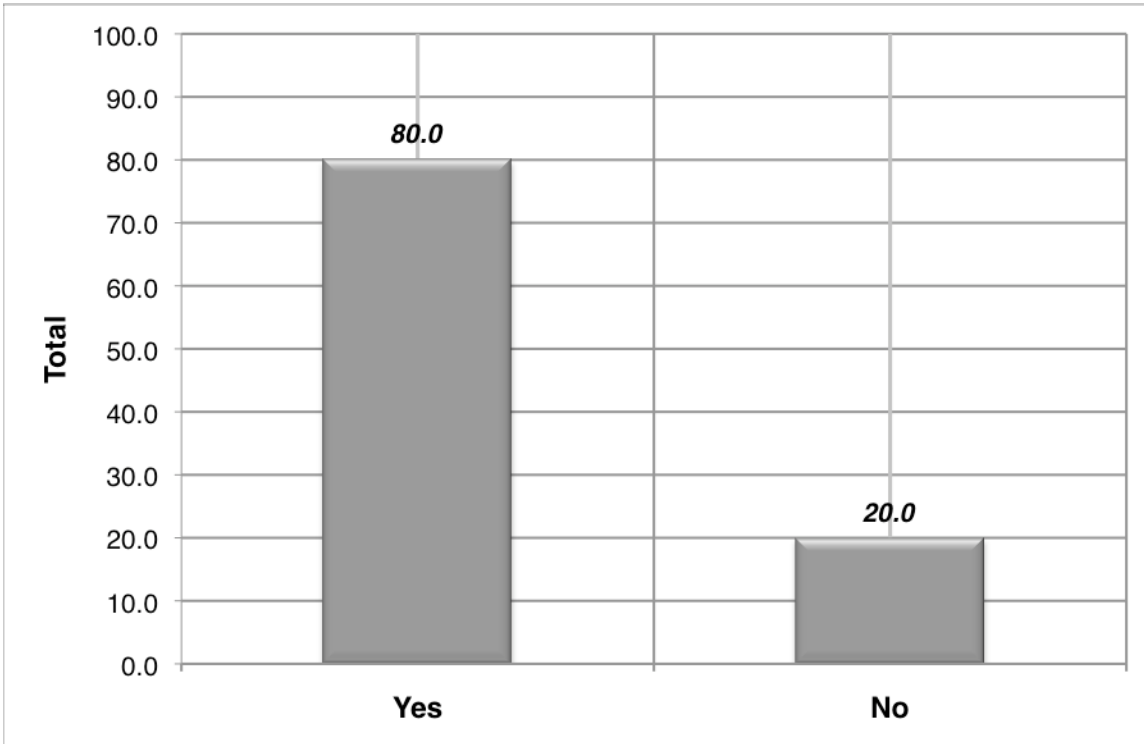
- On parking lots and airports where the microsurfacing does not receive much rolling traffic.

<u>How:</u>

- 9 Wheel pneumatic roller. After the micro has broke but before it is opened to traffic.

- A rubber tired roller (approximately 10-15 ton)

20. Prior to microsurfacing, should tack coat be utilized?



<u>When:</u>
- Only when the underlying asphalt is to dry, or oxidized, or if the contractor has any concerns of the Micro surfacing not adhering.
- Over PCC
- Only over PCC or very dry AC pavements
- Concrete pavements or extremely oxidized asphalt pavements

<u>Type of material:</u>
- CSS-1dilute or CQS-1hP dilute.
- CSS-1H
- SS-1h or similar
- SS-1H, CSS-1H, or CSS-1P

<u>Application rate:</u>
- 0.11 lb per Sy. +-.01
- 0.1 of 50/50
- 10/100 or 50/50 dilute
- Approximately .10-.12 gallons/sy of emulsion diluted 3 parts water to 1 part emulsion

21. Do you have any comments concerning the specified requirement for pre-wetting/fogging the pavement with water prior to microsurfacing?

Comments:

- This should be a decision the contractor is able to make. This may be necessary on some pavements and not necessary on other pavements.

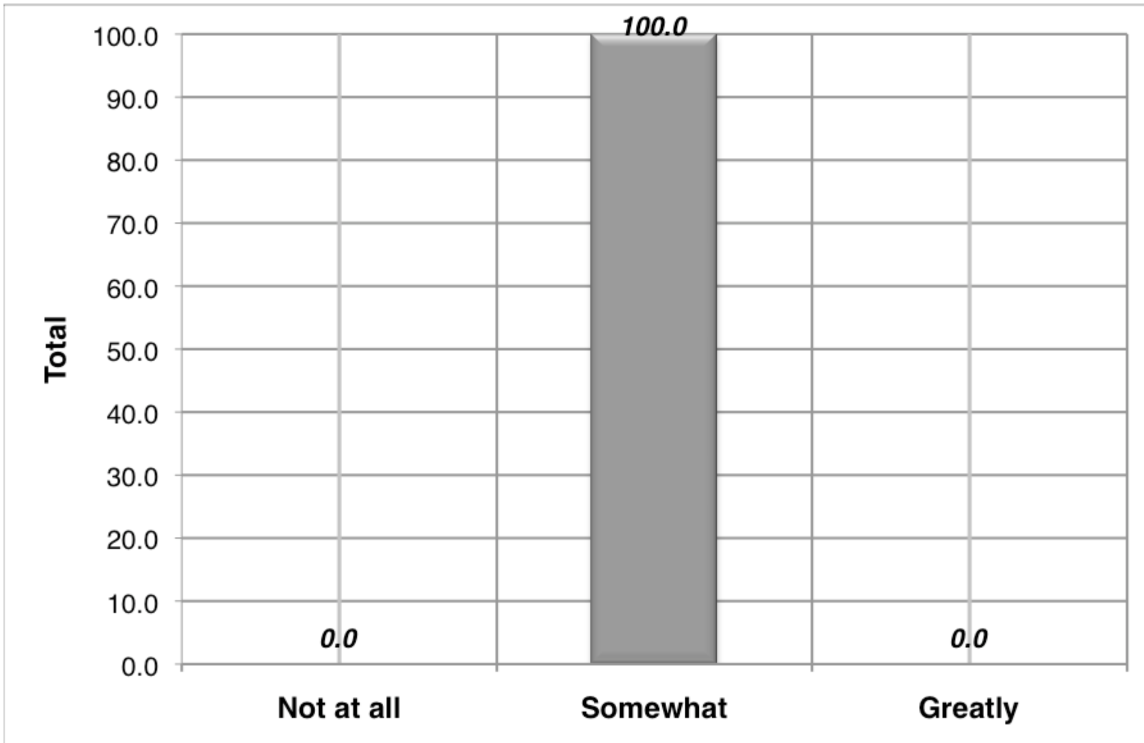
- Seem to work better on day projects with high temps and a dry aggregate pile.

- Pavement surface needs light mist pre-wet to assist in micro layer adhering to existing surface

- Can't be used on bleeding or slick pavements. It makes it hard to achieve the proper application rate of the microsurfacing mix.

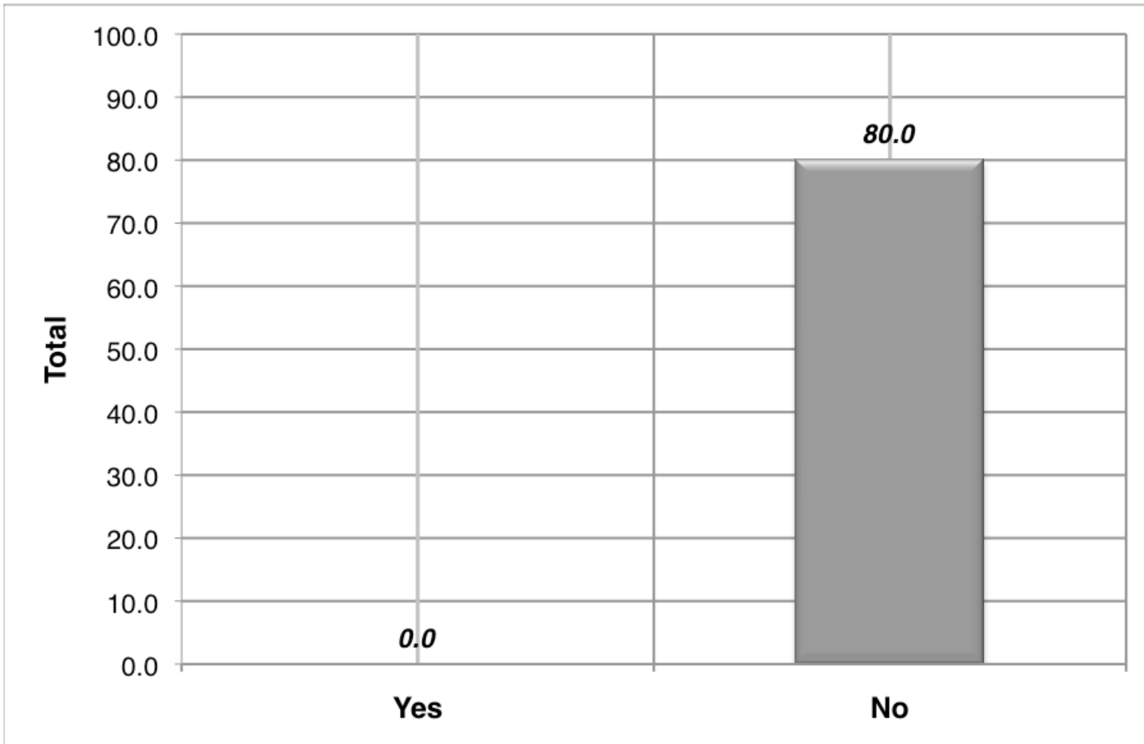
- We think it is a good idea in most situations, but not when the aggregate is extremely wet or the surface is already damp.

22. Do you believe weather conditions during application affect the success of microsurfacing:



- It will affect the curing time, but as long as we are within the season and meet specifications, it is normally not a problem. We generally repair any microsurfacing that is lost due to weather conditions.

