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Constructability Review of Surface Treatments Constructed on Base Courses

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Interim Report

By

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Abstract

It is common practice for TxDOT to construct surface treatments (1-, 2- or 3- course) directly over base courses. Such surface treatments may act as either wearing surfaces or underseals (or interlayers). There are also many other highway agencies, both in the United States and in other countries that use surface treatments directly over base. The decision to use surface treatments is based on a number of factors including low life-cycle cost, low initial construction cost, inexpensive maintenance, historically favorable experience, availability of experienced contractors, and availability of sound local materials.

These surface treatments have a significant influence on pavement performance. Their satisfactory performance is crucial to the serviceability of the pavement structures where they are used. Problems associated with surface treatments include flushing/bleeding in the wearing courses, debonding at the interface with the base layer, poor ride quality, loss of aggregate (raveling) and ineffective sealing of the pavement. When a surface treatment is used as an underseal, its failure may lead to accelerated failure of the overlying surface layer.

Constructability issues related to surface treatments often dictate their performance. However, a formal statewide constructability review of surface treatments over base has not been conducted either by TxDOT or by other state highway agencies in the recent past. Recently concluded TxDOT research project *0-1787: Seal Coat Constructability Review,* was well received by TxDOT personnel as well as the contracting community. It resulted in a number of operational changes in seal coat practices including updates to the specifications and the seal coat inspector training manual. A similar study on surface treatments placed on prepared base can lead to surface treatment construction operations more effective, resulting in longer lasting and higher quality pavements.

This objective of this research project was to conduct a comprehensive constructability review of surface treatment as practiced by TxDOT districts and to identify best practices. A comprehensive survey of existing surface treatment practices was conducted, both by interviewing and contacting highway professionals and by visiting construction projects. Interviews were conducted with TxDOT district personnel, contractors, material suppliers and other State DOT personnel. Information collected from the constructability review was used to develop a district training workshop. The workshop was delivered by the researchers at eight regional locations, and each workshop was attending by TxDOT professionals from at least 3 districts. This interim report highlights the key findings from the constructability review.

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Chapter 1

Introduction

A surface treatment is defined as a single application of asphalt binder, followed by a single application of cover aggregate, both placed on a prepared flexible or stabilized base. In Texas, surface treatments are used as surface courses in low volume roads in the form of either one or multiple course treatments. One-course surface treatments are rare, and they are typically used for only a short period of time before being covered by another one-course surface treatment or other type of surface course. In the case of multiple treatments, two or three courses of surface treatments are applied to provide a durable surface course. These surface treatments provide an economical pavement surfacing alternative compared to hot mix asphalt concrete. A surface treatment used as a pavement wearing surface must be strong enough to withstand the traffic and climate-induced stresses. It also has to be durable. However, most importantly, it seals the pavement base and foundation.

In many instances, surface treatments are also used as interlayers, which are also referred to as underseals, between the base and surface courses. Some examples of such applications are *cape seals* (a combination of an underseal and a microsurfacing) and *stress-absorbing membrane inter-layers* (SAMI's). A surface treatment underseal has several functions in a pavement. An underseal can provide a stronger bond between the base and the HMAC layer, that will significant reduce the stress levels in the HMAC, resulting in a longer fatigue life of that layer. Similar to a surface treatment wearing course, it is a very effective method to seal the base course and foundation of the pavement from moisture. This can significantly extend the service life of pavement. A flexible underseal can also act as a Stress Absorbing Membrane Interlayer (SAMI) that can reduce reflective cracking in the HMAC layer. Hot rubber asphalt surface treatments have shown more effectiveness as a SAMI. Since the underseals are eventually covered with HMAC, they can be used in pavements with high traffic levels.

The application of surface treatment produces a small increase in thickness of the road surface, but is not intended to provide additional structural capacity to the pavement. Therefore, all the structural strength in such a pavement is provided by the base course, which makes its role in the pavement very crucial. Such a pavement structure cannot be effectively used in high traffic volume roadways because the base and subbase layers are unable to provide strength that is sufficient for such pavement structures. However, ASTs provide a variety of benefits; they make the pavement waterproof, provide a skid-resistant wearing surface and lower life-cycle costs.

Most of the rural and farm–to–market roads in Texas experience relatively low traffic volume. Each year, the construction and maintenance of the state-managed road network require a significant appropriation of funds from the state. Therefore, effective utilization of these funds is of utmost importance. Asphalt Surface Treatment (AST) is an appropriate, economical and reliable technique, particularly for low volume roads. Also, ASTs are commonly used by highway agencies in other states and countries.

In this report, an overview of the findings from the constructability of surface treatments constructed on base courses is presented. The study was limited to surface treatments constructed on flexible granular bases, cement stabilized bases and fly ash stabilized bases. In Chapter 2, a review of technical literature on the subject of surface treatments and prime coats is presented. The researchers noted that technical literature on this subject is very limited, but the authors have carefully reviewed the available literature and summarized their key findings in Chapter 2.

Chapter 3 of this report outlines the constructability review method adopted in this research and Chapter 4 outlines the findings from the TxDOT district interviews which formed the bulk of the constructability review. The researchers conducted interviews in all twenty- five TxDOT districts using a comprehensive questionnaire. District personnel involved in the surface treatment process were included in the interview process. The constructability review also included visits to thirty-seven construction projects when surface treatment construction activities were in progress. Key observations that were made during these visits are highlighted in Chapter 5 of this report. The contents of the report and the constructability review are summarized in Chapter 6 under Conclusions.

Chapter 2

Literature Review

2.1 Asphalt Surface Treatment Application

Asphalt surface treatments are typically classified as either one-course, two-course or three-course applications. In Texas, a one-course surface treatment is constructed as a thin bitumen–aggregate application on a prepared road base. The construction method typically involves sweeping (or brooming) of the finished base layer to remove dust and other foreign materials before spraying a heated prime coat binder.

The prime coat is typically a sprayed asphalt binder that has a sufficiently low viscosity and surface tension contact angle with the base material that will allow it to penetrate into the base and create a strong bond (hold) on the base. A prime coat can also be applied by mixing an emulsified asphalt binder to the top of the base material. Such a prime coat is called a cut-in, worked-in or a mixed-in prime.

The application of prime coat is followed by the application of the surface treatment. The objective of the prime coat is to act as a bonding agent between the finished base and the surface treatment binder. The prime coat binder, which is typically a low-viscosity material, penetrates into the base and establishes bonding with its particles. Figure 2.1 shows a schematic of a typical penetration pattern of prime coat binder into the base layer.

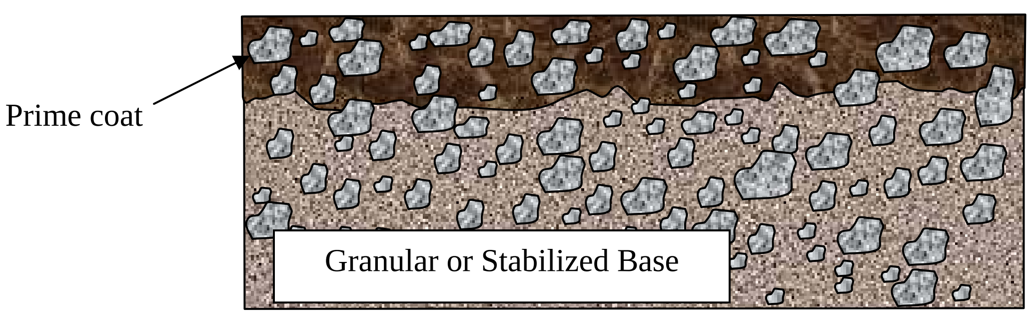

Figure 2.1 Schematic of Prime Coat Penetration into Base Layer

After applying the prime coat, a curing time is typically allowed. Then the surface treatment binder is applied over the prime coat using an asphalt distributor. The cover aggregate is then applied uniformly using an automated aggregate spreader. A pneumatic-tired roller is used to push the cover aggregates into the soft asphalt binder before it cools (or cures in the case of emulsified asphalt) and hardens. The asphalt and aggregate application rates are designed such that approximately one half of the height of each aggregate particle is embedded into the asphalt binder to prevent lost of cover aggregate. It is preferred that single-size cubic aggregate particles are used instead of flaky or elongated ones (McLeod, 1960). It is recommended that the voids space between individual particles when looking from the top is kept at approximately 30 percent. The final product with a one-course surface treatment is similar to that shown in Figure 2.2.

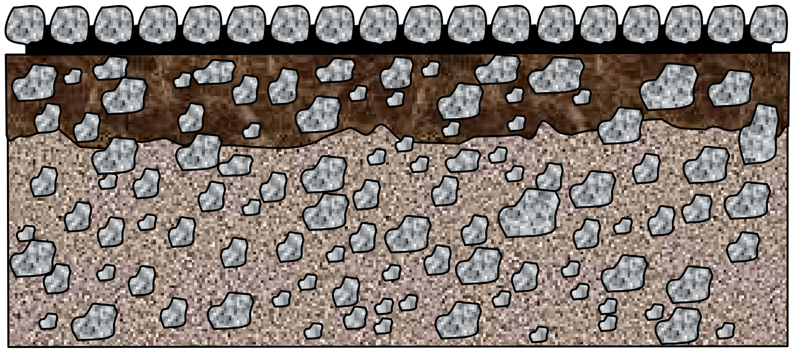

Figure 2.2 Schematic of a Typical One-Course AST.

If the binder–aggregate combination is repeated on the top of the first course, the result is a two-course AST (Figure 2.3). Some states also use three-course AST (Bolander et. al, 1999). When multiple layers of AST are applied, special care must be taken in cleaning the underlying surface to ensure proper bonding (McHattie, 2001).

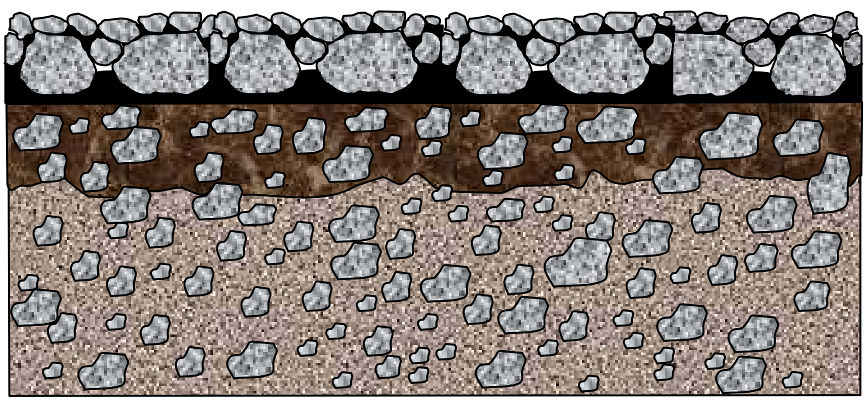

Figure 2.3 Schematic of a Typical Two-Course AST

2.2 Effect of Prime Coats in Asphalt Pavements

In the early 1980's engineers knew the purpose of using prime coats and continued to use traditional medium curing materials such as MC-30 and MC-70 cutbacks, although emulsified asphalts, such as MS-10, were gaining popularity. Ishai and Livneh (1984) conducted research on prime coats at Technion in Israel to compare these cutbacks with the newer emulsions. Four aspects of each material were observed; liquid evaporation, prime penetration, hardness and toughness of primed surface, and adhesion properties between base courses and asphalt layer. To compare evaporation rates, Ishai and Livneh placed an equal amount of prime coat materials, at room temperature, in separate 15cm dishes and observed them every day for one week. The group also applied equivalents to four different spray rates, giving them a total of 12 experiments to also determine how different rates effected evaporation. By weighing the sample every day the group was able to determine how much water evaporated. During this time, viscosity tests were also conducted to compare the viscosity vs. degree of evaporation during curing. In almost every test conducted the MS-10 evaporated twice as fast as the MC-70. After two days the only MS-10 sample to not reach 80% total evaporation was the sample, which was applied at the rate of 30 kg/m^2.

Penetration plays a major role in the use of a prime coat, and Ishai and Livneh tested it using compacted sands. Each prime coat sample was sprayed at its normal distributed temperature and allowed to set for up to one day. Measurements of the penetration were taken by cutting the compacted sand vertically and measuring on the cut face. In this test the MS-10 was outperformed by both the MC-30 and MC-70. This test seemed to be controlled more by the type of base material used rather than the prime material. When applied to compacted quarry sand, the cutbacks outperformed the emulsion by about 3 to 4 inches, whereas when sprayed over dune sand, the emulsion penetrated anywhere from the same amount as the cutbacks and up to 3 inches deeper.

Hardening of the base course is also a major issue and Ishai and Livneh tested this by spraying the three materials on separate samples. The unconfined compression strength of the granular surface was measured immediately after spraying and every day for 24 days using a standard pocket penetrometer and standard cone penetrometer. Once again the MS-10 outperformed the MC-70. While the MC-70 took almost one week to gain any strength and only increased slightly in the remaining two weeks of testing, the sample of MS-10 quickly gained strength and within a week was about seven times stronger than the MC-70. At the end of the testing period the MS-10 was continuing to increase in strength and showed no signs of slowing down.

Interfacial adhesion showed the biggest contrast between the three samples. The setup of this experiment consisted of compacting the base and waiting one day to apply a prime, then applying a hot bituminous concrete layer one day after the primer had been applied. A direct shear test was performed 2 days after the sample had been completely constructed. The parameters tested were the maximum shear stress at failure and the horizontal deformation at this condition. MS-10 outperformed MC-70 again by allowing more shear stress as vertical loading increased. The shear failure interface also suggested higher shear stresses by having a more jagged edge where the shear failure interface of the MC-70 looked almost smooth.

2.3 Materials Used in Asphalt Surface Treatments (AST)

2.3.1 Aggregates

Good quality aggregates are essential in surface treatments. One of the field studies (Bolander et. al, 1999) revealed that a two-course AST failed due to inadequate bonding between aggregate particles and asphalt binder. As a result, a six-mile highway section had to be pulverized and reconstructed. McHattie(2001) emphasized that frozen aggregates are not suitable for AST.

2.3.2 Asphalt Binders

Various grades of emulsified asphalt and cutback asphalt are used in prime coats, and the type and grade used depend on the type of aggregate and the field conditions. Johnson (2001) reported that the most commonly used prime coat binders are AE-P, MC-30, RS-250 and CRS-1h. Some states, for example Minnesota, have moved from cutback asphalt (MC – 3000) to high float emulsions (i.e. HFE–300). Their designs use lower viscosity asphalts in surface treatment than in HMA. The softer binder is designed to minimize transverse cracking and extend the asphalt aging period (Johnson, 2003). Table 2.1 shows the typical asphalt application rates used in Alaska (McHattie 2001).

Table 2.1 Typical Binder Application Rate in AST (McHattie, 2001)

Type of AST		Binder Application (gal./sq.yd)	Allowable Tolerance (gal./sq.yd)
Single layer CRS-2/2P		0.20 – 0.35	0.04
High float HFMS-2S		0.75	0.04
Double layer CRS-2/2P	First layer	0.35 – 0.51	0.04
	Second layer	0.51 – 0.60	0.04

Mantilla and Button (1994) did a comparative analysis of the effectiveness of emulsified asphalt and cutback asphalts as prime coat materials, and reported that emulsified asphalts were not as effective as cutbacks. The emulsified asphalts were found to be more effective when they were diluted with water. They recommended that for best performance, cutback asphalt should be mixed-in with the top 1-2 inches of base material for best performance.