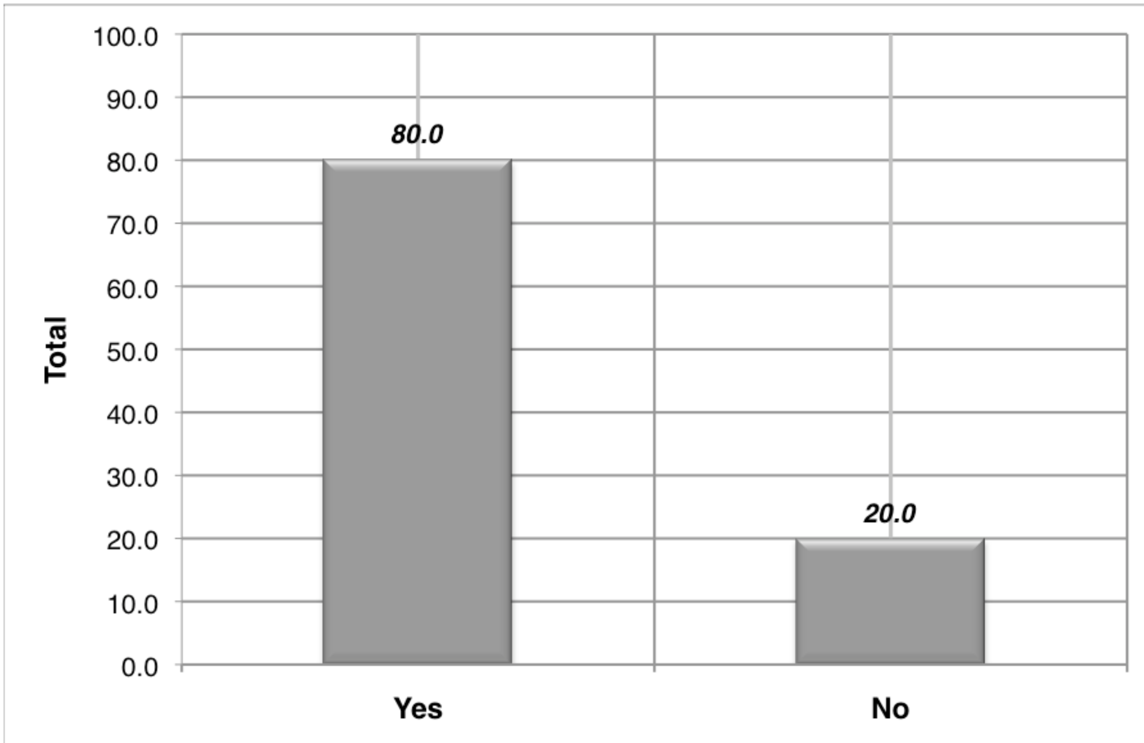
23. Should the existing temperature requirements for microsurfacing be changed?



How:

Why:

24. Do you check and record weather conditions such as temperature, relative humidity, wind velocity, and precipitation daily?



- They are recorded in the superintendent's diary

25. In which months do you typically apply microsurfacing?

- April, May, June, July, August, September, October. April and October are Temperature Sensitive Months and you may not get much work done if it is a cool spring or fall,

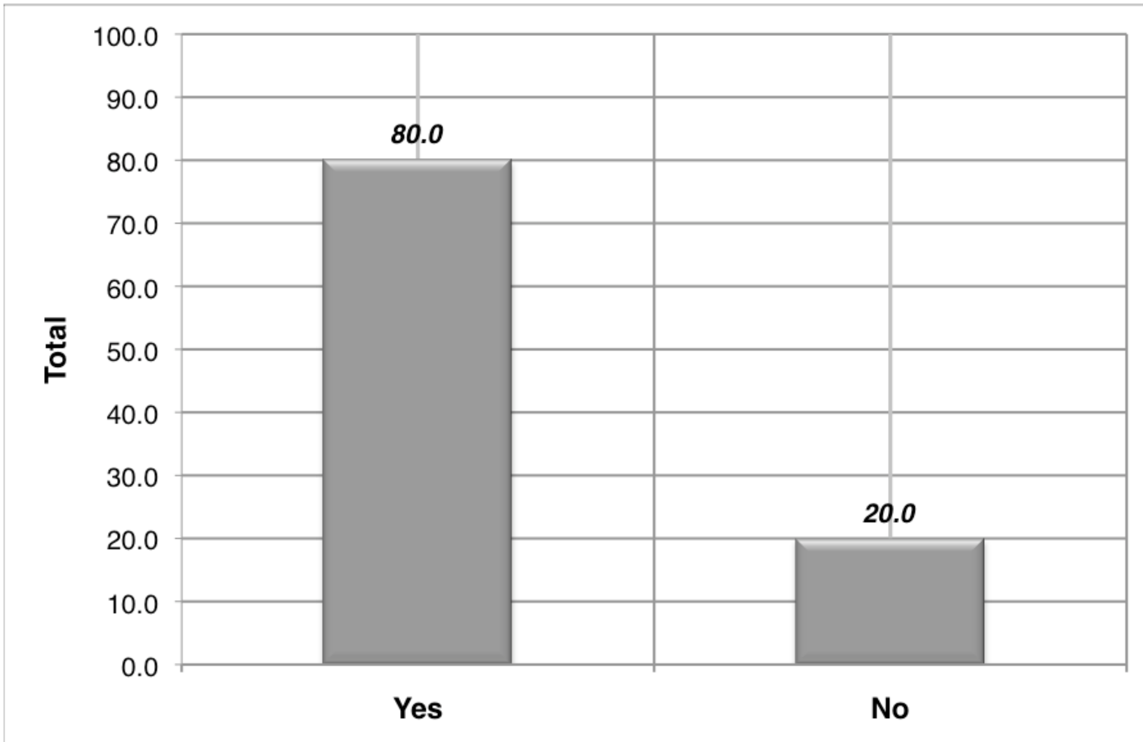
- April through December

- April through November

- April through November

- April through November

26. Do you require training and/or certification for crew members?



<u>If "Yes", what type of training or certification?</u>

- Traffic Control Certification.
ISSA Slurry System Workshop.

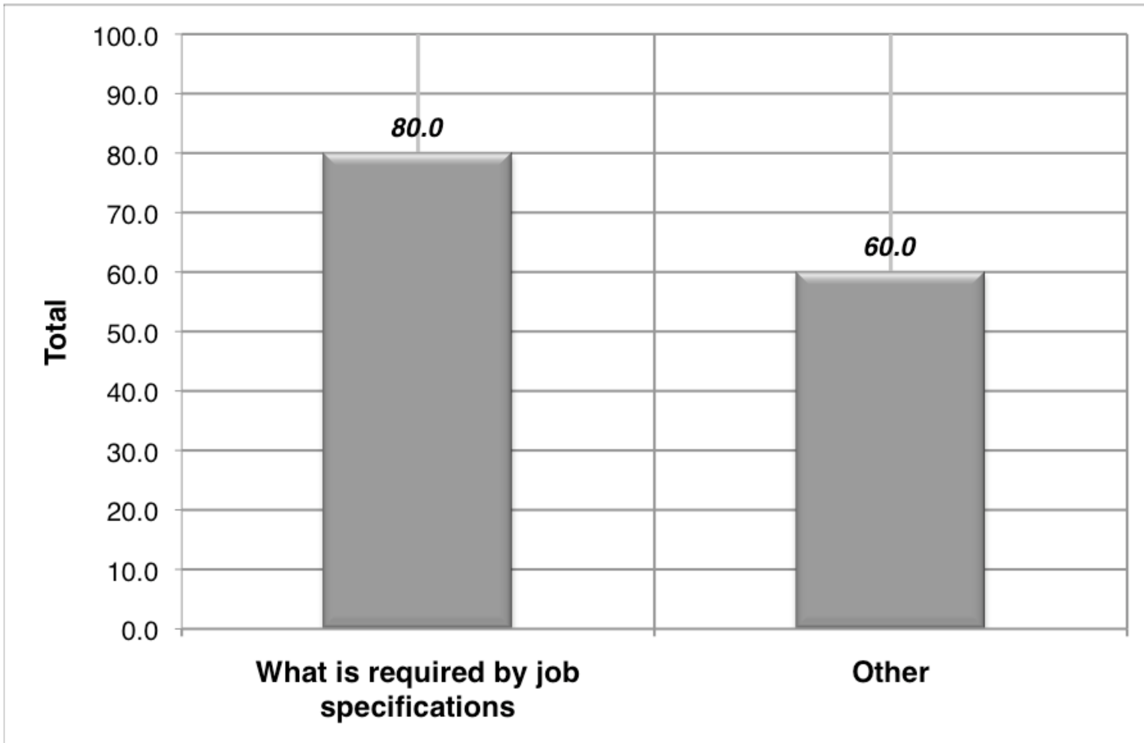
- Mix, Calibration and Laydown

- I also like to do cross training between various crew positions to create better team work

- Only traffic control & safety

- Senior people are sent to the ISSA Slurry Systems Workshop and others are trained on the job by the superintendents and more experienced crew members.