2.3.3 Aggregate Fines

In any emulsion application, the finer material [passing *No. 200* sieve] absorbs the emulsion before it becomes available to adhere to the larger particles (Bolander et. al, 1999). Rapid–set emulsions tend to break on the fine material before coating the larger chip particles. If the larger particles are not coated with the emulsion, they do not act together as a continuous mat and will tend to ravel with traffic. Bolander also indicated that incorporation of fines in the asphalt binder increases its viscosity, decreases penetration, and decreases the ductility of the fines + binder blend.

Excess fines in the base course may cause other problems as well. The free drainage of the base course will be disturbed and it may force the cutter vapor and water to escape through the AST (Bolander et al., 1999). For a reasonably free–draining base, USFS specifications require that fines not exceed 8 percent. In some states, for example Alaska, the specification requires 1 percent or less passing the #200 sieve (McHattie, 2001). He also suggests that if clean aggregate is not available then one or more of the following can be done.

- Wash the aggregate using clean, potable water.
- Use polymer-modified emulsified asphalt (*CRS-2P*). This binder is extremely tacky and will bond more tenaciously to any aggregate.
- Precoat the aggregate chips with asphalt cement. This technique involves putting the aggregate through an asphalt plant and coating it lightly with asphalt. This will bond the dust to the aggregate.
- Precoat the chips with lime/water solution.

2.3.4 Quality Control

An adequate and accurate quality control and quality assurance plan must be in place before construction. The performance and durability of AST depend on the quality of the material used and quality of the work done. *Bolander et al*. summarized some practical reasons why AST failed in one of their study. The summarized details are given below.

Table 2.2 Possible Reasons for Failures in AST (Bolander et al., 1999)

Condition	Primary course(s)	Secondary course(s)
Loss of Grade 7 chips	▪ Too many fines in chips. ▪ Incompatibility of emulsion and chips.	▪ Insufficient cure time prior to freezing. ▪ High traffic speed immediately following construction. ▪ Insufficient brooming to clean the first course.
Secant Adhesion of asphalt cement to Grade 6 chips	▪ Incompatibility between emulsion and chips.	▪ Insufficient cure time. ▪ Dust coating on chips.
Potholing	▪ High traffic speed. ▪ Saturated base.	▪ Smooth table-top base.
Dull, lackluster appearance of binder.	▪ Fines in chips.	▪ Insufficient cure time.
Pinholes in existing surface.	▪ Escaping cutter from emulsion. ▪ Escaping moisture from base.	

2.4 Aggregate–Binder Compatibility

The successful bonding between asphalt binder and aggregate depends on several factors including compatibility, amount of fines in aggregate and absorption. Bolander et al. (1999) indicated that in one of their studies, three emulsions were used to study the aggregate–emulsion compatibility. In this study, aggregates were prepared in three ways; screened and washed, screened but not washed and no screening + no washing. The conclusions from this study were;

- *HFRS-2* with *0.1* percent coating aid might be adequate but there is a possibility of asphalt stripping with time. Use of additional coating aid or use of *CRS-2* would greatly reduce the probability of stripping.
- The aggregates which were free from fines are preferable for construction. However, even with clean aggregate the asphalt would likely to strip with time.

2.5 Effect of Weather and Moisture on AST

The temperature and humidity during construction play a significant role on AST performance. The emulsions "break" because of the neutralization of charges between aggregate surface and asphalt particles in the emulsion. In some manufacturing processes, cutters are added to the emulsions and they help emulsion be wet and adhere to the aggregates. Bolander et al. (1999) indicate that "these cutters also tend to maintain the asphalt cement in a low viscous state until water evaporates". This shows that the humidity has an indirect effect on the bonding interaction between aggregates and emulsified asphalt binder.

Low temperatures during construction can also cause problems in ASTs. Scott et al. (1979) state that "…at low ambient temperatures the emulsion enters a cheesy state. It remains uncoalesced, providing mediocre resistance when shearing forces are applied. Stones are easily pulled out leaving a clean surface or a cheese-like brittle fracture surface".

If the base course is saturated, it could severely damage the AST. Traffic can induce damaging pore water pressures that will push the overlying AST and it may partially or completely disintegrate under such situations. The escaping cutter vapors or water from the base forced upward may cause pinholes in the AST (Bolander et al. 1999).

McHattie (2001) suggests a minimum air temperature for construction of AST of 60 °F, and in the case of high float AST he recommends a minimum temperature of 50 °F. Low air temperature retards evaporation, and in fact the entire curing process. Curing times do not increase linearly with falling temperature. A rule of thumb is that an 18 °F drop in temperature decreases the curing rate by at least one half.

2.6 Additional Research

In addition to the types of surface treatment indicated above, several other types of ASTs are also used by highway agencies. Some of the surface treatment types typically used in South Africa is shown in Figure 2.4 below.

Whether these surface treatments are used as a wearing course or not, unless appropriate construction practices are followed the pavements may fail prematurely, providing poor serviceability to the traveling public. For cape seals, where a surface treatment is overlaid with microsurfacing, Solaimanian and Kennedy (1998) reported the surface treatment needs to be constructed properly before microsurfacing is applied, and the problems in the surface treatment cannot be fixed with microsurfacing. They also indicated that the bond between the surface treatment and underlying base is especially important to avoid failures such as shoving of the pavement surface. The performance of an AST depends on a number of factors including the following:

- Appropriateness of a surface treatment for the project
- Contractor expertise and equipment used
- Plan notes and specifications
- Construction techniques
- Climatic conditions during construction
- Materials used
- Bond between base course and surface treatment
- Inspection procedures

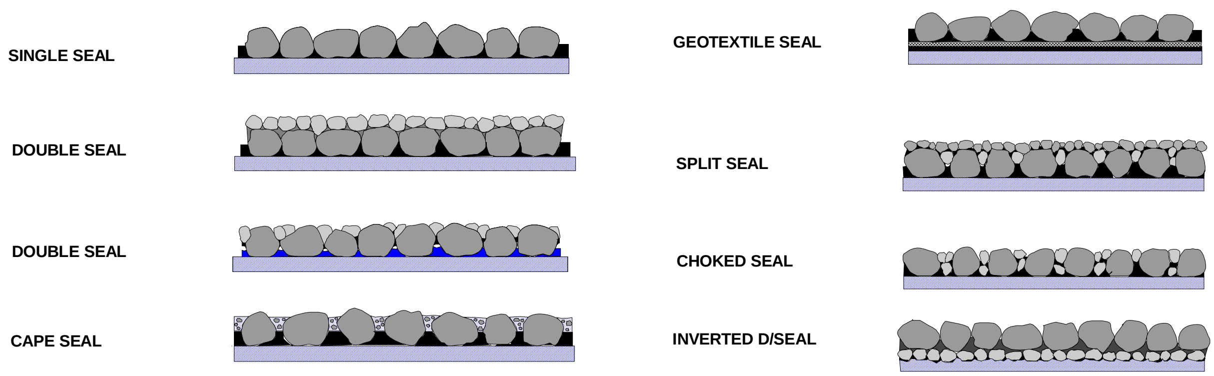

Figure 2.4 Some Surface Treatments Typically Used in South Africa (South Africa DOT 1998)

The bond between the surface treatment and the base course is arguably the most important factor that influences AST performance. Lack of bonding may be due to a number of factors including base material, base preparation, dust on a finished base surface, moisture in the base, temperature at the time of asphalt application and the binder type (McLeod 1960). In many instances, highway agencies use prime coats to act as a buffer between the base course and the surface treatment binder. The benefits accrued from the use of a prime coat may depend on the specifics of a particular project. When properly applied, prime coats can result in improved pavement performance (Ishai and Livneh 1984). The functions of the prime coat, in addition to improving the bond between base and surface treatment binder, may include the following:

- Seal the pores on the surface of base course
- Strengthen the surface of base course near its surface
- Waterproof the top of base course
- Deal with the surface dust

Chapter 3

Constructability Review Method

3.1 Background

In addition to the factors indicated above, many others can significantly influence the performance of a surface treatment. Many practitioners involved in surface treatment and seal coat work consider them to be more of an “art” than a science. Such reflections give indications of the strong influence construction practices have on the performance of surface treatments. A large body of research has already been done on various technical aspects of surface treatment materials and their properties. However, a very good understanding of the “physics” of the problem des not always translate to a satisfactory surface treatment because the field personnel directly involved in construction and inspection are routinely called upon to make pivotal, often subjective decisions that may have a long-lasting effect on the performance of the surface treatment. Success in making such critical decisions requires sound technical judgment and a wealth of experience under local conditions. Therefore, the practice of producing high quality surface treatments requires a good training program for the inexperienced practitioner, and a continuing education program for the seasoned practitioner to keep up with the latest technologies and materials.

A sound specification is a prerequisite to producing a good quality surface treatment, but that alone cannot ensure consistent quality in a construction process. Field personnel who must both apply and enforce the terms of the specification must be trained to recognize good and bad construction procedures. More importantly, they must fully understand the capabilities of equipment used in the industry to complete projects. Seemingly insignificant details such as the moisture content of a finished base, and the amount of dust accumulated on the base surface can alert the contractor to remedy the problem on the spot and make the difference between a successful surface treatment and one that fails due to insufficient boding between the asphalt and the finished base. Thus, the primary focus of this project will be to identify construction practices that consistently produce good surface treatments, and create a training program for TxDOT practitioners who are responsible for the execution, inspection, and acceptance of surface treatment projects.

3.2 Process

The methodology to be used for this purpose is a formal constructability review of the surface treatment construction process, similar to the method adopted in TxDOT research project 0-1787: *Seal Coat Constructability Review* (Senadheera.et al. 1999). Constructability is a term of art which has come to encompass a detailed review of design drawings, specifications, and construction processes by a highly experienced construction engineer before a project is put out for bids. It is defined as "the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives" (CII, 1986). The purpose of the constructability review is to identify the following five items:

- Design errors, both material selection and dimensional

- Ambiguous specifications
- Project features which will be difficult or exceedingly costly to construct as designed
- Project features which exceed the capability of the industry to properly build
- Project features which are difficult to interpret and will be hard to accurately bid

The researchers picked apart, piece by piece, the surface treatment process from planning to construction completion looking for those portions of the processes that are inherently variable and difficult to replicate in the field. The performance of a surface treatment is often a function of the following broadly classified factors:

- Appropriate project selection
- Quality of design
- Quality and consistency of construction
- Quality and consistency of materials
- Environmental conditions
- Traffic conditions

The study focused primarily on construction and materials. These are the two factors that show the most promise for control through better training of field personnel. The quality of a surface treatment or seal coat project's performance is influenced by at least eight construction process variables (McLeod, 1960):

- Preparation of the surface of base layer
- Uniform distribution of binder
- Time between applying binder and aggregate application
- Time between the application of successive treatments
- Material variation
- Compaction method and duration
- Embedment of aggregate
- Climatic conditions prior to, during and after construction
- Interval between completion and opening to traffic

As a part of this constructability review, a vast volume of research material was collected. During the literature review and state-of-practice review of this research, researchers contacted state DOTs and also reviewed information from several countries. The state-of-practice review focused primarily on communicating with surface treatment practitioners from other highway agencies.

The researchers made attempts to contact all 50 states to obtain information on their surface treatment practices. Information requested from other state DOTs was not nearly as extensive as that of TxDOT districts. Repeated attempts to obtain the required information resulted in only 28 states responding to the request. Appendix A presents the questionnaire that was used when interviewing other State DOTs.

Six of the 28 states indicated extensive use of surface treatments directly on base courses. Three other states indicated limited use of surface treatments and 19 states do not use surface treatments directly on base as a general practice.

The researchers also investigated surface treatment practices used in other countries. It was found that surface treatments (on base) are used by many countries worldwide. South Africa, Australia and New Zealand were three countries that showed extensive surface treatment use in their highway networks.

Chapter 4

District Interviews

4.1 Background

The research team visited and interviewed surface treatment practitioners from all twenty-five TxDOT districts. The district constructability review consisted of the following two phases.

- A face-to-face interview on the subject of surface treatments (constructed on base) with a team of personnel assembled by each district
- Visits to surface treatment construction projects

The face-to-face district interview was guided by a questionnaire consisting of 83 questions that covered topics related to surface treatments ranging from project selection to continuous improvement. A copy of this questionnaire is included in Appendix B of this report.

The surface treatment process can be broken down into the following three parts. The remainder of this chapter is structured based on this sequence of activities.

- Design
- Construction
- Performance

During district interview visits, the researchers requested for the latest general notes used by each district in surface treatment projects. A selected list of general notes is presented in Appendix C of this report. A surface treatment practices profile was also prepared for each district based on the findings from the interviews, and a summary of that profile is presented in Appendix D. A variety of surface treatment material application rates are used by each district. A summary of these rates are presented in Appendix E of this report.

4.2 Design of Surface Treatments

The design process of a surface treatment is comprised of the following steps.

- Project selection
- Design of the prime coat method
- Design of the surface treatment

The statewide constructability review revealed the 2-course surface treatments (2-CST) is by far the most popular surface treatment in the state, used by 18 districts. The underseal is used by nine districts. Three districts use 3-course surface treatments. In some of these districts, a 1-course ST is applied late in the fall, followed by a 3-CST during the next asphalt season, resulting in a 4-course surface treatment. One district indicated that in a few instances, they have been able to use a 1-CST for an extended period of time in roadways with a very low traffic volume. The statewide use of surface treatment types is illustrated in Figure 4.1 below.

It is very important that appropriate projects are selected for surface treatment work. A number of factors are considered in the project selection process and these factors are discussed in the next few pages. TxDOT districts use a number of criteria to decide if a surface treatment wearing surface is to be used for a pavement construction project. The top nine such criteria identified by districts are listed below. The number in parenthesis indicates the number of districts that consider that particular criterion in surface treatment project selection decisions.

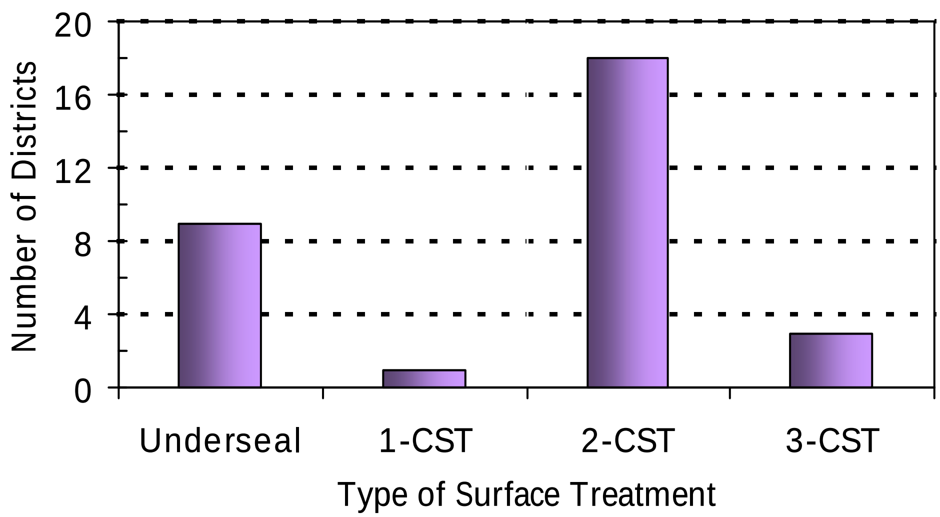

Figure 4.1 Use of Different Surface Treatment Types by TxDOT Districts

- ADT of highway (19)
- Highway section location (10)
- Percent trucks (8)
- Cost (8)
- Highway classification (6)
- Existing pavement type and condition (4)
- Traffic control plan (3)
- Presence of turning traffic (2)

The Average Daily Traffic (ADT) is the most widely used criterion, and it is used by 19 districts to identify projects suitable for surface treatments. This is followed by, in the order of decreasing use, highway location (urban or rural), percent trucks, cost of surface treatment (and its competing wearing courses) and the highway classification. Less often used project election criteria included the nature of traffic control plan needed, existing pavement structure, what's around the pavement section and the presence of turning traffic.

Traffic level is the most often cited factor in the decision making process. Figure 4.2 shows the breakdown of statewide percent roadbed miles by ADT group. It can be seen that 43 percent of roadbed miles have traffic levels less than 1000 ADT, and these are prime candidates to use surface treatments as a wearing course. District responses suggest that surface treatment wearing courses can be successfully used in highways with ADT levels up to 5000, and in a few instances there has been success with ADT levels up to 12000. However, increasing traffic levels also brings to the forefront other factors that may significantly influence surface treatment decisions. Some of these factors sill be discussed in the following sections of this chapter. Figure 4.3 shows the percent roadbed miles less than 1000 ADT for each of district in the state. This chart clearly highlights the districts that either have or may become significant users of surface treatment wearing courses.

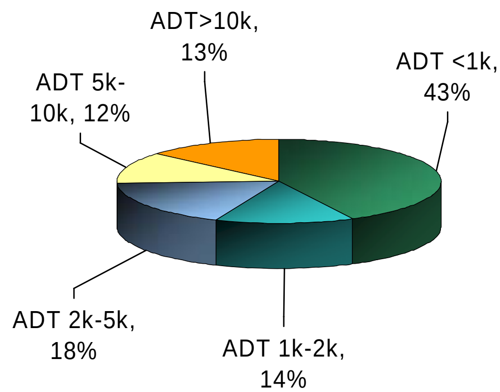

Figure 4.2 Breakdown of Percent Roadbed Miles by Traffic Level (ADT group)

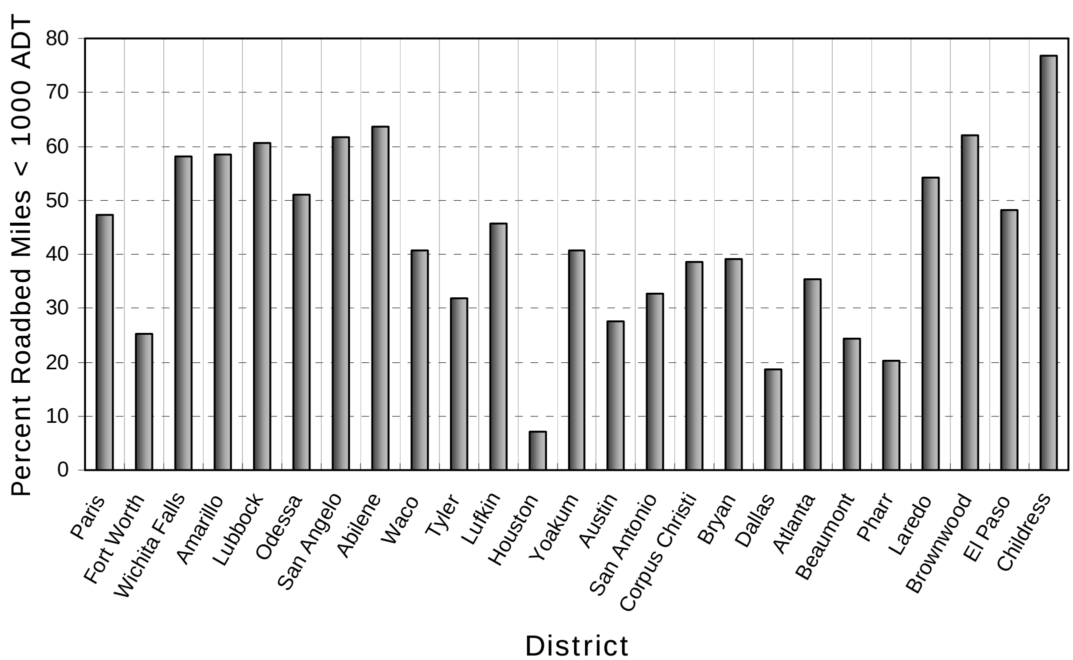

Figure 4.3 Percent Roadbed Miles With Traffic Less Than 1000 ADT

The next most often cited criterion that influences surface treatment selection is the location of highway. Most highways with surface treatment wearing courses are located in rural areas. This is a consequence of high traffic levels and concerns of road noise from surface treatments in populated areas. Twenty districts indicated that roadway noise is not a significant criterion when surface treatment is considered as a wearing course. However, several of the twenty districts did indicate that it is something they keep in mind particularly if the roadway is in an urban area. Three districts indicated that they do consider roadway noise in the decision to use a surface treatment. The two remaining districts did not use surface treatment as a wearing course.

Pavements constructed on 'moving' subgrades such as expansive soils, have a very high likelihood of cracking (See illustration in Figure 4.4). Design of the pavement structure on such subgrades would require a very thick asphalt concrete layer which may not be cost effective for roads with low traffic levels. Even with such a layer, the pavement is likely to crack prematurely without expensive mitigation methods to control soil movement. A surface treatment wearing course that uses a binder with low susceptibility to cracking can be a candidate for such projects. If HMAC must be used, a surface treatment underseal could be a viable option.

Figure 4.4 Severe Cracking of Surface Course in a Pavement Built on Expansive Soil

The next topic in the design process is the prime coat. It includes the selection of an appropriate prime coat method, selection of a binder type and an application rate. The design of the prime coat is done with serious consideration given to its constructability. All TxDOT districts that use surface treatments either as a wearing course or as an underseal use prime coat. The following section provides an introduction to the prime coats used by districts.

The prime coat plays a very important role in pavement structures. Its primary benefit is the facilitation of bond between the surface treatment and the base layer. The binders used in the surface treatment courses need to be strong and durable. Such binders do not have the low viscosity needed to penetrate the base layer and grip it, to prevent it from debonding due to shear stresses exerted by traffic and other factors. A prime coat which uses a low viscosity binder can act as an intermediary between the surface treatment binder and the base. The gripping effect of the prime coat onto the base strengthens the base layer by providing more cohesion to the top of the base.

There is usually a time lag between the completion of base layer construction and the application of surface treatment. A well-applied prime coat can protect the base layer from adverse weather conditions and from wear due to construction and regular traffic until the surface treatment is applied. This is particularly useful in situations where surface treatments are constructed under traffic with no satisfactory method of traffic control. It can also either prevent or slow down the formation of dust on the surface that will have a serious negative impact on the bonding of binder to base.

The penetration of the prime coat into base is very important to get the maximum benefit from the prime coat. The amount of penetration would depend on a number of factors including the prime coating method, prime coat binder, base material, base finishing technique and the porosity of the base course. Typical penetration of a sprayed cutback prime could be in the range of 1/8-3/8 inches. Figure 4.5 shows a schematic of prime coat penetration into flexible base, with the picture in the inset showing penetration of an MC-30 prime for a limestone base specimen prepared for this research at Texas Tech. The picture shows a saw-cut face of the specimen to expose the prime-coat penetration depth.

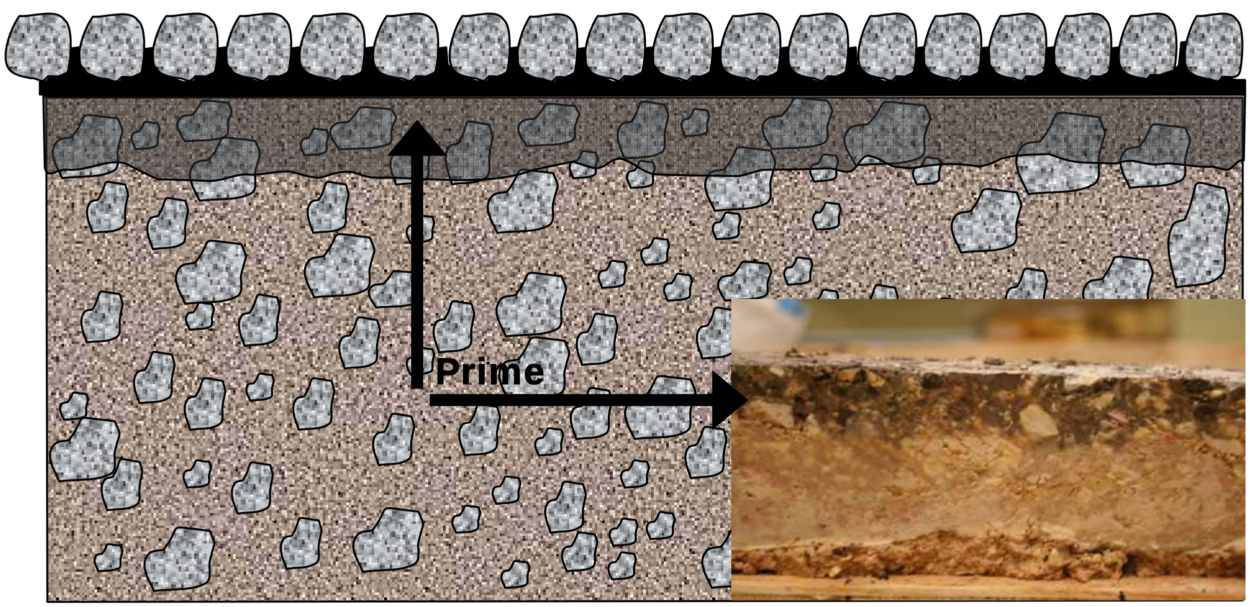

Figure 4.5 Schematic of Prime Coat Penetration into Base

At least four different prime coat types are used by TxDOT districts. Figure 4.6 shows a typical cutback prime coat sprayed using an asphalt distributor. The most commonly used spray prime coat binders are MC-30, AE-P and RC-250. The typical spray prime binder application rate is 0.2 gallon persquare yard, which may be adjusted depending on the tightness of base finish and if construction traffic has to be allowed on the primed surface. When construction of a spray prime coat is done under traffic, blotting sand may be spread on the prime coat binder within minutes after the binder is sprayed, and traffic can be allowed on the primed base within a fraction of an hour.

Figure 4.6 Sprayed Prime Coat on Limestone Base

Figure 4.7 shows a worked-in (sometimes referred to as cut-in) prime coat application where a diluted emulsified asphalt is sprayed on the finished base, which is then covered with a thin coating of fine base material dust by working the windrow with the motor grader. This process is usually repeated 2-3 times to get a total emulsion application rate of 0.2 gallon per square yard. The emulsions commonly used for this purpose are SS-1, CSS-1h and MS-2. This leaves an asphalt-sand layer on the finished base that is approximately 1/8 in. thick (see inset).

Figure 4.7 Application of Worked-In (Cut-In) Prime on Limestone Base

Figure 4.8 shows a covered (or inverted) prime applied on the finished base. This covered prime is similar to a course in the surface treatment where RC-250 cutback is first applied on the finished base, which is covered by spreading Grade 5 rock. This ‘priming’ technique is particularly useful when traffic must be allowed on the primed surface before the other half of the roadway is primed. This type of a prime can provide 2-3 months of satisfactory service as a very temporary wearing course under favorable traffic conditions including little or no turning traffic or heavy traffic.

Figure 4.8 Covered (Or Inverted) Prime Using RC-250 and Grade 5 Rock

The type of prime coat not shown in these pictures and videos is the “mixed-in prime”. This is when the base density is achieved and the base is completed up to the blue-tops, the top 2-3 inches of base is remixed with a diluted emulsion and then re-compacted. It must be mentioned that there is some ambiguity in the way terms such as “Cut-in”, “Worked-in” and “Mixed-in” are used to describe the prime coat. In this report, the authors have made an attempt to consistently use the following terminology:

- ‘Cut-in’ or ‘Worked-in’ prime essentially means when the prime coat binder, diluted emulsified asphalt, is sprayed on the finished base and the base material windrow is worked back and forth to create a thin sand-asphalt layer that acts as the prime coat.
- A mixed-in prime is where the top 2-3 inches of base is remixed with diluted emulsion and then re-compacted.

The third and final step in the design process is the design of the surface treatment itself. This involves the decision on the number of surface treatment courses (including their construction sequence), the selection of aggregate type and grade, selection of binder type and grade and the design of material application rates. In many situations, a one-course surface treatment is applied in late fall, which is used as a temporary wearing surface for several months until the next warm weather season arrives when the subsequent course(s) are applied. If a covered prime

– a single course with grade 5 aggregate – is applied, the service life one can expect to get as a temporary wearing course may be no more than three months.

The aggregate rate used for a surface treatment course is an important part of the surface treatment rate design, and it is often the first item designed. The general guideline is to leave sufficient room (i.e. 15-25% in plan view) between rock particles so that they can 'wiggle' and settle to the most stable position when rolled. A 'Board Test' is used by some districts to help determine the rock rate. The board test uses a 1 yard by 1 yard board on which aggregate is spread to the required coverage level, and then determines the application rate by using the calculation method outlined in the TxDOT Seal Coat and Surface Treatment Manual (2004). Typically, a correction to the rock rate is determined using the board test to suit field conditions. The key is to avoid over-application of stone. If too much rock is applied, rock particles may not be seated in a stable manner, and result in rock loss due to lack of embedment.

Table 4.1 shows the aggregate gradations commonly used by districts in different courses of a surface treatment. Grade 4 aggregate is the most common for 1-CST (or underseals). For 2-CST, the most common aggregate grade in the first course is Grade 3, and for the second course, it is Grade 4. In addition to the grades indicated for 3-CST, one district is using Grade 2 rock in the first course.

Table 4.1 Summary of Aggregate Grades Used in Surface Treatment Courses

ST Type	Course	No. of Districts		
		Grade 3 Aggregate	Grade 4 Aggregate	Grade 5 Aggregate
1CST		4	8	2
2CST	1st Course	19	9	1
	2nd Course	3	19	1
3CST	1st Course*	4	4	1
	2nd Course	4	2	0
	3rd Course	1	4	1

* - One district uses Grade 2 rock in the first course

Figure 4.9 shows the use of aggregate grade combinations for two-course surface treatments, which has the widest use in the state. The most commonly used combination is Grade 3 in the first course followed by Grade 4 in the second course. Similar combinations for three-course surface treatments are shown in Table 4.2.