27. What do you typically do for your internal quality assurance on microsurfacing projects?

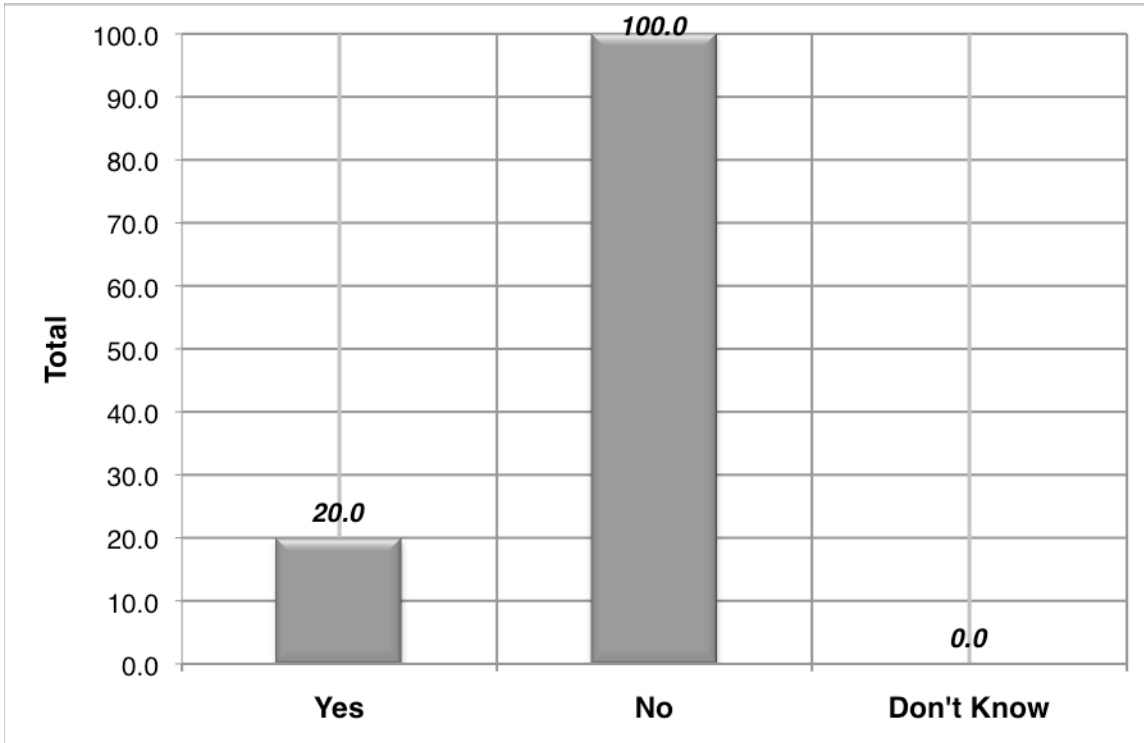


- Gallon meter on emulsion delivery system.
- Computerized Micro surfacing equipment.
- Verification of emulsion and aggregate quality properties.
- Verify daily quantities with material log.

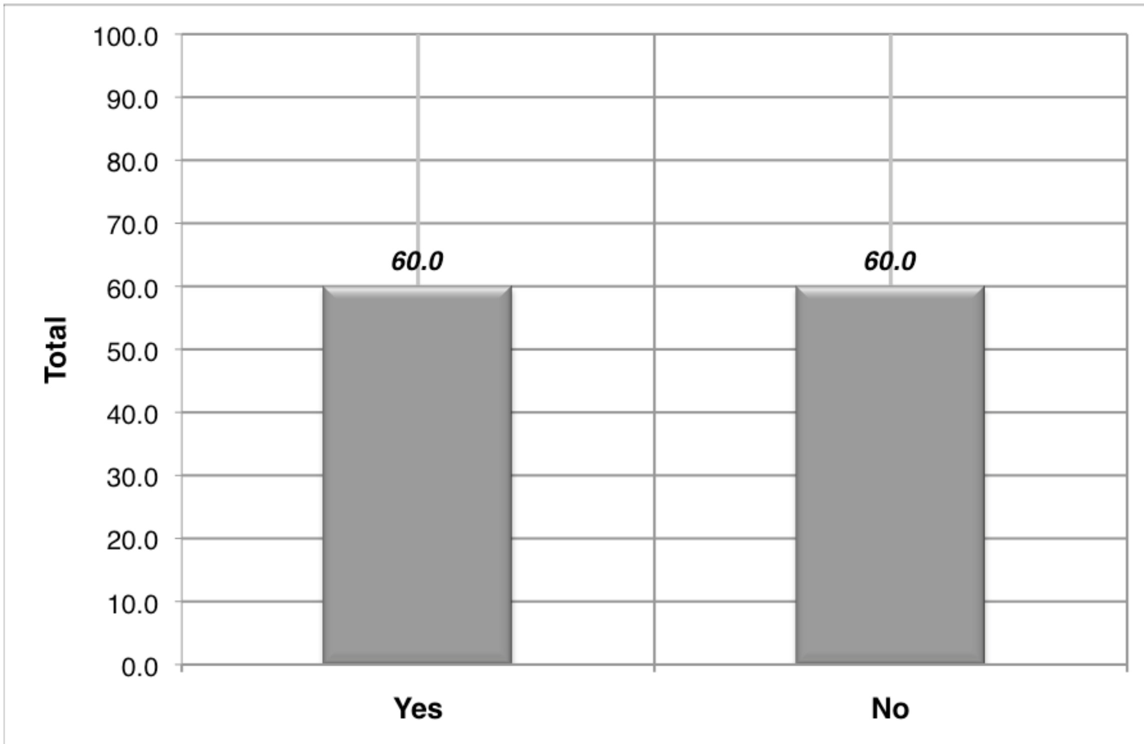
- In-house quality control training for management personnel

- We monitor the inventory of materials delivered to the project, and compare it to our calibration daily reports. We also monitor the aggregate producer's gradation reports and run our own gradations if we suspect a problem.

28. Does it matter if you change brands of mineral filler during a project?



29. Do you check the quality of the water source used for a microsurfacing project?



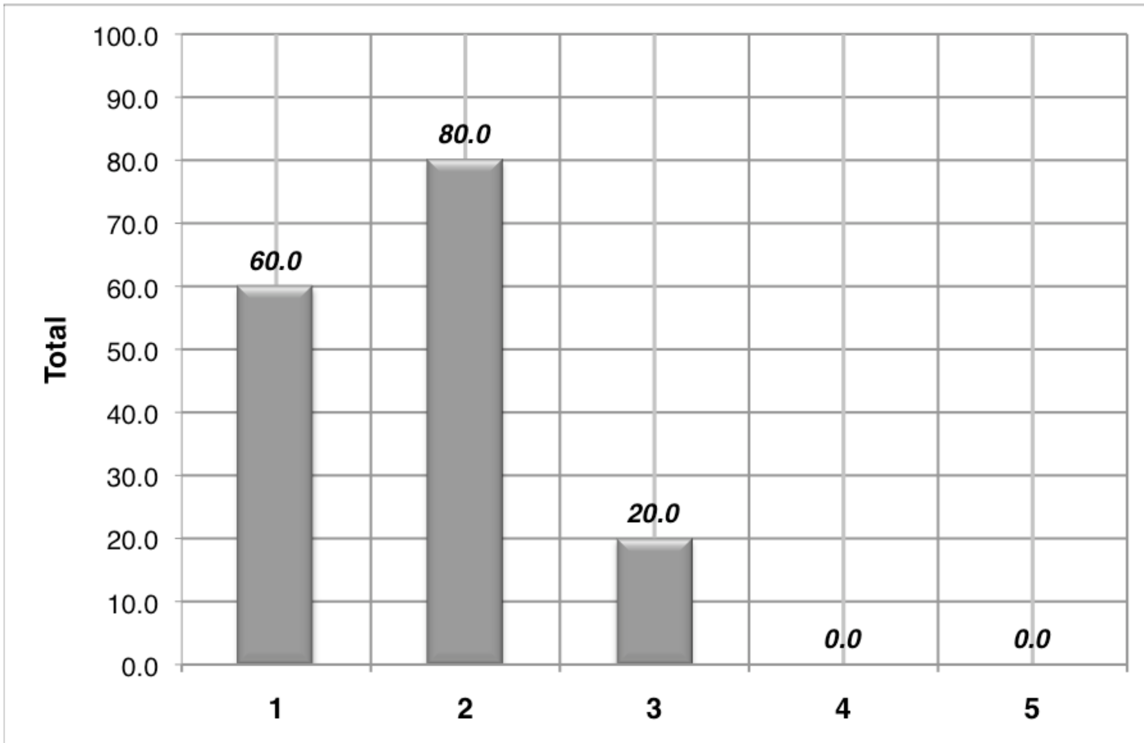
<u>If "Yes", how?</u>

- Ph level, If we are forced to use a non typical water source we also send a sample of the water source to be used in the mix design. The same water that is to be used on the project.