Table 4.2 Use Of Aggregate Grades By Districts In Three-Course Surface Treatments

Aggregate Grade Sequence Bottom-Middle-Top	No. of Districts
2 – 3 – 4	1
3 – 3 – 4	1
3 – 3 – 5	1
3 – 4 – 4	1
3 – 4 – 5	1
4 – 4 - 5	1

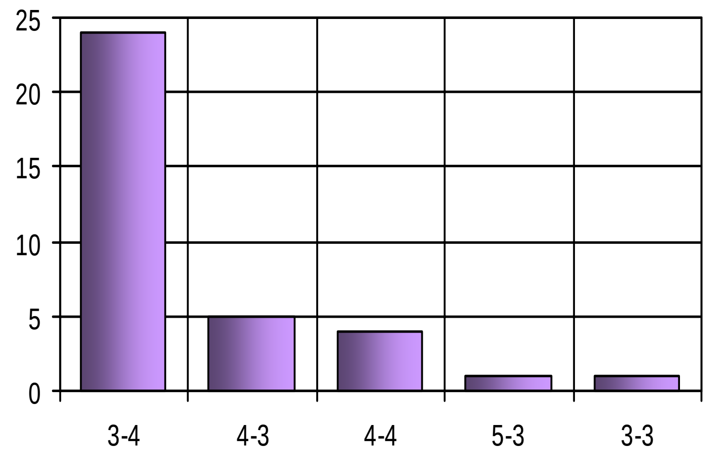

Figure 4.9 Use Of Aggregate Grades By Districts In Two-Course Surface Treatments

A variety of binder types and grades are used by districts in surface treatment courses. These binders can be classified into those used in warm weather and those used in cool weather. The commonly used warm weather asphalts in surface treatment construction are listed below. The number in parenthesis indicates the number of districts that use the binder grade. AC-20 5TR is the most commonly used warm weather ST binder, followed by AC-15P and AC-5.

- AC-20 5TR (14)
- AC-15P (6)
- AC-5 (3)
- AC-10+Ltx (2)
- AC-5+Ltx (2)
- AC-15 XP (2)
- CRS-2P (2)

The commonly used cool weather asphalts used by districts in surface treatment construction are listed below. The emulsion grade CRS-1P is the most commonly used cool weather ST binder, followed by AC-5 and AC-12 5TR.

- CRS-1P (14)
- AC-5 (6)
- AC-12 5TR (3)
- AC 10+Ltx, (2)
- AC 5+Ltx, (2)
- CRS 2P, (2)
- MC-2400, (2)
- MC-3000, (2)

The design of surface treatment binder rates begins with seal coat binder rate design. Districts design seal coat binder rate in several ways. The most commonly used method is based on the aggregate type and grade, aggregate rate, % embedment needed and traffic level (ADT and % trucks). The procedure to perform the binder rate design is outlined in the TxDOT Seal Coat and Surface Treatment Manual of 2004. Binder rate designed in this manner is used in the preparation of plans.

Some districts determine the binder rate based on experience, but this approach is recommended only when sufficient experience is gained by the designer for the conditions under which the seal coat is used (i.e. binder grade, source, aggregate and traffic level). At the time of seal coat construction, the binder rate used in the plans are adjusted to suit field conditions including pavement surface condition, ADT, percent trucks and aggregate type/grade.

The binder rate design in seal coats is closely related to the percent embedment of aggregate into the binder. Typically, a 30% embedment is used for high traffic volume roads and a 40% embedment is recommended for low traffic roads. The percent embedment depends on the binder type and grade, aggregate type and grade and the traffic level. Generally, a higher % embedment is used when a larger rock is used, because more binder is needed to retain the aggregate. Since the asphalt binder is the most expensive item in a surface treatment, the strategy is to use the lowest quantity (i.e. application rate) of binder without allowing rock loss. If too much binder is used, the surface treatment may experience flushing and/or bleeding with time, creating maintenance problems.

Even though seal coat binder rate design can be used to guide the binder rate design for multiple-course surface treatments, some key adjustments must be made to account for the design and construction sequence of the surface treatment. If successive courses are applied quickly one after the other, allow for drain-down of binder (i.e. use a lighter rate for the lower course, and heavier for the upper course). This may be achieved by considering the existing surface to be highly textured (coarse). If an upper course is applied months later, use a heavier rate at the bottom and lighter at the top.

4.3 Construction of Surface Treatments

The next phase of the surface treatment system is the construction process. The ST construction process can be divided into the following five parts:

- Construction Management
- Base Finishing
- Prime Coat
- Surface Treatment Application
- Quality Control

The construction management process plays a very important role in the performance of surface treatment. In the next section, we summarize a few of the responses.

Much discussion has centered on the possibility of using specifications other than methods specifications for repetitive processes such as surface treatments. Districts were asked whether surface treatment projects were good candidates for performance-based or warranty specifications. Sixteen districts indicated that STs would be good candidates for such specifications, and many of them indicated that research is needed to explore ways to move in that direction. A warranty period of one year was considered by many to be appropriate. Eight districts indicated they don't think performance-based or warranty specifications are feasible for surface treatments due to likely obstacles to implementation. There seemed to be some overlap in thinking between those who responded as either "yes" or "no". The differences between them appear to be whether they think this is a feasible endeavor or not.

Surface treatments are generally a part of a larger contract that involves other construction elements. The researchers felt that in a constructability review, it would be important to know if surface treatment work is typically done by the prime contractor or a sub-contractor. Fourteen districts indicated a prime contractor does their ST work more than 70% of the time. Eight districts indicated a prime contractor does their ST work less than 40% of the time. Three districts indicated a prime contractor does the ST work 40-70% of the time.

Districts were asked about the problems they commonly experienced with contractors. The issues most often mentioned were;

- Contractor's expertise, both in general and that of equipment operators
- Contractor's work load. i.e. several contracts handled by the contractor result in some districts getting a sub-standard workforce (B-Team)
- Timely availability of materials, particularly aggregates
- Finish quality of the surface treatment
- Poor condition of contractor's equipment
- Contractors' inability to adhere to established asphalt rates

Other problem topics included contractor not mobilizing on time, work-zone safety issues and contractor unfamiliarity with materials used in surface treatment (the binder in particular).

Finishing of the base is extremely important to the bonding of surface treatment to base. In this section, several aspects related to base finishing are discussed. The base materials most commonly used with surface treatments are listed below in the order of decreasing use.

- Limestone
- Caliche
- Iron Ore Gravel
- Gravel
- Fly Ash Stabilized Base
- Cement Treated Base
- Asphalt Stabilized Base

Limestone is by far the most common, with fourteen districts using them. The next most common base material is caliche with six districts using it. Of the stabilized bases, cement and fly ash stabilized bases are most common. Asphalt stabilized bases were not included in this research because of its unique interaction with an underseal compared to other stabilized and flexible base materials.

Both the pneumatic roller and the steel-wheel roller are used to finish the base. The pneumatic roller is used first, followed by the steel-wheel roller. The kneading action of the pneumatic roller helps the initial rolling to even-out the bladed surface. The steel-wheel roller helps get an even and less rocky surface before the prime coat is applied.

TxDOT districts use three base finishing methods.

- Slush rolling
- Blade and roll
- Trimming

Slush rolling is the most common method with twelve districts using it. However, this base finishing technique varies among districts depending on the amount of water used. Some districts use little water, whereas others use a lot of water.

The blade-and-roll technique is the next most common technique with seven districts using it. The trimming technique uses the subgrade trimmer used by districts to finish the base. Excess base is used to compact the base 1-2 inches above the blue-top level, and then the trimmer is used to cut it down to the required finish level. The trimmed surface is rolled next, which eliminates the need to do slush rolling. The excess material is used in other miscellaneous construction operations.

One of the most critical elements of surface treatment construction is the priming of the base. The prime coat helps the surface treatment binder adhere to the base course by penetrating and sticking to the base. In this section, some findings on the construction of the prime coat are presented.

Several conditions may be identified as "optimum" for a base to have before a prime coat is applied. Under these conditions, the base should be

- Reasonably smooth
- Reasonably porous

- Not dusty
- Structurally strong

The base should not have standing dust when the prime is applied, and the finished base is broomed to remove the dust. However, brooming has to be done carefully not to disturb the base layer particles.

These “optimum’ conditions for the base may not necessarily be “compatible” with each other. For example, a “reasonably smooth” finished base is required to achieve a desirable ride quality in the finished surface treatment. However, an overly smooth base can prevent the prime coat binder from penetrating into the base and achieve a good bond between the base and the prime. Therefore, some porosity (fine or small pores) is needed for this bond to be developed. The desirable pore size is determined by the prime coat binder and its wet-ability of the base material. In many instances, slush rolling is used to obtain a smooth finished base surface. However, unless care is taken to control the ‘slushing’ water content, excess water can weaken the base significantly by lowering its density.

The timing of the prime coat application is of great significance in achieving a good bond with the base. The moisture content in the base must be “just right” for the prime to penetrate into the base. The 2004 TxDOT Standard Specification Item 247.4E stipulates “Cure the finished section until the moisture content is at least 2 percentage points below optimum or as directed before applying the next successive course or prime coat.” Therefore, base must be allowed to dry to some extent after finishing before the prime coat is applied. However, too dry a base can generate a fine dust coating that inhibits the bonding of the prime coat to the base. This can result in freckling of the binder that leaves uncoated open spots on the base where surface treatment binder may not bond well. Therefore, ‘skeeting’, which involves a light sprinkling of water on an overly dry surface to make it more suitable to apply the prime coat binder, is done. This picture shows that the shaded areas, which are common in east Texas, dry slower than non-shaded areas. If the prime coat is applied under these conditions, it may not stick to the base and will eventually delaminate.

The worked-in prime coat layer is strong enough to run traffic for several days when applied under the ‘right’ circumstances, which are given below:

- Prime applied under appropriate base moisture condition
- No traffic allowed on the primed surface for at least one day
- Reduced-speed traffic allowed for the first few days, particularly at intersection approaches

When a “worked-in” prime is used and if traffic is allowed on the primed base for several days, it is recommended that there are drainage paths for storm water.

The first decision a TxDOT project manager or inspector must make with regard to surface treatment application is whether the primed pavement is ready for a surface treatment application. The researchers asked the districts how long they would wait between priming and applying the surface treatment. The responses varied from the same day to 10 days. This time lag between the prime and the surface treatment depends on the following factors:

- Type and grade of binder (i.e. provide time for cutback volatiles to evaporate and for emulsions to cure and penetrate)
- Type of base (allow prime to penetrate)
- Contractor's construction schedule
- Work-zone management

However, the following general practices emerged from the survey:

- Wait at least 3 days when the prime coat binder is an emulsion.
- Wait at least 7 days if the prime coat binder is a cutback.

One of the most often discussed issues in surface treatment and seal coat construction is the timing when aggregate is applied on the binder. For both hot asphalt and emulsion, the answer would be an enthusiastic 'as-soon-as-possible'. The district responses to this question did suggest some differences in opinion, but most districts appear to put the aggregate as soon as practically possible.

The district response to the question 'What should the minimum time lag be between first and second courses of a multiple-course surface treatment (MCST) when the binder is AC?' varied from 1 day to 14 days (and more). The variation in responses appeared to be based on the district's belief of whether it was more desirable to allow traffic on the first course for some time before the second course is applied. There were a few districts that applied the first and second courses the same day.

The response to the same question for emulsified asphalt ranged from 1 day to several months. The variation in responses appeared to be based on the following factors.

- Allow sufficient time for emulsion in the first course to cure, and the opinions on this vary from 1 to 7 days.
- Use the emulsion in the first course toward the latter part of the asphalt season or during winter to obtain several months of service so that the next course could be applied during the asphalt season using AC binder

For cutback asphalts, the responses depended on the type of "first" course used. Several districts use a 'covered (or 'inverted') prime, which can be considered as a first course in a ST. In this case, RC-250 cutback asphalt was used as the binder, and 7 days appear to be sufficient for the volatiles to escape the rapid curing RC-250. In the case of cutback surface treatment binders such as MC-2400 or MC-3000, a minimum of 90 days is recommended before the second course is applied.

Quality control is arguably the most important part of any construction process. It encompasses many aspects of construction including materials used in construction, conformance to plans and specifications and workmanship. Due to the 'low-bid' contract method adopted by TxDOT, the inspector has to be mindful about the contractor's expertise and the skill set, particularly if the inspector has no prior experience working with the contractor. In such a situation, certain key adjustments must be made in the inspection of surface treatment process.

The chief inspector in a construction project must provide effective leadership to the inspection crew as well as to the construction project itself. It is important that the construction crew establish an effective working relationship with the contractor's personnel. The first step in achieving a good rapport with the contractor is to establish effective lines of communication between the inspection crew and the contractor's crew. This will minimize miscommunication at the construction site between the two parties.

During district interviews, researchers asked TxDOT district interview subjects for general comments regarding the quality control process., and the following comments were often repeated by districts.

- Inspection forces are dwindling
- TxDOT is losing a lot of experience in inspection staff
- Some surface treatment inspectors handle multiple jobs, and therefore some project tasks cannot be inspected effectively
- Surface treatment training is needed for new inspector hires
- In many cases, surface treatment work is contractor-driven primarily due to lack of inspector expertise

Over the past several years, the Department has seen a significant depletion of the inspection pool, particularly the experienced inspectors. This has placed a significant burden on the remaining inspectors, and as a result they are often asked to handle several concurrent jobs. Therefore these inspectors must manage their time effectively among different projects, or within various work locations within one project to ensure that all key work tasks are inspected in a timely and effective manner.

Also, in some situations the Department is compelled to place newly hired inspectors with limited training in positions of authority, which may put them in 'difficult-to-handle' situations. This can also cause problems in a project. The inspector is the client's representative at the project site. Therefore, he/she has to establish the client's authority at the construction site. If the inspector is unable to resolve certain situations or disputes at site, the inspector has to make the judgment whether or not to call the Engineer to resolve the issue. It is important for the inspector to recognize that the contractor is a partner in a construction project, and that it is reasonable to expect them to make a decent return on their investment in the business. Therefore, the inspector must make every effort to resolve questions or issues that arise in a timely manner, so that the contractor can make satisfactory progress.

Often, contractors have a wealth of experience in the construction work they do. Therefore, it is in the client's best interest to effectively utilize such expertise to the benefit of the project. Allowing contractors some freedom to handle certain construction situations on which they are experts will facilitate a positive working relationship between the inspector and the contractor.

A list of general construction inspection tasks to be performed by the inspector is shown below.

- Get contractor to conform to specs/plan notes
- Workmanship
  - General workmanship
  - Expertise of personnel such as equipment operators
- Materials
  - Quality (stockpile evaluation of aggregate, etc.)
  - Application of proper rates
- Equipment calibration
- Finishing of Base
  - Use of an effective method
  - Finish quality
- Prime Coat
  - Timing of Prime (water content in base)
  - Prime coat method
  - Prime coat binder rate
  - Precautions (cutouts, keeping traffic off, reduced speed traffic)
- Surface Treatment
  - When to apply first course
  - Timing of rock application
  - Rolling (primarily for hot asphalt)
  - Control of loose rock
- Work-Zone control
  - Safety
  - Access to property
- Job Acceptance
  - Execute previously agreed repair policy
  - Finish quality of surface treatment

It is the inspector's duty to ensure that the contractor is performing the work in conformity with the specifications and plan notes that are a part of the construction agreement. The general workmanship of the contractor must be in accordance with reasonable norms. Furthermore, the inspector has to ensure that contractor personnel who operate key equipment have the requisite skills.

The materials used in a construction project are purchased from approved sources, transported and stored at the construction site by the contractor. The inspector must ensure that such materials meet the specifications which are a part of the construction agreement before they are used on the project. The inspector must ensure that these materials are used in accordance with the design. In a surface treatment construction project, this applies to the material application rates for both asphalt binder and the aggregate. The inspection of aggregate stockpiles includes checking the dustiness of aggregate. If the aggregate is too dusty, the inspector must ensure that the contractor wet the stockpiles to wash down the aggregates. In order to facilitate drainage of wash water, the stockpiles must be located in a location that will facilitate such drainage.

The final general inspection item in a construction project is the calibration of equipment. In a surface treatment project, this involves the verification of asphalt distributor application rates (from nozzles), temperature gage in the asphalt distributor, and the aggregate spreading rates (from spreader gates). The frequency of such calibrations is generally specified in the plans and specifications.

Two inspection tasks that are unique to the surface treatment construction process are the finishing of base and the prime coat. These two processes are often related to each other. The base finishing method is a very important part of the surface treatment construction process. This <u>does not</u> include the construction of base and the achievement of required density. Generally, the base is constructed for a certain roadway length (often referred to as the <u>construction land</u>) at one time, before the base finishing and prime coat of that section is undertaken.

The use of an effective method to finish the base is of utmost importance. The base finishing method has to be done without compromising the quality of the base, and it has to be compatible with the prime coating method. It is also important to consider the constructability of the activity, particularly if the contractor has the expertise to do the base finishing work as stipulated in the plans. The finish quality of the base must be checked by the inspector, because it dictates the final ride quality of the surface treatment. It would be a much easier to ask the contractor to refinish the base rather than having to ask the whole surface treatment to be re-done. Traditionally, most inspectors conduct a “seat of the pants” test to ensure the quality of base finish. However, a few districts (ATL, BWD, ODA, SJT, YKM in particular) are using the International Roughness Index (IRI) calculated using the profiler measurements to check the finish quality of the finished (or primed) base. Several other districts are also taking a serious look at this method. This provides inspectors with a much easier task of evaluating the base finish, but it is important to ensure that the contractor is using appropriate methods to achieve the base finish.

The prime coating process also involves several key steps that require inspector involvement, and the most important of them is checking the readiness of the finished base to be prime coated. The attainment of the right moisture content of the base is of utmost importance. Most experienced inspectors may be able to check the moisture content using simple techniques such as looking at the base surface and by digging into the base at several locations. However, it is recommended that a moisture content measurement be made to verify the state. The new 2004 TxDOT specification recommends a moisture content of base optimum moisture content (OMC) minus 2% to be optimum before prime coating. Having too much water in the base may prevent effective bonding of the prime, and can trap too much moisture in the base making it weaker (low modulus) that it was designed for. Too much drying of the base generally creates a thin coating of dust that will also reduce the effectiveness of bonding. In such a situation, a light spray of water (skeeting) can help alleviate the situation.

The other key items in the inspection of the prime coating process are the use of an appropriate prime coat binder rate and the prime coating technique itself. The inspector must ensure that the contractor takes all possible precautions to protect the prime coat. These may include the use of cutouts to prevent water-logging of the primed base (when base material windrows are used in the priming process) and to minimize traffic on the primed base which may wear the prime. Wearing of the prime can prevent the surface treatment binder from bonding to the base.

Once the prime coat is applied on the base, the next step is to apply the first course of the surface treatment. The inspector has to ensure that the contractor applies the surface treatment course at the optimum time. If traffic has to be put on the primed base, the surface treatment must be applied as soon as possible to prevent potential damage to the primed base. However, the inspector must ensure that the contractor allows sufficient time for the prime to cure before the surface treatment is applied. If emulsified asphalt is used for the prime, it must be cured appropriately (all the water is evaporated). When cutback asphalt is used, all the volatiles must be evaporated from it, or the surface treatment will be weakened once applied. The surface treatment binder must be applied at the proper rate and temperature. The inspector must check the nozzle angles and the spray bar height to ensure proper binder rate application. The shots must be marked, and the distributor must be periodically strapped to ensure that the computer readings are accurate.

Aggregate (rock) must be applied as soon as possible for both hot asphalt and emulsified asphalt. The inspector must check the aggregate stockpiles for dust, and debris, and ensure that aggregate gradation is appropriate. In the case of precoated aggregate, proper precoating coverage must be ensured. The inspector must mark rock lands, and ensure that the loader operator loads trucks consistently so that proper application rate can be checked using rock lands. Rolling of the aggregate is very important to ensure that aggregate particles are seated on the pavement in their most stable position (lowest center of gravity). This will ensure that aggregates will maintain a satisfactory bond with the binder. The inspector must pay particular attention to the roller coverage of the surface treatment and if the specified number of roller passes is used. When surface treatment is done in the morning and later afternoon, particular attention must be made to the binder temperature, and the number of roller passes could be increased in such situations to ensure that design embedment is achieved.

Loose rock on the pavement can cause numerous problems to the traveling public as well as construction personnel. It is a safety hazard, and it may also contribute to windshield damage. On the other hand, having loose rock on the primed base can damage the prime (and the base), and timely removal of loose rock is very important. One way to reduce damage to prime due to loose rock is to shoot the surface treatment binder a little wide, and then to overlap it with the adjoining binder shot.

Almost all surface treatment construction projects require the contractor to effectively manage work zone traffic and access to nearby property. Safety of the traveling public and construction personnel during construction is of supreme importance, and therefore, the inspector must ensure that the contractor abides by the plans and specifications in this regard. The inspector should also check, on a daily basis, if continuous access is provided to personal and commercial property from the construction zone. When access to property has to be curtailed to allow construction activity to proceed, the inspector must ensure that the public is notified of such activity well in advance to minimize inconvenience.

Under current TxDOT specifications, the acceptance of the job after the completion of surface treatment construction is a key milestone. Once accepted, the roadway becomes the client's (TxDOT) responsibility, and therefore, the inspector must ensure that the job is accepted in good condition. The inspector must ensure the quality of a completed construction project is checked as per specifications. An important part of this process is checking the completed structure for any damage during construction. The inspector must ensure that such damage is repaired by the contractor as stipulated in the contract prior to the acceptance of the job by TxDOT.

4.4 Ride Quality of Surface Treatments

One of the hottest topics in surface treatment construction is the use of a ride quality specification to quantify its ride quality. A ride quality can be specified on either the finished base layer, the primed base or finished surface treatment. It can be used as a job acceptance criterion, and it can also be used to introduce bonus/penalty clauses to a contract. Several districts have already implemented specifications for this purpose. The Atlanta District is using a ride quality specification using IRI for finished base. The Yoakum District is using the special provision 247-011 for flexible base that call for a maximum IRI of 125 inches per mile for each wheel path on base primed with RC-250 cutback asphalt and Grade 5 rock. Brownwood, Odessa and San Angelo Districts are working together on a comprehensive ride quality specification that may one day lead to a bonus-penalty clause contract. Preliminary investigations by districts suggest that the following IRI criteria can be used with the available statewide contractor pool.

- 60-90 inches per mile on finished base
- 80-110 inches per mile on covered (or inverted) prime or first course of surface treatment

4.5 Performance of Surface Treatments

The next section of the surface treatment process is its performance aspects. Surface treatments have some unique performance characteristics, and in this section, surface treatment distresses, and how they are rectified, are discussed.

The following four distresses are associated with surface treatments. The number in parentheses indicates the number of districts that identified that distress as one they have encountered.

- Peeling of Prime (3)
- Peeling of ST (4)
- Bleeding/Flushing (22)
- Raveling/Rock Loss (20)

Even though bleeding and flushing are two different distresses, they are identified together due to similarities in the way they develop. These distresses can occur both in the short-term (during construction) and long-term (during performance of the surface treatment). Both these types of distresses are discussed in the next few slides.

Figure 4.10 shows a prime coat that peeled during brooming. Generally, a light brooming is done on the primed surface to remove any dust accumulated on it before the surface treatment binder is sprayed. In this case, the peeling of prime may have been due to the following two factors:

- Turning traffic at this location that exerts higher shear stresses on the primed base
- Shaded area may have contributed to the prime curing slowly

Traffic should only be allowed on the prime coated base when it is absolutely necessary. On projects such as the one shown in Figure 4.11, traffic was allowed on the prime coated base because it was an existing two-lane roadway. However, opening for traffic for too long, particularly when significant heavy traffic is present, can cause the prime coat to wear off and cause problems. In such situations, the surface treatment will not stick well in the area where the prime is worn out. Re-priming of the affected area must be done in these situations.

Figure 4.10 A Prime Coat That Peeled During Brooming

Figure 4.11 A Prime Coat Worn Out Due To Excessive Exposure To Traffic

When rainstorms occur on an exposed primed base that is open to traffic, both the prime and the base are likely to be damaged. This is particularly true when drainage paths are not allowed for storm water during construction (See Figure 4.12). Roadside base material windrows can create such situations. The inspector must ensure that when primed (or un-primed) base is opened to traffic, proper drainage channels are provided.

Figure 4.13 illustrates the damage caused to a prime coat because of loose rock on the primed base. In this case, loose bounced-off rock from the chip spreader can be the cause of prime coat damage when traffic on the primed base drives the loose rock into the base. Therefore, it is important to minimize the presence of loose rock on the primed base. One way to achieve this is by shooting the surface treatment binder about 6 inches wide, so that any bounced off-rock from the chip spreader can be retained. Since this extra width of asphalt is to the end of the distributor, it leaves a lighter asphalt coating, and it can be overlapped when the next lane is shot.

Figure 4.12 Damaged Prime Coat Due To Water-Logging

Figure 4.13 Damaged Prime Coat Due To Loose Rock

Figure 4.14 shows two examples of the pickup of the newly constructed prime and the first course of surface treatment due to construction traffic. This can be caused by sudden movement of tires in construction vehicles. It can also be caused by poor bonding between the base and the prime or between the prime and the surface treatment. In the case of Figure 4.14(a), it appears that the failure occurred between the base and the prime. Failed areas such as this one must be repaired quickly by the contractor. In Figure 4.14(b), the prime was applied on a cool and cloudy afternoon, and the ST was applied the next morning. The cause for the peeling appears to be the high level of moisture in the base, which did not allow the prime to stick to the top of the base.

(a) (b)

Figure 4.14 Peeling of Surface Treatment During Construction

Figure 4.15 shows the flushing and bleeding of asphalt in a surface treatment. Flushing of a surface treatment shows the loss of macro-texture in the pavement surface. Bleeding is when excess soft and sticky asphalt is present on the pavement surface, and it causes a loss of aggregate-tire contact. In Figure 4.15(a), the aggregate is flushed with the asphalt, and unlike in bleeding [Figure 4.15(b)], there is still some aggregate-tire contact remaining. Both flushing and bleeding are caused by aggregate particles driven into the soft pavement by traffic.
Bleeding is the advanced stage of the flushing distress which is illustrated in the next slide.

Figure 4.16 shows two pavements with surface treatment wearing courses losing some of their rock. This is also referred to as raveling. Rock loss generally occurs outside the wheel-paths because at these locations, traffic usually helps in the bonding of aggregate to the binder.

Loss of rock is typically an indication of one of the following:

- Incompatibility between the aggregate and the binder
- Insufficient binder to hold the rock
- Cold and/or wet weather too soon after the surface treatment
- Dusty aggregate
- Application of aggregate too late after binder is sprayed

- Application of surface treatment in cooler weather
- Insufficient rolling (particularly in the case of hot asphalt)

(a) (b)

Figure 4.15 (a) Flushing and (b) Bleeding in Asphalt Surface Treatments

Figure 4.16 Raveling (rock loss in surface treatments)

Figure 4.17 shows the “freckling” of the binder when the base is too dusty. In this project, an AC-5 “prime” was applied on a cement-treated limestone base. The base was significantly rough (uneven), which left some dust accumulated in the crevices of the base. Even though brooming was performed on this base, it did not remove the dust in the low spots. The binder, when applied on this base, did not stick to the areas where dust was present, and began to “freckle” within seconds after its application which left many exposed small areas in the base.

The following list identifies district practices on how to correct raveling (or rock loss) from a surface treatment. If done very early, a fog seal can slow down aggregate loss and may save a surface treatment. In most situations, if a significant amount of rock is lost, the section needs to be re-shot, either full-width or a strip.

- Fog Seal (13)
- Re-shoot (5)
- Strip Seal (2)

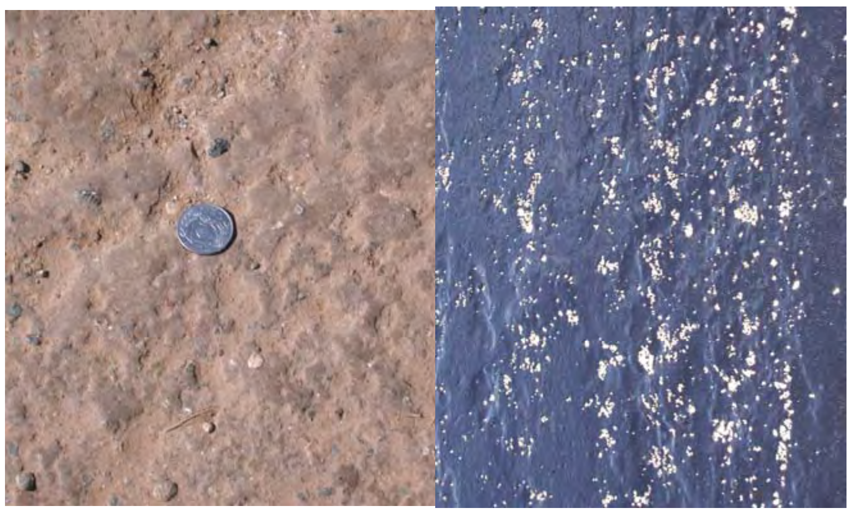

Figure 4.17 Freckling of Asphalt Applied on Dusty Base

Bleeding surface treatments often create headaches for maintenance personnel. Two ways to correct bleeding surface treatments are:

- Sprinkling of small aggregates (grade 5 or 6 rock, aka ice rock) on the bleeding area, which can provide only temporary relief. This is because the newly applied rock will also get pushed into the bleeding asphalt within days if the hot weather continues.
- A more effective remedy for bleeding asphalt is the spraying of lime water. Lime water is typically sprayed on a bleeding pavement in late morning on a very hot day before the hottest temperatures occur.

Lime water can provide relief to a bleeding pavement in 3 ways.

- The spraying of lime water cools the hot pavement
- Due to the white pigment left on the pavement by lime water, the pavement absorbs less heat
- Most importantly, lime reacts with asphalt to make it harder. This has the best chance of curing bleeding.