- If we suspect there may be a problem, we would send a sample to our lab

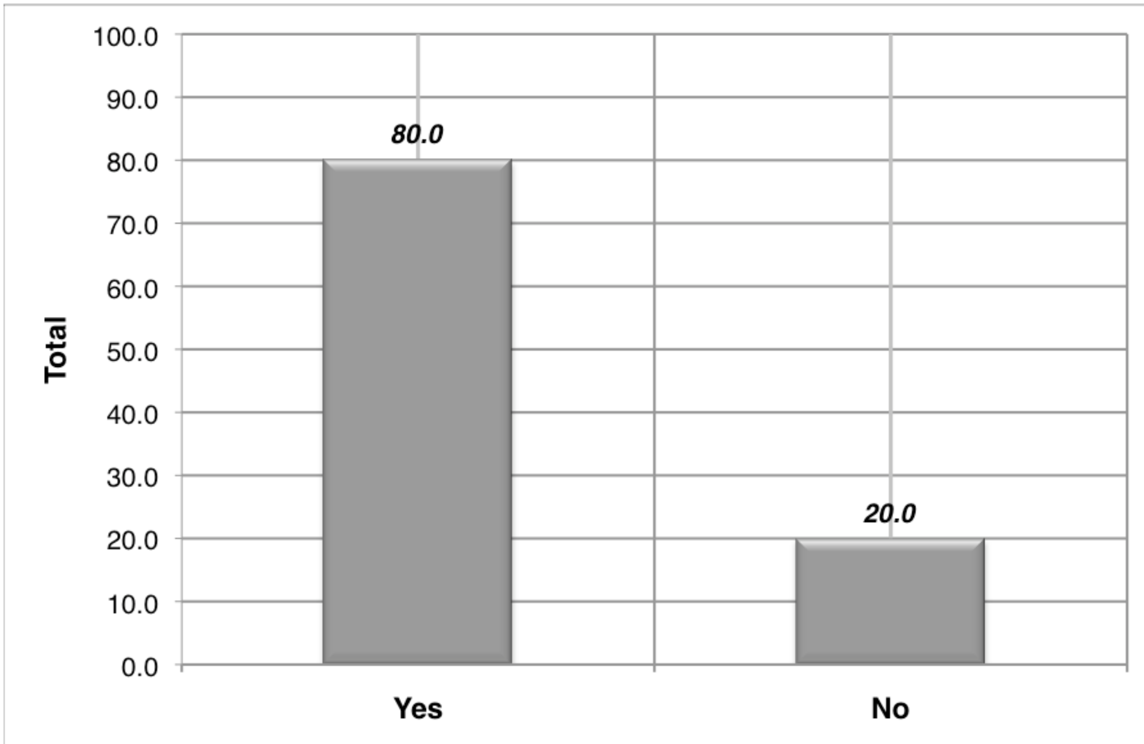
- We would check hardness

30. When testing and accepting the aggregate for specification compliance, where is the acceptance test conducted?



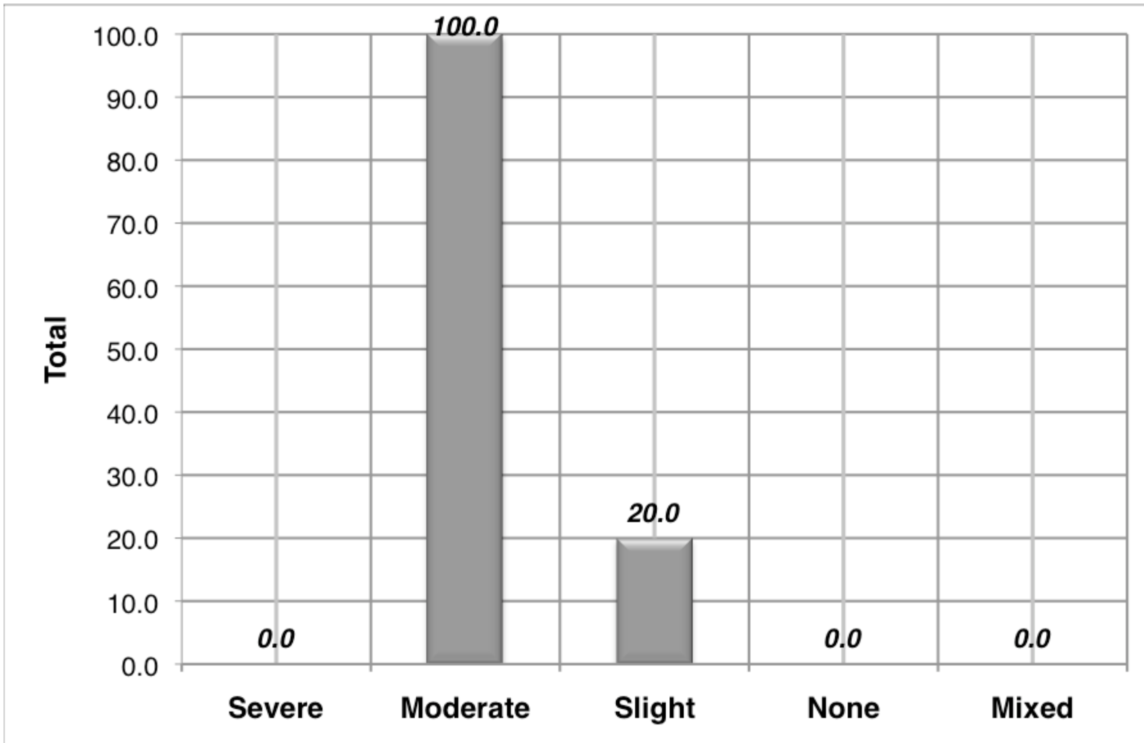
1. The pit/source
2. The stockpile
3. While transferring into the nurse units
4. Just before it enters the microsurfacing paver mixing chamber
5. Don't know

31. Do you feel TxDOT is adequately qualified to inspect microsurfacing projects?



- Have not worked with TxDOT to answer this question.

32. How would you describe the level of distress on roads that generally receive a microsurfacing treatment?



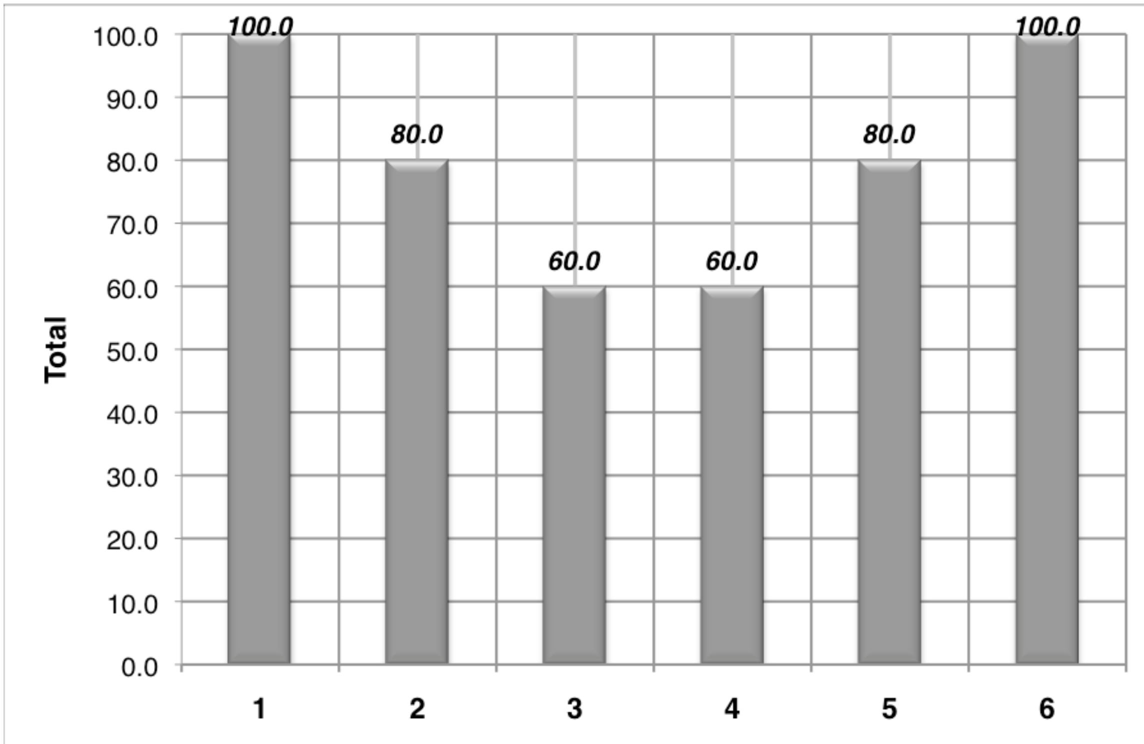
- The success of any thin layer treatment is directly related to the condition of the pavement being treated! With budget shortfalls we worry that microsurfacing may be used a little too late in many cases because TxDOT cannot afford a more expensive treatment.

33. What types of microsurfacing application methods have you performed?

<u>Other, Please Specify:</u>

- Filling in rumble strips (shoulder texturing)

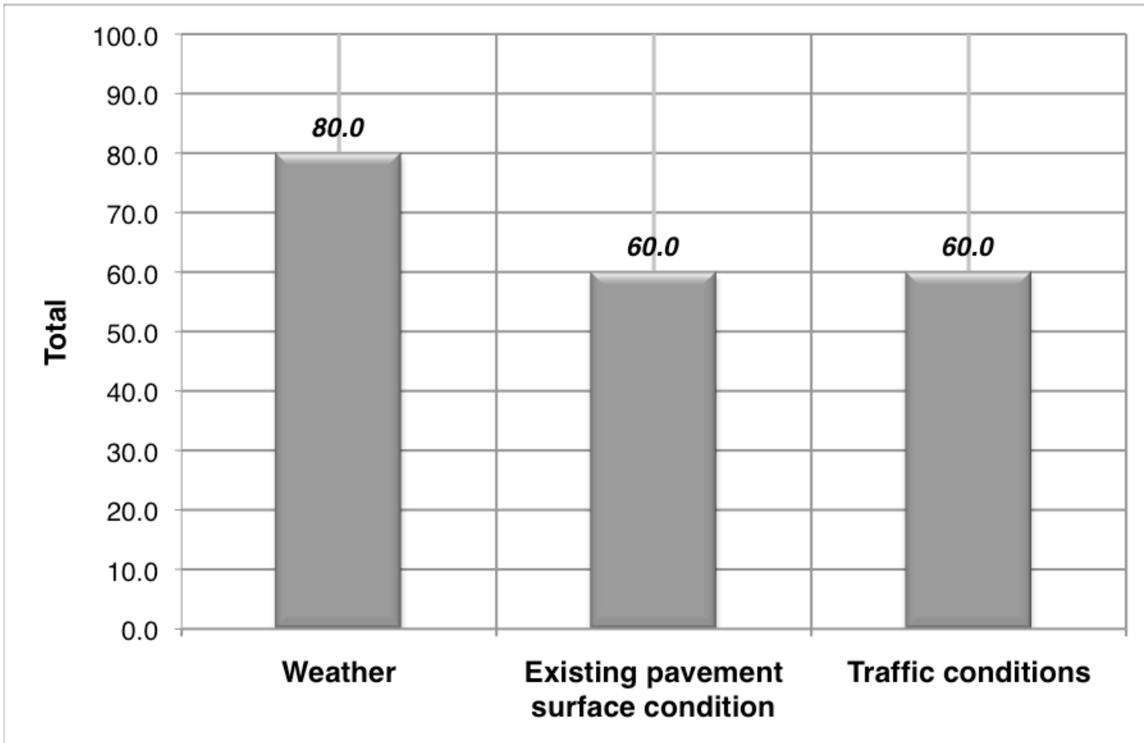
34. After the mix design has been submitted and approved should the contractor be allowed to adjust any of the following to account for weather conditions?