Chapter 5

Construction Project Visits

5.1 Overview

The district interviews were combined with visits to surface treatment construction projects to observe construction operations and to interview field personnel. Sixty-six projects were earmarked for possible site visits during construction, and the researchers were able to visit thirty-seven of them when construction work was in-progress. During each visit, data on the project including materials used, material application rates and the construction process were collected. Informal interviews were conducted with TxDOT field personnel (inspectors) and contractor personnel at the project site. The construction process was also recorded on digital pictures and video. Several other pavement sections were visited after the construction was completed. Figure 5.1 shows the statewide distribution of construction projects visited by researchers when surface treatment work was in-progress.

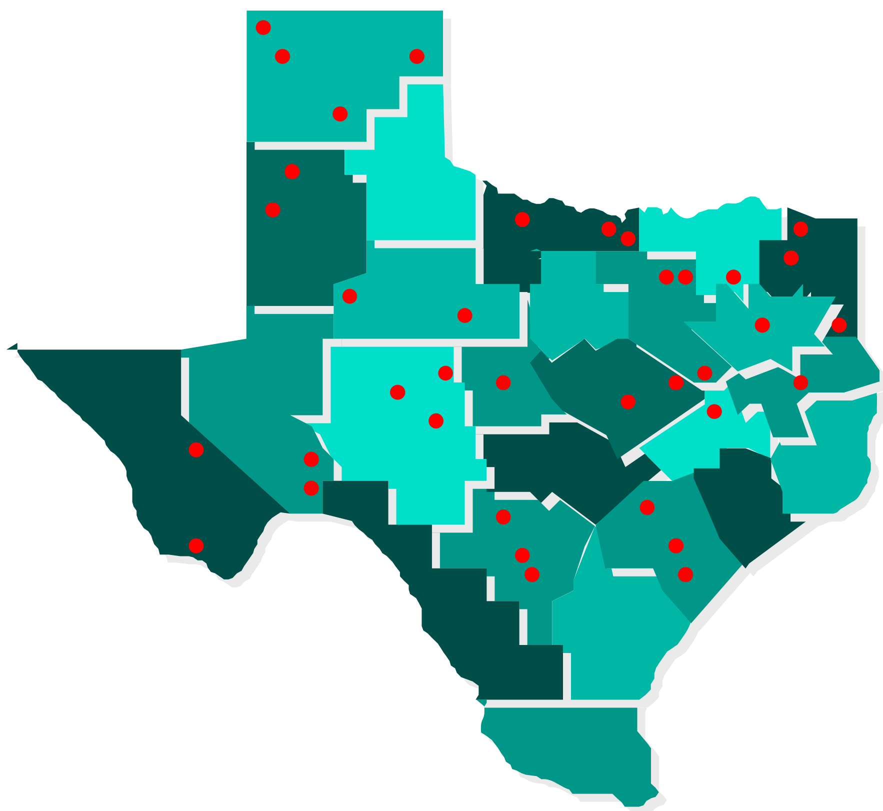

Figure 5.1 Locations of Surface Treatment Projects Visited by Researchers

Table 5.1 Summary of Surface Treatment Construction Projects Visited by Researchers

District	Project (County)	Remarks
ABL	FM 204 (Taylor) FM 1054 (Borden) FM 669 (Howard)	Contract Paving - 1st and 2nd courses of 2CST Jones Bros - LS base;AE-P prime; 1st of 2CST Price Construction
AMA	FM 1727 (Dallam) SH 33 (Hemphill) US 287 (Armstrong) US Hwy 87 (Dallam)	J. Lee Milligan - LS base finished using Trimmer Gilvin-Terrill - Finished base for MC-30 prime J. Lee Milligan - Trimmed LS base with AE-P J. Lee Milligan - Primed LS base with MC-30
ATL	FM 699 (Panola) US 259 (Cass) FM 576 (Bowie)	Pinto Const. - LS base finish; MC-30 prime; IRI DL Lennon - Iron Ore Gravel (IOG) base finish; SS-1 prime; underseal Widening - IOG base; MC-30 prime
AUS		
BMT		
BWD	FM 3064 (Brown) FM 2214 (Eastland)	Prater Equipment – Underseal Jay Mills Contracting
BRY	FM 489 (Freestone) PR 40 (Walker) SH 40 (Brazos) FM 2 (Grimes) SH 7 (Leon)	A.L. Helmcamp - LS base finish; inverted prime Ajax Equipment Glenn Fuqua Glenn Fuqua Young Contractors
CHS		
CRP		
DAL	FM 1394 (Navarro) FM 2194 (Collin) FM 75 (Collin)	Big Creek Construction - Limestone (LS) flex base installation; considering use of base laydown machine and premixed base & prime 2nd course of 2CST prior to HMAC overlay; evaluated 2 sections (6 and 12 months old) 2nd course of 2CST prior to HMAC overlay
ELP	FM 170 (Brewster) SH 17 (Jeff Davis)	Gilvin-Terrill - LS base treatment (full depth) finishing with MS-2; 1st and 2nd courses of 2CST (in place) Jones Bros - 1st course of 2CST (in place); remove existing pavement section to subgrade
FTW	FM 8 (Erath)	Jay Mills Contracting
HOU		
LRD	US 277 (Maverick) FM 624 (LaSalle)	Price Construction Foremost Paving
LBB	SH 214 (Bailey) SH 194 (Castro)	Amarillo Road - MC-30 prime; 1st course/2CST Amarillo Road - Completed 3CST in one day
LFK	SH 103 (Angelina)	Pinto Construction - Inverted prime; base finishing on cement-treated iron ore base; first course of 2CST + HMAC

Table 5.1 (continued)

District	Projects (County)	Remarks
ODA	SH 349 (Terrell)	Jones Bros - MS-2 prime cut-in; 1st and 2nd courses of 2CST
PAR	SH 276 (Rains) I-30 Frontage Road (Hopkins) FM 3236 (Hopkins)	D.L. Lennon - LS Base finish; SS-1 cut-in prime D.L. Lennon - Cement treated sandstone (SS) base finish; SS-1 cut-in prime A.K. Gillis & Sons - 2CST on CTB
PHR		
SJT	SH 208 (Tom Green) US 67 (Runnels) US 87 (Concho) RM 337 (Real)	Reece-Albert - Primed base with AE-P Reece-Albert - 1st and 2nd course of 2CST Stephens-Martin - LS base finish; MC-30 prime Allen Keller
SAT	SH 16 (Bandera) SH 173 (Atascosa) SH 16 (Atascosa) RM 1051 (Uvalde) Spur 98 (Kerr) FM 1688 (Uvalde) FM 624 (McMullen) FM 3175 (Atascosa) FM 1343 (Medina) FM 471 (Medina) FM 1052 (Uvalde) FM 1957 (Medina)	Capital Excavation - LS base; AE-P; peeling u/s Ray Faris - Inverted prime (underseal) using AC-5 and Grade 5 rock Salinas Construction - MS-2 prime on LTB E.E. Hood & Sons Capital Excavation E.E. Hood & Sons - Inverted prime over cement treated LS base (CTB) Foremost Paving E.E. Hood & Sons E.E. Hood & Sons (new project - not started) E.E. Hood & Sons (new project - not started) E.E. Hood & Sons E.E. Hood & Sons
TYL	Loop 49 (Smith)	Young Contractors - LS base finish
WAC	FM 638 (Limestone) FM 1695 (McLennan) SH 195 (Bell)	Young Contractors - Cut-in CMS-2 prime Big Creek Construction - LS base using Ingersoll-Rand base laydown machine; prime with pugmill premixed base & emulsion Woodard Const. (asphalt subcontractor) Marvin Dean Whittingburg
WFS	FM 51 (Cooke) FM 372 (Cooke) US 277 (Wichita)	AUI Contractors - Base finish Rushing Paving - LS base slushed; MC-30 Duininck Bros - LS base finish; MC-30 prime
YKM	FM 153 (Fayette) FM 616 (Jackson) FM 2433 (Calhoun) FM 1163 (Wharton) FM 3131 (Jackson) FM 1291 (Fayette)	Hunter Ind. - Covered prime; 1st of 2CST Brannan Paving Garey Construction Faltisek Paving Brannan Paving Big Creek Construction

A large volume of construction project data, along with video footage and still pictures of construction activities, was collected during these project visits. The important elements of a few selected projects are highlighted in this chapter to illustrate unique surface treatment practices.

5.2 Project 1

This project was a rehabilitation of a rural FM road in west Texas. The two-course surface treatment was constructed on a limestone flexible base. The unique thing in this project was the use of a subgrade trimming machine to finish the base. Surface treatment construction projects in this area have had poor ride quality due to a dearth of skilled motor grader operators. The contractor for this project had approached the district about using the trimming machine that would eliminate the need for accurate blading to finish the base. Figure 5.2 shows four images related to this trimming machine. In this case, the limestone base was compacted to the specified density about 1.5 to 2 inches above the blue-tops and the trimmer was used to cut the excess height to achieve the desired base elevation. Once trimmed, the base is rolled to achieve a smooth finish.

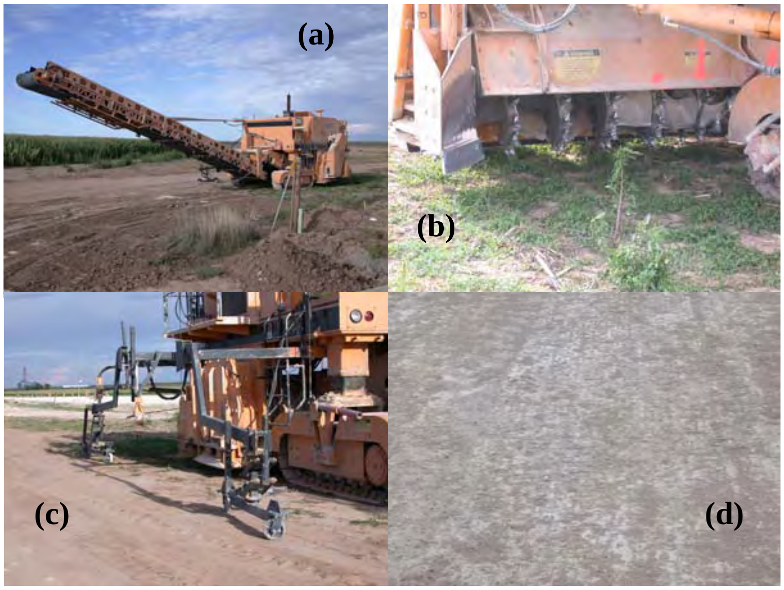

Figure 5.2 Trimming Machine Used in Base Finishing (a) Machine with Excess Material Loading Conveyor (b) Cutting Blades, (c) Guide Roller Assembly and (d) Finished Base Surface After Rolling

This trimming machine can be a satisfactory alternative for base finishing under certain conditions. However, the operation of this equipment requires some acquired skill. It also generates excess base material that cannot be used in the project being constructed due to changes in its gradation from the trimming operation. In an area where base material is expensive, this can add to the cost of the project. However, in this instance the contractor offered to use this equipment at no additional charge for excess base. The excess material can be used in TxDOT incidental construction projects.

5.3 Project 2

This project was a rehabilitation of a low traffic FM road in east Texas. A two-course surface treatment was to be constructed on crushed limestone base using MC-30 spray prime. A ride quality requirement was introduced for the finished base through general plan notes, with a maximum IRI specified at 120. This IRI value specified was considered preliminary because this project was one of the first in this district to use IRI. The district personnel believe that the maximum IRI specified could be even lower. Since this was a two-lane FM road with minimum shoulder width, traffic had to be allowed on the primed lane almost immediately. While being primed, traffic was diverted to single lane using a pilot car. Once the MC-30 prime was sprayed field sand was sprayed on the prime within 10 minutes of the prime spray. This was done using a fertilizer spreader truck. Traffic was allowed on this lane within one hour after the prime coat binder was sprayed. Figure 5.3 shows the different steps involved in the construction process in this project.

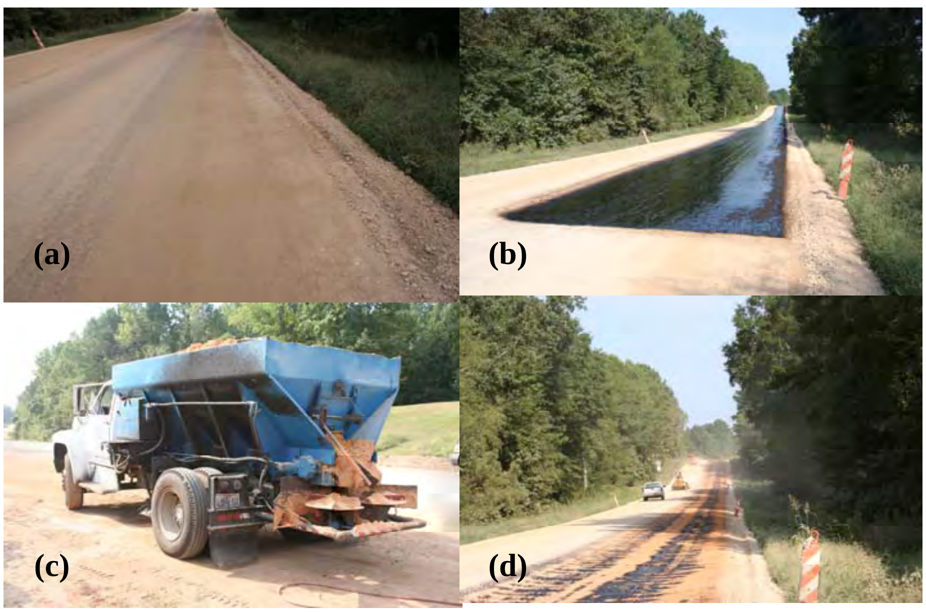

Figure 5.3 Spraying Prime on Limestone Flexible Base (a) Finished With IRI of 112, (b) Spray Prime Applied (c) Fertilizer Spreader Used to Spread Field Sand for Blotting, and (d) Brooming of Blotting Sand to Finished Lane

5.4 Project 3

This construction project in West Texas involved a three-course surface treatment. All three courses were constructed using hot asphalts on the same day. In reality, this was a four-course surface treatment considering that a one-course surface treatment was already applied after priming the base to allow temporary traffic. The three courses that were applied on the same day included a first course with grade 2 rock followed by a second course with grade 3 rock and the third course with a grade 4 rock. Some key steps in the construction process are highlighted in Figure 5.4 below. The grade 2 rock was uncoated river gravel [see Figure 5.4(a)], and due to these aggregate particles being heavy, a standard brooming of the aggregate was not conducted since it might create a safety hazard for the construction personnel. Instead, a locally made drag broom [see Figure 5.4(b)] was used to ensure that the grade 2 rock particles were appropriately seated on the binder before rolling using a heavy steel-wheel vibratory roller [Figure 5.4(c)]. A steel wheel roller could be used because of the relatively high hardness of gravel aggregate particles. In this project, the shoulder of the highway had only a two-course surface treatment and this created a problem of edge drop-off between the main lanes and the shoulder [Figure 5.4(d)]. Ideally, such a situation requires a gradual transition from the main lane to the shoulder, and the contractor had to rectify this problem.

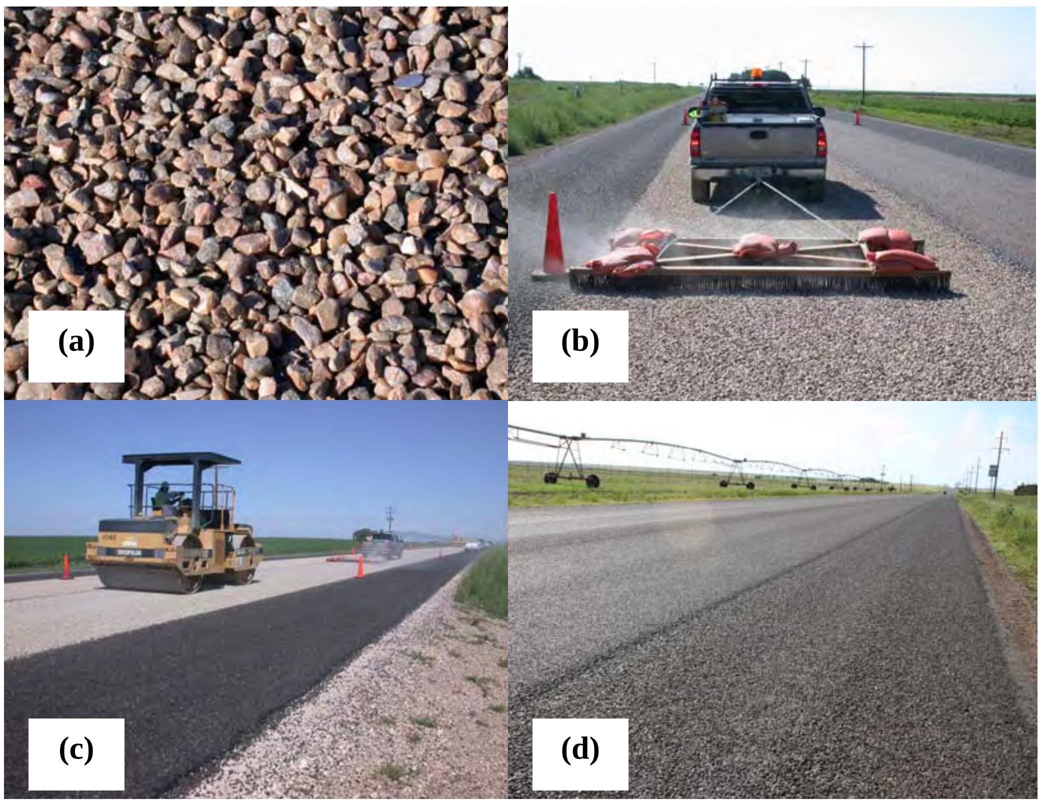

Figure 5.4 Construction of Three-Course Surface Treatment in West Texas (a) Grade 4 Rock in First Course (b) Drag Broom used for Grade 2 First Course (c) Use of Heavy Roller for Grade 2 Rock First Course (d) Edge Drop-off Between Three-Course Main Lane and Two-Course Shoulder

5.5 Project 4

The crushed limestone base was finished using the blade-and-roll technique. A diluted MS-2 asphalt emulsion (5% emulsion and 95% water) was sprayed on the finished base. Since the prime is worked into the base, the finished base was not broomed before the asphalt emulsion was applied. A pneumatic roller was used on the prime coat binder to push the asphalt emulsion into the base, and also to mix it with any fines on the finished base surface [Figure 5.5(b)]. The motor grader was then used to work the base material windrow over the prime coat binder once [Figure 5.5(c)]. The pneumatic roller was used on the bladed base [Figures 5.5 (d)]. This was followed by using the steel wheel roller [Figure 5.6(a)]. Subsequently, a second coat of prime was applied followed by the surface treatment courses [Figure 5.6(b)].

The finished surface showed a very good ride quality. Preliminary profiler measurements and IRI calculated on the finished base reported IRI values in the range of 60-70 inches per mile. When the Grade 3 first course was applied, the IRI went up to 80-90 inches per mile, and the Grade 4 second course brought the IRI back down to 70-80 inches per mile.

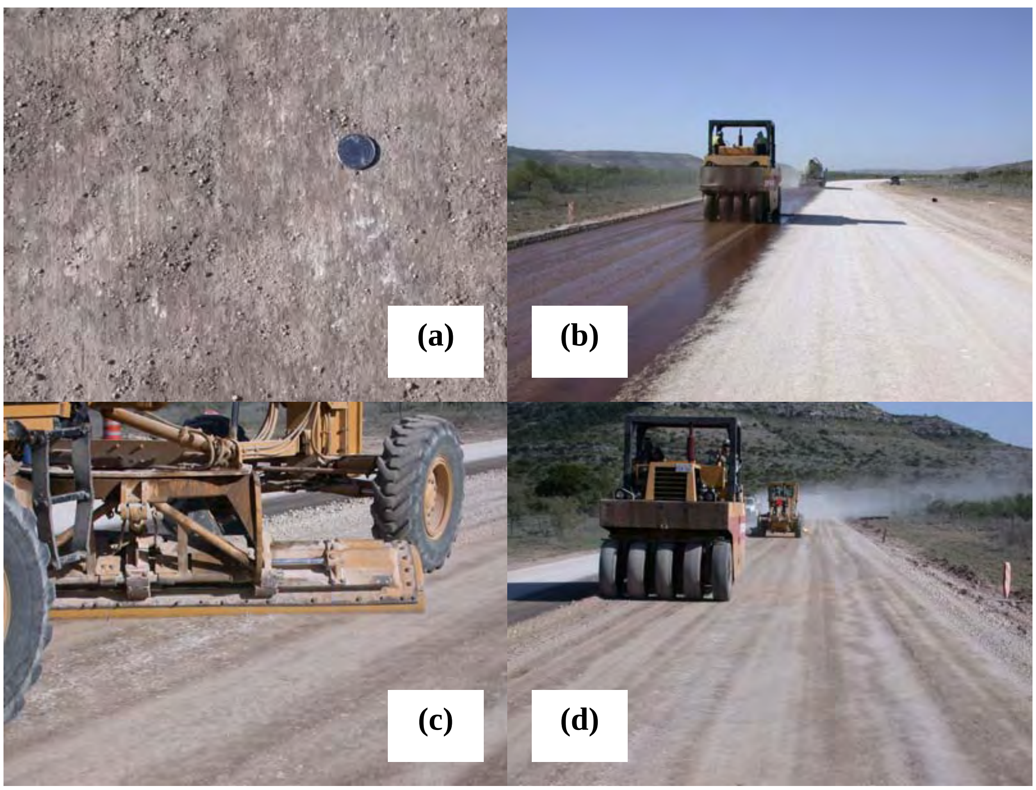

Figure 5.5 Construction of Two-Course Surface Treatment in West Texas (a) Finished Base Surface before Priming (b) MS-2 Prime Diluted 5% Emulsion/95% Water on Finished Base (c) Base Material Spread over Prime (d) Rolling with Pneumatic Roller

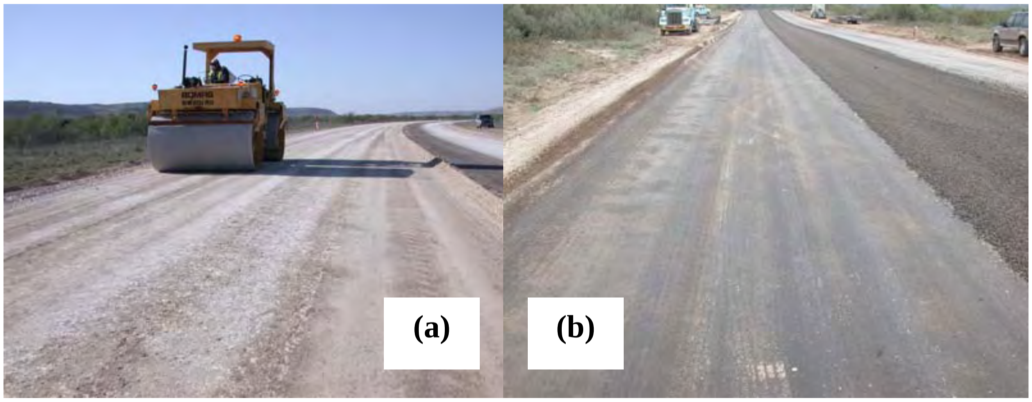

Figure 5.6 Construction of Two-Course Surface Treatment in West Texas (a) Rolling with Steel Wheel Roller (b) Second Prime Coat Applied Over First Course

5.6 Project 5

In this project, a four-lane highway was constructed along an existing 2-lane highway alignment. A worked-in (or cut-in) prime was applied on crushed limestone flexible base. The limestone base was finished by slush rolling using a heavy vibratory roller [Figure 5.7(a)]. The amount of water used during rolling to slush the base was high. Once the base was finished, the motor grader was used to even out the base while leaving a windrow of material on both sides of the roadway [Figure 5.7 (b)]. A 50/50 diluted SS-1 emulsion was sprayed on the bladed base [Figure 5.8(a)] and the windrow was bladed across the lane three times [Figure 5.8(b)]. At each pass, the motor grader was followed by a medium pneumatic roller [Figure 5.8(c)]. This process of spraying and blading was repeated two more times [Figure 5.8(d)]. The SS-1 emulsion application rate was set so that a total asphalt residual of 0.2 gallons per square yard. After the third application of prime, a 'paint' coat of emulsion was also sprayed before the surface treatment was applied [Figure 5.8(e)]. The worked-in prime technique leaves a flake of asphalt-sand that is approximately 1/8 inch thick [Figure 5.8(f)].

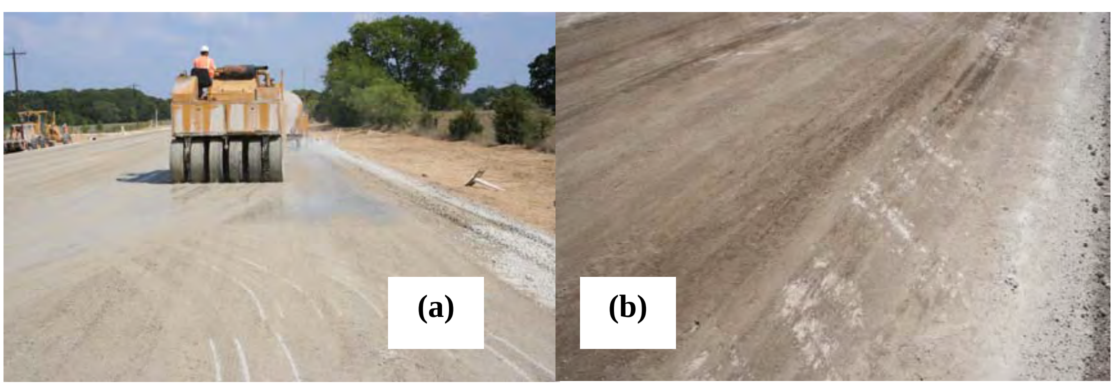

Figure 5.7 Construction of Two-Course Surface Treatment in East Texas (a) Slush Rolling (b) Bladed Surface Ready to be Primed

Figure 5.8 Construction of Two-Course Surface Treatment in East Texas (a) Spraying Diluted SS-1 Emulsion Prime (b) Working-in Base Fines from Windrow (c) Rolling of Fines into the Diluted Emulsion using Medium Pneumatic Roller (d) Application of Second Coat of Prime (e) 'Painted' Primed Base Ready for First Course of Surface Treatment (f) Flake of Asphalt-Sand Prime Coat

5.7 Project 6

This two-course surface treatment construction project was constructed in the Texas hill country area. It is highlighted in this chapter due to two problems that surfaced during its construction. A spray prime coat (AE-P binder) was applied on a finished crushed limestone base. Figure 5.9 illustrates four important steps in the construction process to highlight the problems mentioned above. Figure 5.9(a) shows the AE-P prime sprayed on the finished limestone base. Construction traffic caused certain parts of the prime coat to be peeled-off [see Figure 5.9(b)].

This could have been caused by either a lack of bonding between the finished base and the prime or by shaded areas on the road causing a slow-down of the curing process of prime coat binder. The surface treatment was applied on the primed base, and the construction traffic driving on the prime caused the prime and the surface treatment to peel off completely. It was clear that the failure shown in Figure 5.9(d) occurred at the base-prime coat interface, indicating the failure of bond between those two layers. The failure was quite extensive, and a closer look at the failed surface treatment revealed that application of the prime coat had taken place before the base had adequately dried. It is likely that pressure created by water vapor trapped in the base by the prime coat caused the bond to fail. This highlights the importance of applying the prime coat when the appropriate moisture level has bee reached in the base. Current TxDOT specifications recommend a moisture content two percentage below the optimum for that base material as a suitable level.

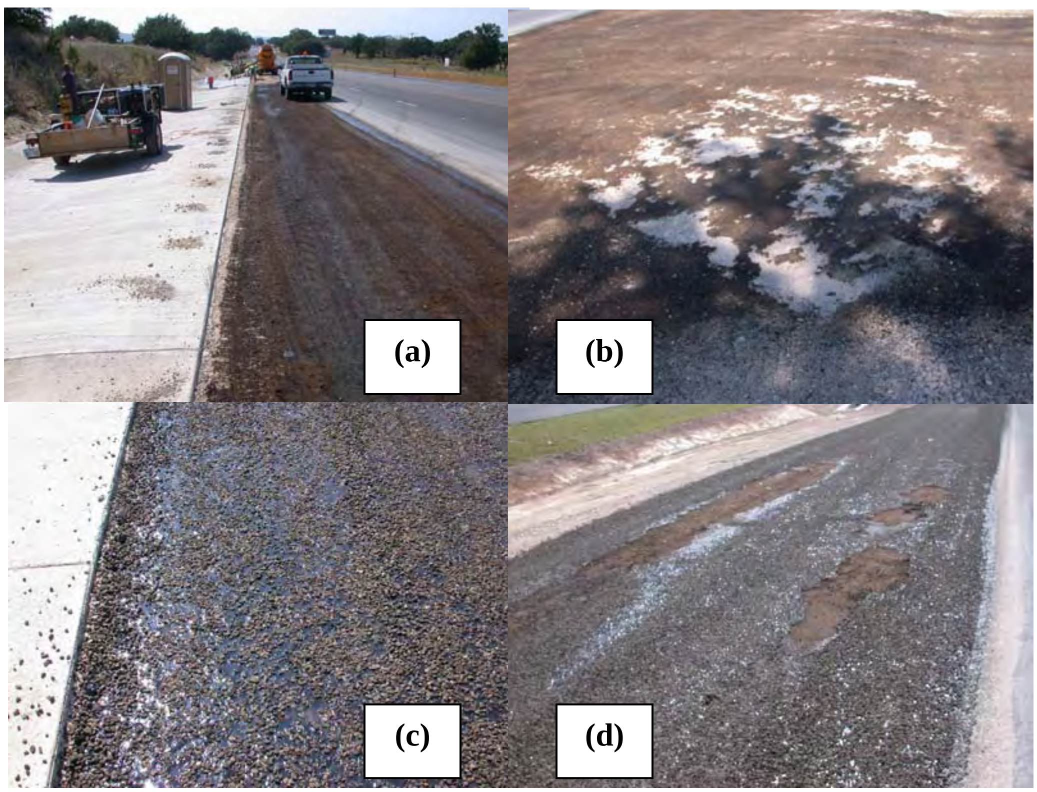

Figure 5.9 Construction of a Surface Treatment in Texas Hill Country (a) AE-P Spray Prime Applied (b) Prime Peeled-off at Shaded Area Due to Construction Traffic (c) First Course of Surface Treatment Applied (d) Failed Surface Treatment Due to Construction Traffic

5.8 Project 7

This construction project was located in central Texas and it involved the construction of an underseal surface treatment. This project was included in this chapter to highlight relatively new equipment that has entered the surface treatment construction market in Texas. It is a base lay-down machine which is somewhat similar to an asphalt concrete paving machine which is capable of laying down both flexible base and emulsified asphalt base. One contractor approached the TxDOT district about using this equipment to showcase its potential. The researchers had the opportunity to observe this equipment when the contractor was laying down a short section of emulsified asphalt (EA) base. The EA base was mixed in a pugmill away from the jobsite and trucked to the project.