1. Water
2. Mineral filler
3. Asphalt emulsion
4. Application rate
5. Speed of the laying operation
6. Time till opening to traffic

- As long as adjustments stay within design tolerances

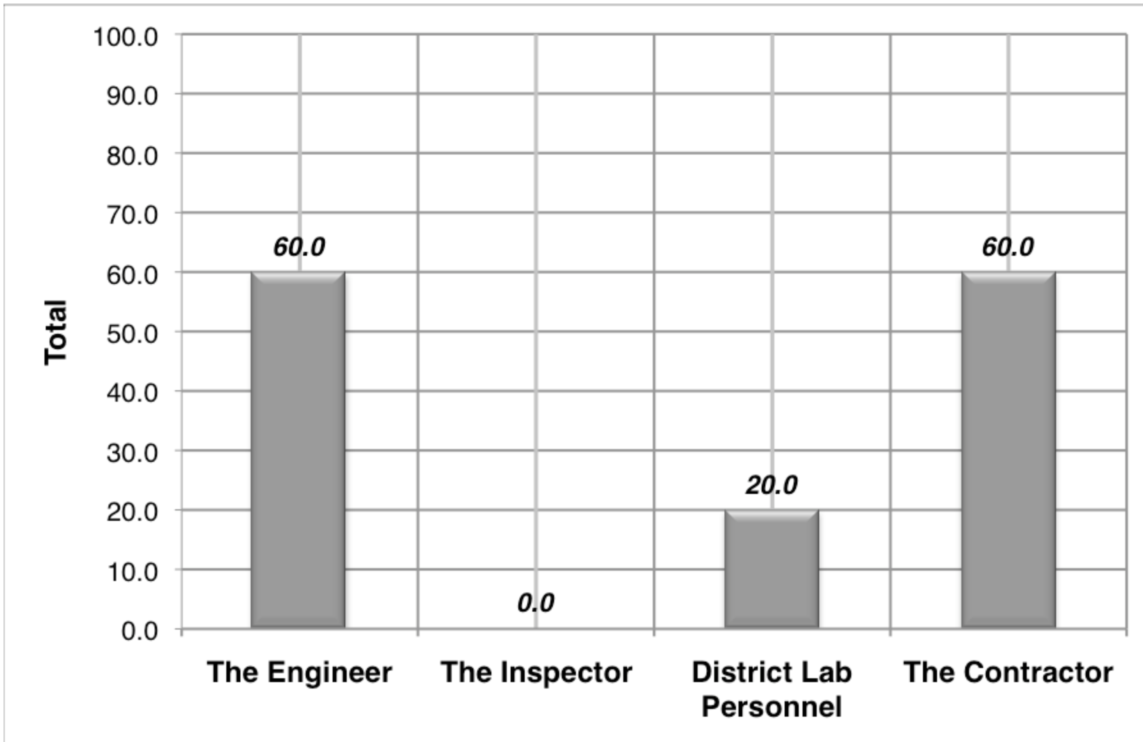
35. Should the contractor be allowed to adjust the mix design to account for:



- As long as adjustments stay within design tolerances

- No

36. Who has the authority to adjust the mix design to account for project specific field conditions?

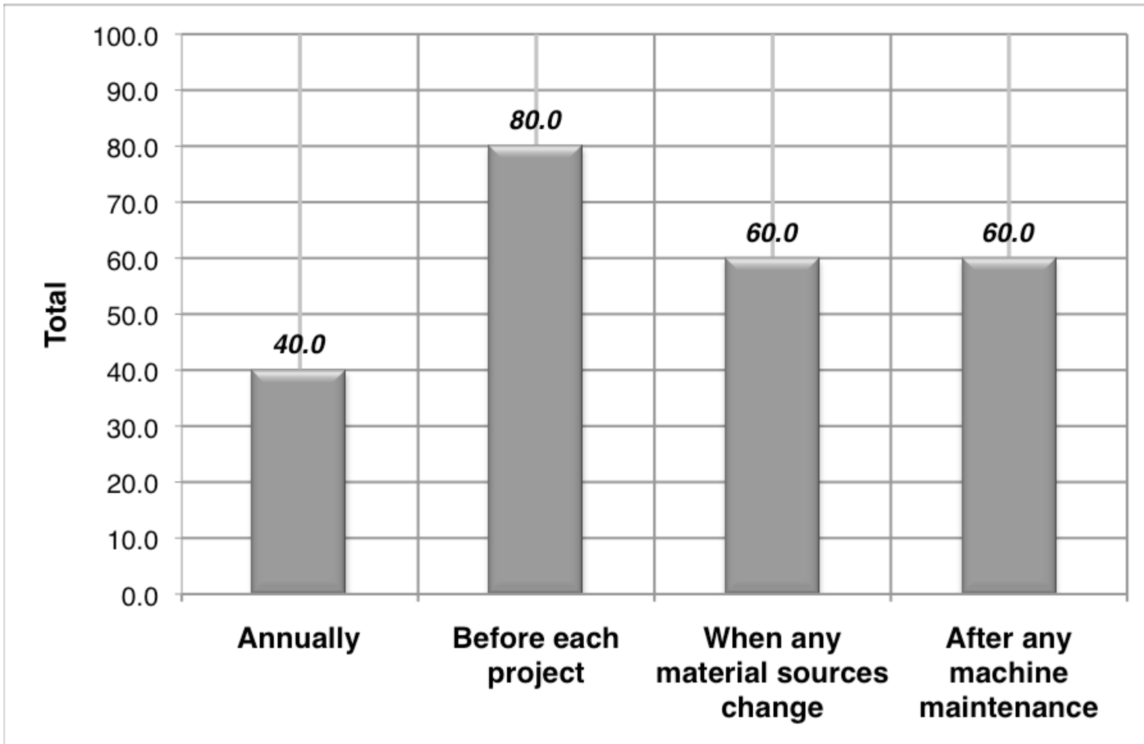


- As long as adjustments stay within design tolerances

- Only done through the mix design provider

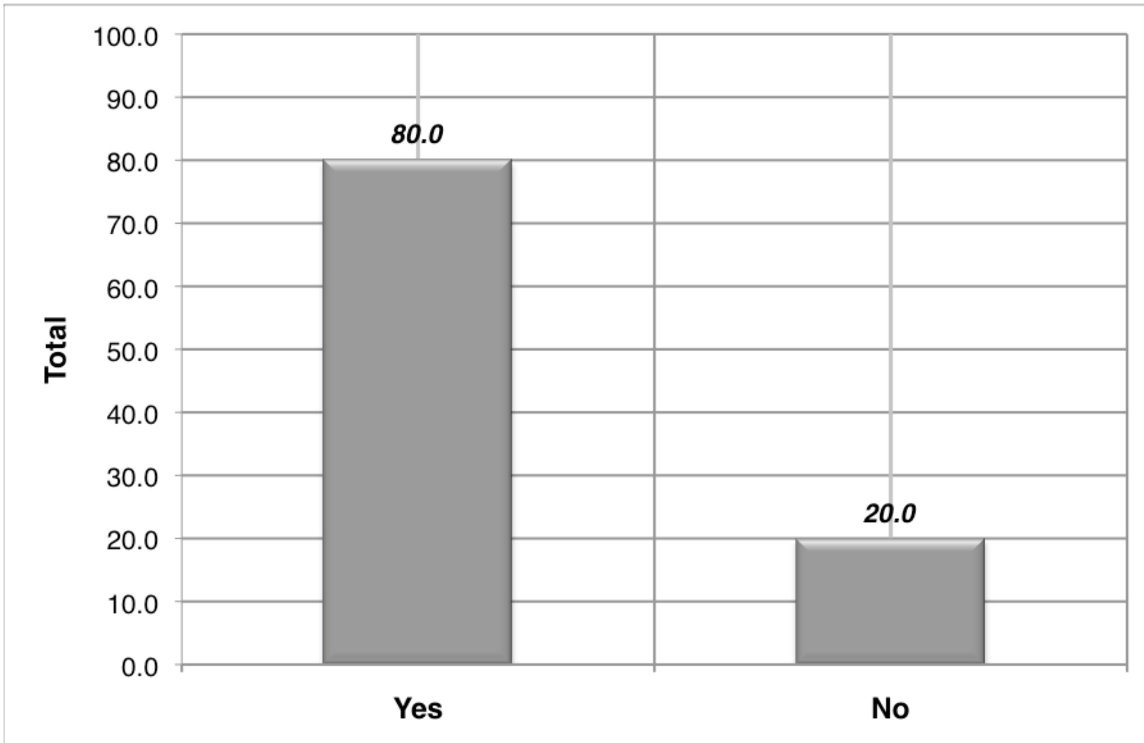
- These two should partner in making to decision and agree on the changes!

37. Do you calibrate your mixing equipment (check all that apply):



- After any maintenance or repair the affects the material deliver systems on the machine

38. Beyond calibration of mixing and spreading equipment, do you perform any other field tests to check material application rates?



If "Yes", what tests are done?

- Periodically throughout the day the supervisor will check the application rate with his measuring wheel, and compared it to the tonnage the machine is placing, to verify his application rate.

- Aggregate, Emulsion, and Cement checks per run.

- Calculate application rates back to our certified scale

- Production output is matched to material inventory and compared to the area covered to verify rates

39. What tolerances are allowed for application rate and speed of microsurfacing?

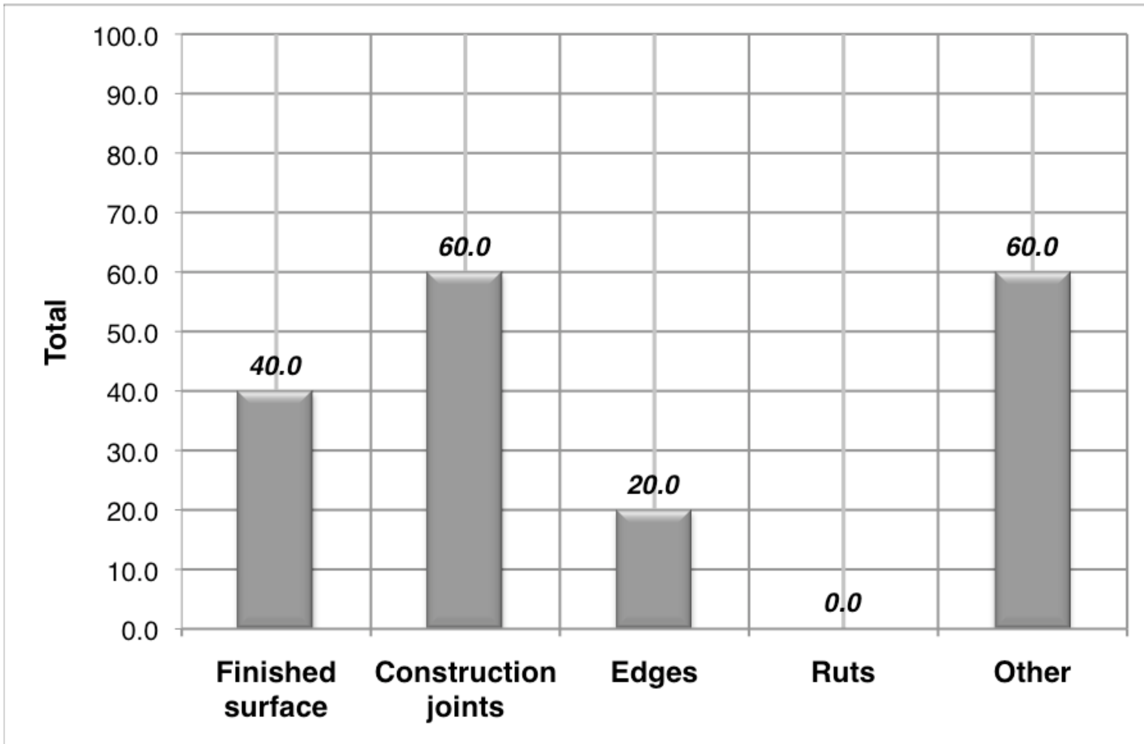
- Aggregate; +/- 2 pounds
  Binder; +/- 0 .5%
  Material cannot be placed to thin or to fast or it will leave wavy marks in the mat.

- Application +/- 2% per run, no speed tolerances

- Calculate application rates back to our certified scale. Road conditions should dictate application rates. Application rates do control the speed of the paving machine.

- Varies by road conditions and constant discussion with inspectors & project supt.

40. What workmanship issues cause the most difficulties for your crews?



<u>Other, Please Specify:</u>

- Hand work areas where the machine and box cannot apply microsurfacing.

- Workability (mixing and setting time of the material)

41. What is the typical time span between final spreading and opening to reduced speed traffic?

- 30 minutes

- One hour

- 5 – 15 minutes

- One hour

- 30 – 90 minutes

42. What is the typical time span between final spreading and opening to full speed traffic?

- 90 minutes

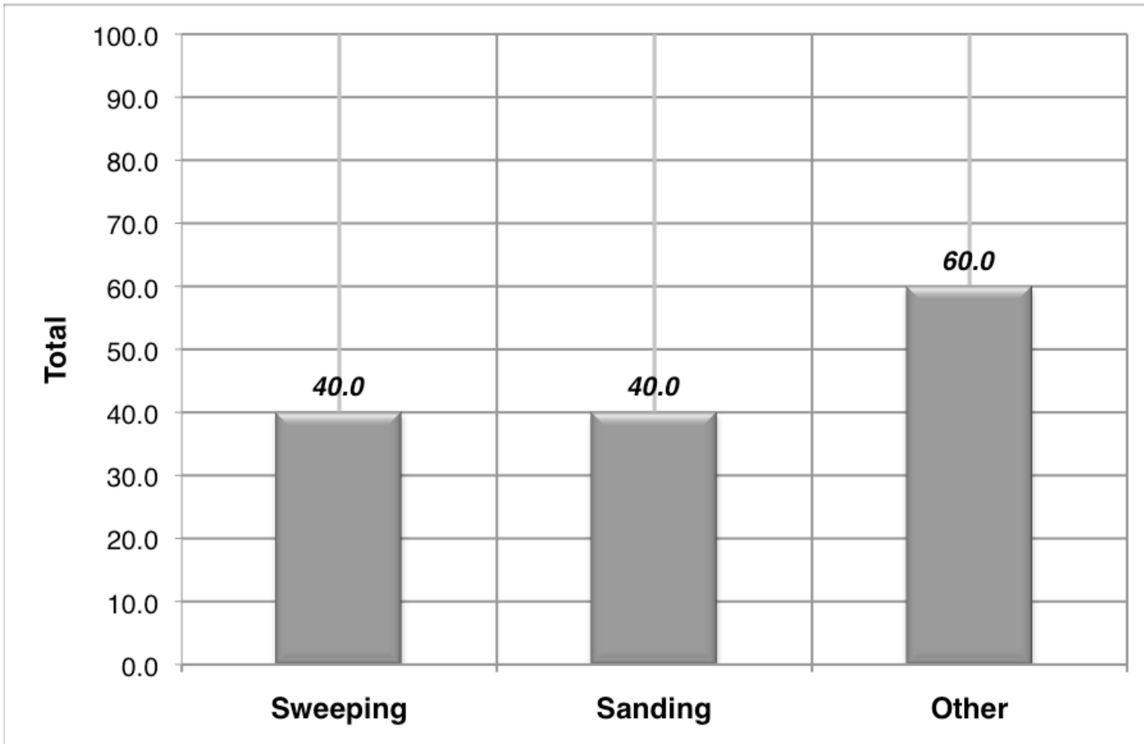
- One hour

- 30 – 60 minutes

- One hour

- 30 – 90 minutes

43. Which of the following treatments are performed post-microsurfacing?



Other, Please Specify:
- N/A
- Joint grinding
- None

44. If any of the above treatments are done, who conducts the treatments and when?

- N/A
- Contractor
- Traffic control personnel, for crossing or stopping traffic before mix is ready
- Contractor

45. If sweeping is done, what kind of broom is used?

- N/A
- Multi
- Rotary of pickup
- Rural areas – Rotary / Kick off broom; Urban or curbed areas – Regenerative air sweeper (Tymco)

46. Rank the top 5 reasons for microsurfacing successes in order from greatest impact (1) to least impact (5).

	1	*2*	*3*	*4*	*5*	*Response Count*
Contractor experience	1 (25.0%)	2 (50.0%)	1 (25.0%)	0 (0.0%)	0 (0.0%)	4
Project selection	3 (60.0%)	1 (20.0%)	0 (0.0%)	1 (20.0%)	0 (0.0%)	5
Material quality	1 (33.3%)	1 (33.3%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	3
Workmanship	0 (0.0%)	0 (0.0%)	2 (66.7%)	0 (0.0%)	1 (33.3%)	3
Mix design	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1
Type of contract (Warranty/Non-warranty)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Weather	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	1
Proper application rate	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1
Aggregate quality	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Aggregate gradation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Vehicle speed control after the mix is deposited	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Ability to control traffic	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)	2
Aggregate/binder compatibility	1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	3
Proper proportioning	1 (50.0%))	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	2
Proper surface preparation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	1
Field construction procedures	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1

Other, Please Specify:

47. Rank the top 5 reasons for microsurfacing failures in order from greatest impact (1) to least impact (5).

	1	2	3	4	5	Response Count
Contractor experience	2 (40.0%)	2 (40.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)	5
Project selection	2 (40.0%)	3 (60.0%)	0 (0.0%)	0 (00.0%)	0 (0.0%)	5
Material quality	1 (50.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	2
Workmanship	0 (0.0%)	0 (0.0%)	2 (50.0%)	1 (25.0%)	1 (25.0%)	4
Mix design	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Type of contract (Warranty/Non-warranty)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Weather	0 (0.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)	2
Improper application rate	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	2
Dirty or dusty aggregate	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Aggregate gradation	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1
Vehicle speed control after the mix is deposited	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Early open the traffic after the mixture is deposited	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	1
Aggregate/binder compatibility	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	1
Improper proportioning	1 (50.0%))	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	2
Improper surface preparation	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1
Field construction procedures	0 (0.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)	2

Other, Please Specify:

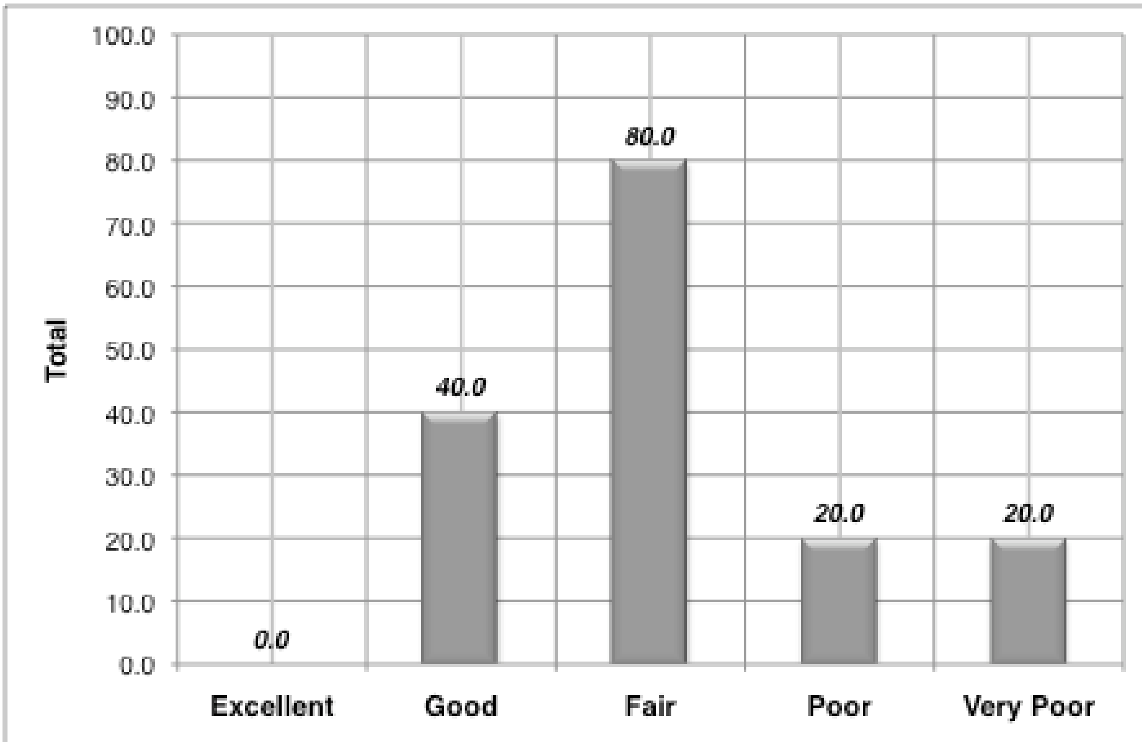
48. Which factors are most critical in determining the *life* of your microsurfacing projects? Please indicate the top three in order of importance.

	1	*2*	*3*	*Response Count*
Field construction procedures	0 (0.0%)	1 (50.0%)	1 (50.0%)	2
Original substrate surface quality	1 (33.3%)	1 (33.3%)	1 (33.3%)	3
Underlying pavement structure	3 (60.0%)	1 (20.0%)	1 (20.0%)	5
Maintenance funding	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Friction loss	0 (0.0%)	0 (0.0%)	0 (0.0%)	0
Traffic	0 (0.0%)	1 (100.0%)	0 (0.0%)	1
Cold climate considerations (freeze/thaw cycles, snowplowing, etc.)	0 (0.0%)	0 (0.0%)	2 (100.0%)	2

Other, Please Specify:

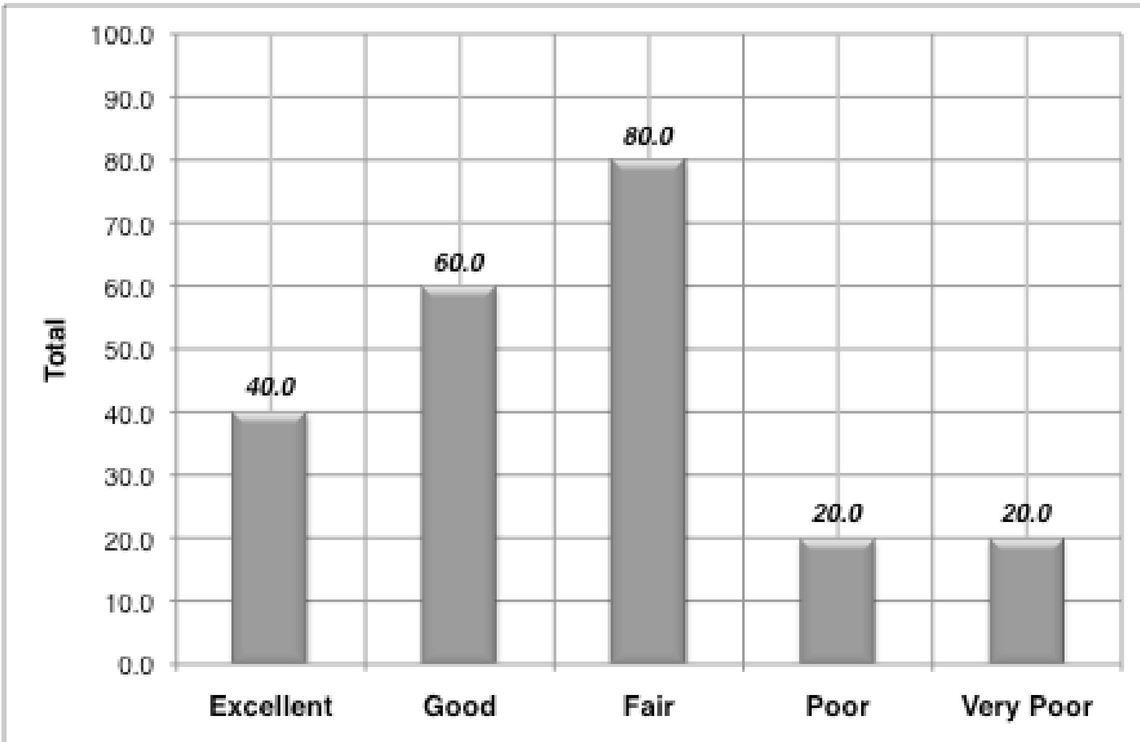
- Was microsurfacing to proper choice?

49. How would you describe the pavement ride on a road immediately before receiving a new microsurfacing?



- Depends on the condition of the existing roadway.

50. How would you describe the pavement ride on the same road immediately after receiving a new microsurfacing?



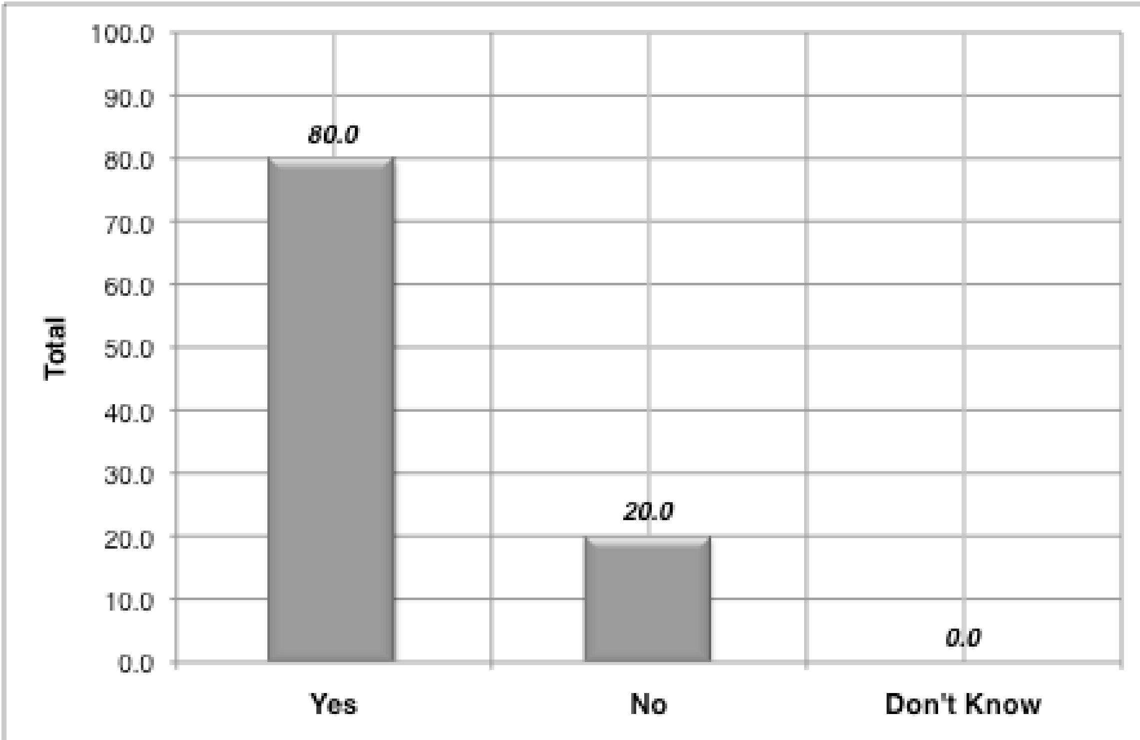
- Again, it depends on the ride that we start with. But microsurfacing normally does give a minimal ride improvement.

- Slightly better than before the application. Has not been measured by TxDOT because microsurfacing is generally not used to correct “ride” Public may have issues because they do not know the difference between HMAC & microsurfacing

51. Which types of distress will microsurfacing correct?

	Yes	*No*	*Response Count*
Fatigue Cracking	0 (0.0%)	5 (100.0%)	5
Reflection cracking	1 (20.0%)	4 (80.0%)	5
Streaking/color variations	4 (80.0%)	1 (20.0%)	5
Raveling	5 (100.0%)	0 (0.0%)	5
Delamination	3 (60.0%)	2 (40.0%)	5
Corrugation/poor ride quality	3 (60.0%)	2 (40.0%)	5
Poor transverse joints	3 (60.0%)	2 (40.0%)	5
Bleeding	4 (80.0%)	1 (20.0%)	5
Poor longitudinal joints	3 (60.0%)	2 (40.0%)	5
Potholes	0 (0.0%)	5 (100.0%)	5
Surface texture variations	5 (100.0%)	0 (0.0%)	5
Loss of friction/skid	5 (100.0%)	0 (0.0%)	5
Permeability	3 (60.0%)	2 (40.0%)	5
Rutting	4 (80.0%))	1 (20.0%)	5

52. Are current microsurfacing specifications adequate to produce a quality product?



If "No", how can they be improved?

- Performance Specifications (how long will the contractor back up his product). It should not always be who can lay the low bid material at the lowest cost to the agency. The best value is what is going to last the longest.

- Higher performance mix design testing

53. What does a *good* microsurfacing contractor do that is important?

- Pre work testing, knowing the material will perform and last. Trained and competent operators that know how to work with the material. Makes sure materials are placed to contract specifications.

- Treat every job like his future depends on it!

- Pay attention to materials, equipment, calibrations and laydown

    1. Training of personnel

    2. Equipment maintenance

    3. Demand Quality

- Extensive maintenance and upkeep of paver and spreader box.

- Closely monitor quality control practices of their crews. Make the needed adjustments to correct problems.

54. What does a *poor* microsurfacing contractor do that is harmful?

- Shows up on the job and goes to work thinking they will be able to work through any problems and work the bugs out as they go down the road placing, Continues to work through the problems instead of figuring out what the problem is.

- Lack of experienced personnel
- Poor quality, and poorly maintained equipment
- Uses poor quality materials
- Takes unnecessary risks with weather
- Poor attention to workmanship

- Puts production & profit before quality!

- Lack of calibrations, lack of maintenance, lack of training

1. Use of poor materials

    2. Poor equipment Maintenance

    3. Trying to make a quick buck

- Lack of material control, and equipment upkeep.

- They only concern themselves with profitability and not with maintaining high quality control standards to further promote the product.

Please identify three representative projects and evaluate their performance.

55. Project 1

a. Project name and Location:

- TxDOT Grayson County. FM 121, Gunter to Tioga.

- Lubbock, Texas, 2010

- Hill County, IH35W – IH35E to the Johnson County Line, North of Hillsboro, TX

- Marshall Area Office Microsurfacing in fall of 2005

b. Determine the overall level of success of this project

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success (5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	*Did you use it?* Yes	No	*Level of success* (0 to 5)
Meets expected service life	**(75.0%)**	**(25.0%)**	**4.33**
Does not fail shortly after construction	**(75.0%)**	**(25.0%)**	**4.50**
Achieves desired friction/skid number	**(75.0%)**	**(25.0%)**	**4.25**
Qualitative measures-look, color, etc.	**(100.0%)**	**(0.0%)**	**4.25**
Meets project specification	**(100.0%)**	**(0.0%)**	**4.75**
Other, please specify:	**(25.0%)**	**(75.0%)**	**5.00**

Other, please specify:

- Designed with enough tonnage to provide sufficient fix

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress. (Non-existent=0, Low=1, Medium=2, High=3)

Distress	*Did you observe it?*		*Level of sensitivity immediately after construction? (0 to 3)*	*Level of severity currently? (0 to 3)*
Raveling	Yes No	(25.0%) (75.0%)	(0) (0) (0) (0)	(0) (0) (0) (0)
Bleeding	Yes No	(25.0%) (75.0%)	(0) (0) (0) (0)	(0) (1) (0) (0)
Corrugation	Yes No	(25.0%) (75.0%)	(0) (0) (0) (0)	(0) (0) (0) (0)
Crack reflection	Yes No	(50.0%) (50.0%)	(0) (0) (0) (0)	(0) (1) (1) (0)
Streaking	Yes No	(25.0%) (75.0%)	(0) (0) (0) (0)	(0) (1) (0) (0)
Transverse joints	Yes No	(50.0%) (50.0%)	(0) (1) (1) (0)	(0) (1) (1) (0)
Longitudinal joints	Yes No	(50.0%) (50.0%)	(0) (1) (0) (0)	(0) (1) (2) (0)

<u>Other, please specify:</u>

56. **Project 2**

a. Project name and Location:

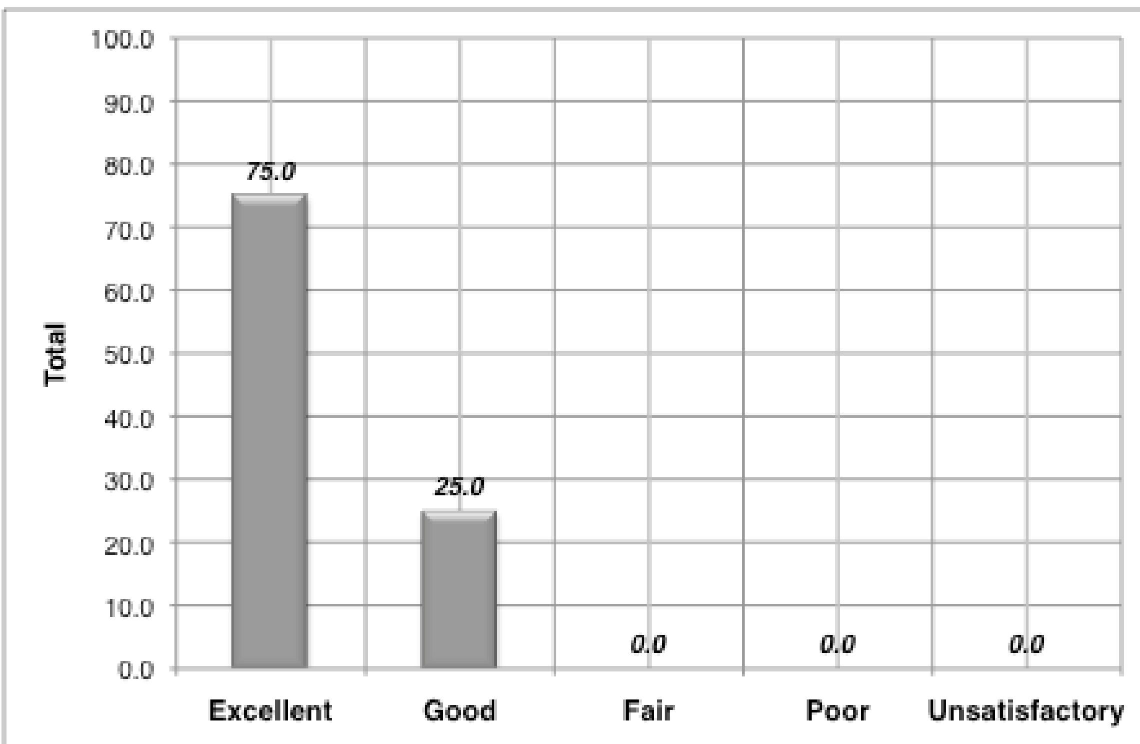
- Hughes, TX in fall of 2005

-Ellis County, Hwy. 287

- Sutton County, IH10 – West of Junction to West of Sonorra

- El Paso, Texas 2010

b. Determine the overall level of success of this project



c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success (5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	*Did you use it?* *Yes*	*No*	*Level of success (0 to 5)*
Meets expected service life	**(100.0%)**	**(0.0%)**	**5**
Does not fail shortly after construction	**(75.0%)**	**(25.0%)**	**4.75**
Achieves desired friction/skid number	**(75.0%)**	**(25.0%)**	**4.50**
Qualitative measures-look, color, etc.	**(100.0%)**	**(0.0%)**	**4.50**
Meets project specification	**(100.0%)**	**(0.0%)**	**4.50**
Other, please specify:	**(25.0%)**	**(75.0%)**	**5.00**

Other, please specify:

- Paved an existing concrete pavement

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress. (Non-existent=0, Low=1, Medium=2, High=3)

Distress	Did you observe it?	Level of sensitivity immediately after construction? (0 to 3)	Level of severity currently? (0 to 3)
Raveling	Yes (50.0%) No (50.0%)	(0) (0) (0) (0)	(1) (0) (0) (0)
Bleeding	Yes (50.0%) No (50.0%)	(0) (0) (0) (0)	(1) (0) (0) (0)
Corrugation	Yes (25.0%) No (75.0%)	(0) (0) (0) (0)	(0) (0) (0) (0)
Crack reflection	Yes (75.0%) No (25.0%)	(0) (0) (0) (0)	(1) (1) (2) (0)
Streaking	Yes (25.0%) No (75.0%)	(0) (0) (0) (0)	(0) (0) (0) (0)
Transverse joints	Yes (50.0%) No (50.0%)	(0) (0) (0) (0)	(0) (0) (2) (0)
Longitudinal joints	Yes (50.0%) No (50.0%)	(0) (0) (0) (0)	(0) (0) (2) (0)

Other, please specify:

57. <u>Project 3</u>

a. Project name and Location:

- Jacksboro, TX in fall of 2008

- City of Waco, Tx.

- Houston County, US 287, Groveton, TX to the Polk County Line & LP304 (Crockett, TX) to Grapeland, TX

- Big Bend, Texas. National Park for FHWA

b. Determine the overall level of success of this project

c. Which of the following performance measures did you use to determine the level of success of this project? For each performance element you used please determine the level of success (5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Unsatisfactory, 0= did not use)

Performance measures	*Did you use it?* Yes	No	*Level of success* (0 to 5)
Meets expected service life	**(100.0%)**	**(0.0%)**	**4.75**
Does not fail shortly after construction	**(75.0%)**	**(25.0%)**	**4.75**
Achieves desired friction/skid number	**(75.0%)**	**(25.0%)**	**4.50**
Qualitative measures-look, color, etc.	**(100.0%)**	**(0.0%)**	**4.25**
Meets project specification	**(100.0%)**	**(0.0%)**	**4.75**
Other, please specify:	**(0.0%)**	**(0.0%)**	**0.00**

Other, please specify:

d. Which common distresses did you observe in your completed microsurfacing projects? Please indicate the level of severity of each distress. (Non-existent=0, Low=1, Medium=2, High=3)

Distress	*Did you observe it?*		*Level of sensitivity immediately after construction? (0 to 3)*	*Level of severity currently? (0 to 3)*
Raveling	Yes No	(25.0%) (75.0%)	(0) (1) (0) (1)	(0) (0) (0) (0)
Bleeding	Yes No	(25.0%) (75.0%)	(0) (0) (0) (0)	(0) (1) (0) (0)
Corrugation	Yes No	(100.0%) (0.0%)	(0) (0) (0) (0)	(0) (0) (0) (0)
Crack reflection	Yes No	(50.0%) (50.0%)	(0) (0) (0) (0)	(2) (1) (0) (1)
Streaking	Yes No	(25.0%) (75.0%)	(0) (0) (0) (0)	(0) (0) (0) (0)
Transverse joints	Yes No	(0.0%) (100.0%)	(0) (1) (0) (0)	(0) (0) (0) (0)
Longitudinal joints	Yes No	(50.0%) (50.0%)	(0) (1) (1) (0)	(0) (0) (2) (0)

Other, please specify:

58. If there is anything that you would like to add that was not covered in this questionnaire which you feel would benefit this study, please write your comments below:

- Microsurfacing is one of the most difficult products to apply correctly that I know. There are so many variables involved that can change break-time, set-time, consistency, and general cosmetics of the mix. Experience is a must, not only for the contractor, but also the emulsion manufacturer and aggregate producer if you have any chance of constructing a successful project. But when it is done properly, there are several uses where microsurfacing is hard to beat, especially for the price that you pay.

- We see most microsurfacing projects done to correct pavement problems and would suggest that TXDOT should consider more use of microsurfacing as a preventive maintenance treatment to maximize the life of existing HMAC.

- Microsurfacing has also been utilized successfully as a rut filler by many other agencies. Brownwood district is successfully using microsurfacing as surface preparation prior to a seal coat, and many researchers believe that alternating chip seal and microsurfacing is a very good strategy for roadways which do not require HMAC overlays.