The machine was designed in Germany, and the equipment used in this project was manufactured by Ingersoll-Rand. This equipment has been used in a few projects by this contractor and it has shown promise. However, even though we included this in the section of our workshop on best practices, the researchers believe that more close observation is needed to evaluate its impact in TxDOT base construction. Since this construction project was completed, two other TxDOT districts have used this equipment with satisfactory results. It does appear to provide benefits by way of a better finish of the base surface (ride quality) and better control of base moisture content during construction because it is mixed in a pugmill. This is a huge benefit considering that many TxDOT districts still use the slush rolling technique to achieve the desired ride quality on the finished base even though it is likely to lead to premature base failure. In this project, 7 inches of flexible base was laid down using this machine, and that was overlaid by the emulsified asphalt base. A surface treatment underseal is to be placed on the emulsified asphalt base, followed by the hot mix asphalt layer.

Figure 5.10 shows this equipment in operation. It has a hopper with a conveyor taking the base material to the screed area [see Figure 5.10(a)]. As shown in Figure 5.10(b), conveyor-bed dump trucks bring the material from the pugmill and it is loaded into the hopper of the lay-down machine. The lay-down machine was traveling at approximately 5 meters per minute (16.4 feet per minute or 0.2 miles per hour) during the construction operation observed by researchers. The material is laid down and compacted by two bars that oscillate vertically. The manufacturer claims that the equipment is capable of achieving up to 92% density of a typical base material behind the lay-down operation prior to rolling. Limited field experience has shown densities very close to this number.

Other TxDOT projects where this equipment was used showed good results and a lot of promise. Some segregation of the base material has been observed. However, this could be easily be overcome by adjusting the moisture content in the base according to the speed of the lay-down operation.

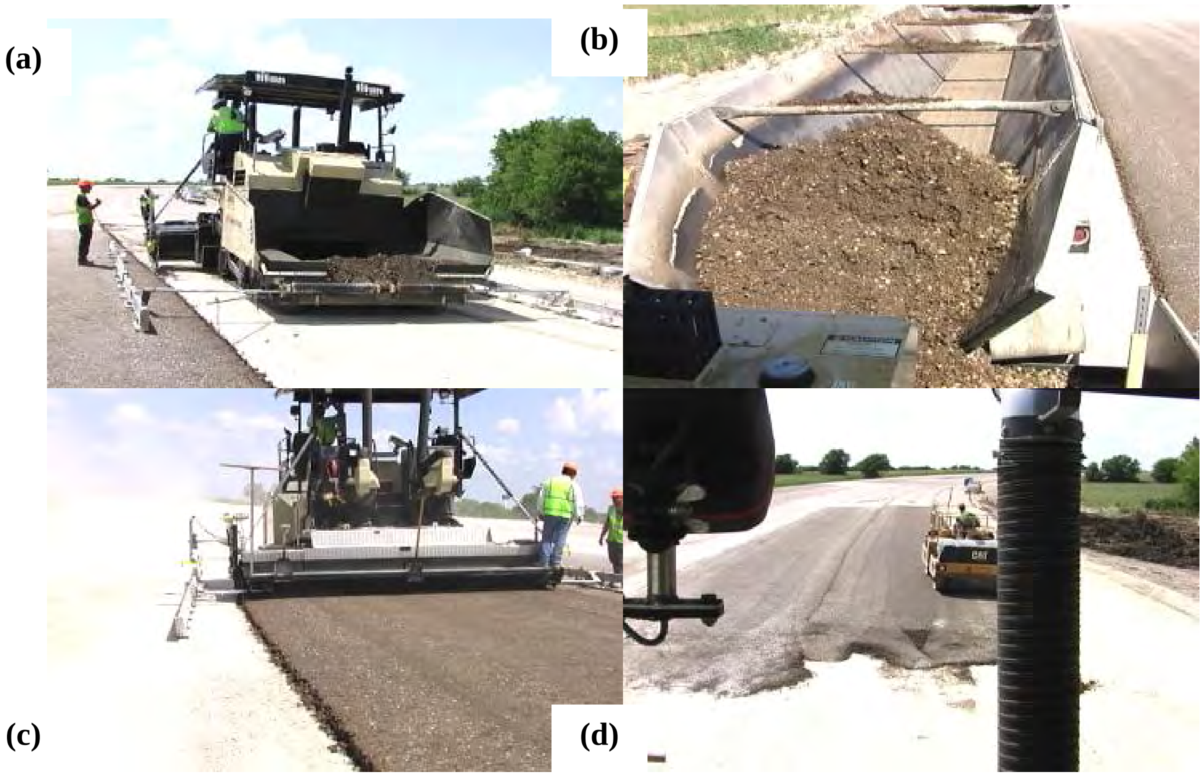

Figure 5.10 Base Lay-Down Machine in Operation (a) Lay-down Machine and its Conveyor – Driven Hopper (b) Mixed Base Material Transported from Pugmill to Lay-Down Machine Hopper (c) Lay-Down of Emulsified Asphalt Base in Progress (d) Rolling of Laid-Down Base

5.9 Project 8

This project, located in central Texas, was selected to showcase the covered prime coat construction. Several districts use a covered prime as an effective surface treatment construction element. It is also referred to as an inverted prime. In this application, the finished base is sprayed with RC-250 cutback asphalt and is immediately covered with a dense Grade 5 aggregate layer. It is very similar to a surface treatment course. The RC-250 cutback being a thick and sticky binder holds the aggregate in place quickly enough to allow slow-moving construction traffic to travel on the primed surface. This is the biggest advantage of using a covered prime. However, it is neither strong nor durable enough to withstand traffic for extended periods of time. Some districts that use covered prime coats claim that it can be used as a temporary wearing surface for up to three months. Figure 5.11(a) shows the finished limestone base ready to be primed, and Figure 5.11(b) shows the covered prime applied on the pavement. Figure 5.11(c) shows the lightweight pneumatic roller in operation and a close-up of the covered prime can be seen in Figure 5.11(d). This primed surface was covered with a surface treatment once the whole project was primed.

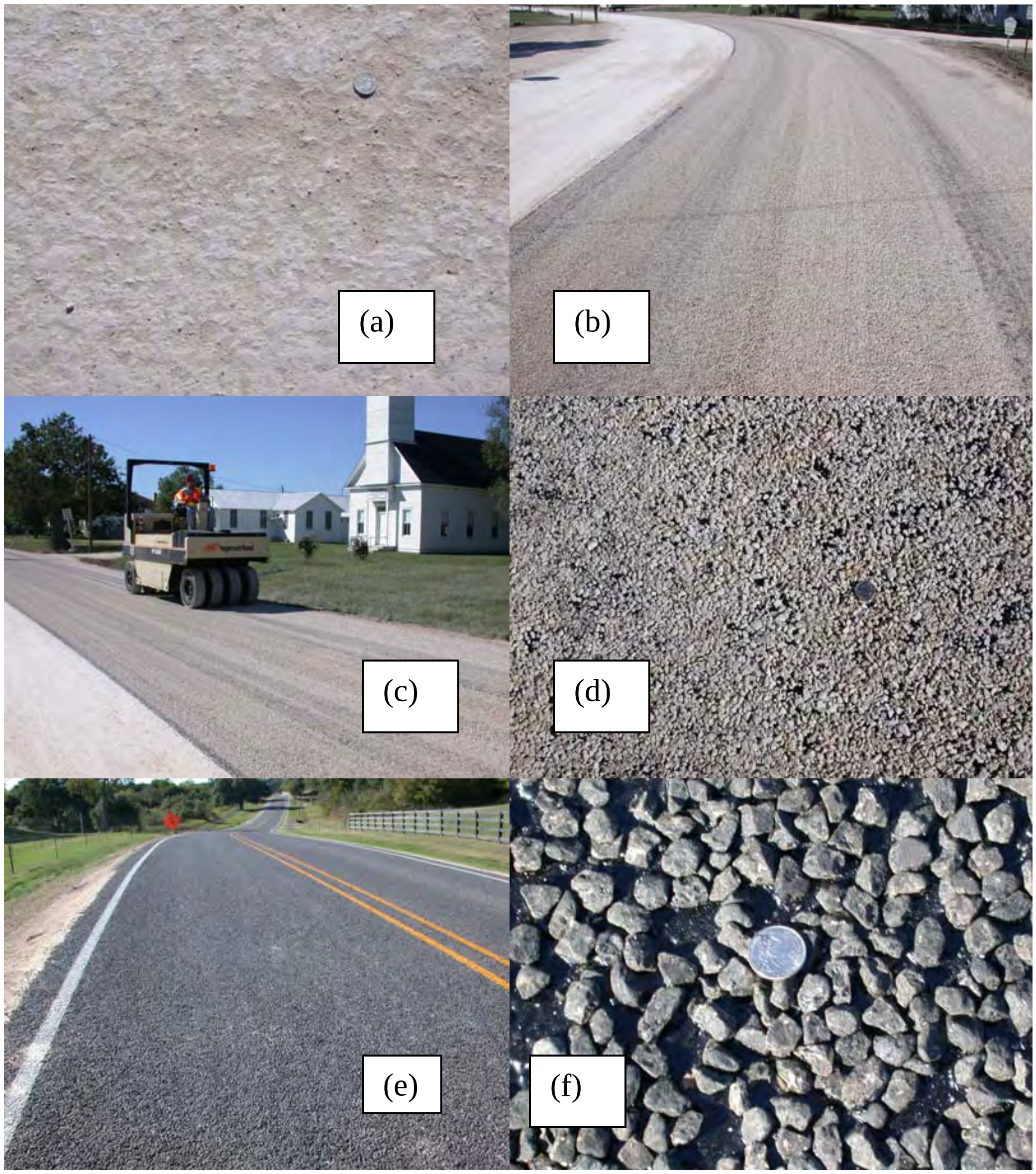

Figure 5.11 Surface Treatment Construction Project in Central Texas Using Covered Prime
(a) Finished Limestone Flexible Base (b) Covered Prime of RC-250 and Grade 5 Rock Applied
(c) Rolling of Covered Prime (d) Close-Up of Covered Prime Showing Grade 5 Rock
(e) First Course of Surface Treatment Applied on Covered Prime
(f) Close-Up of Surface Treatment with Grade 4 Rock

Chapter 6

Conclusions

This interim report is intended to provide the reader with a detailed overview of the constructability review of surface treatments constructed on base courses. The study included all types of base materials except asphalt stabilized bases. It also included one-course surface treatments (underseals) as well as two-course and three-course surface treatments. The application of surface treatment produces a small increase in thickness of the road surface, but it is not intended to provide additional structural capacity to the pavement. Therefore, all the structural strength in such a pavement is provided by the base course, which makes its role in the pavement very crucial. Such a pavement structure cannot be effectively used in high traffic volume roadways because the base and subbase layers are unable to provide strength that is sufficient for them. However, asphalt surface treatments provide a variety of benefits; they make the pavement waterproof, provide a skid-resistant wearing surface and lower the pavement life-cycle costs.

The application of a surface treatment is a simple and straightforward process. However, its success depends to a great degree on the effectiveness with which the base layer is finished and on the method used to ensure sufficient bonding between the surface treatment and the base. In Texas, all surface treatment construction projects use a prime coat on base to achieve this end. The techniques used to construct prime coats vary significantly both within and between districts.

The surface treatment design and construction practices in the state vary widely. A constructability review of the surface treatment process was undertaken by the researchers to systematically evaluate the processes involved and to arrive at recommendations that could improve the performance of surface treatments constructed on base. Constructability is a term of art which has come to encompass a detailed review of design drawings, specifications, and construction processes by a highly experienced construction engineer before a project is put out for bids.

As a part of this constructability review, a vast volume of research material was collected. During the literature review and state-of-practice review phases of this study, researchers contacted state DOTs and also reviewed information from several countries. The state-of-practice review focused primarily on communicating with surface treatment practitioners from other highway agencies. The researchers made attempts to contact all 50 states to obtain information on their surface treatment practices. Information requested from other state DOTs was not nearly as extensive as that of TxDOT districts. Repeated attempts to obtain the required information resulted in only 28 states responding to the request. Appendix A presents the questionnaire that was used when interviewing other State DOTs. Six of the 28 states indicated extensive use of surface treatments directly on base courses. Three other states indicated limited use of surface treatments and 19 states do not use surface treatments directly on base as a general practice. The researchers also investigated surface treatment practices by other countries. It was found that surface treatments (on base) are used by many countries worldwide. South Africa, Australia and New Zealand were three countries that showed extensive surface treatment use in their highway networks.

The research team visited and interviewed surface treatment practitioners from all twenty five TxDOT districts. The district constructability review consisted of a face-to-face interview on the subject of surface treatments with a team of personnel assembled by each district. The researchers also visited thirty seven construction projects when the surface treatment construction was actually in progress. The district interviews were guided by a questionnaire consisting of 83 questions that covered topics related to surface treatments ranging from project selection to continuous improvement. The surface treatment process was divided into three parts; design, construction and performance, to facilitate analysis of data and other information collected.

Two of the most important topics related to the surface treatment process are base finishing and prime coating. Many districts use the slush rolling technique to finish the base primarily to achieve a smooth base finish that is critical to the final ride quality of the surface treatment. The research team noted that there are several interpretations of what slush rolling really is. Some districts refer to a light sprinkling of water to wet a dry base as slush rolling. Others use slush rolling techniques that involve the virtual flooding of the compacted base to drive the fines in the base to the top during rolling. Such a practice, though resulting in a smooth finish, is definitely harmful for the pavement in the long run because of the weakening of the base that results. Several districts have been very successful at producing smooth pavements without using slush rolling. These practices are highlighted as best practices in this report and they will also be incorporated in the design and construction guide that will be published later as a part of this research.

Four primary prime coating methods were observed. The most commonly used technique is the spray prime using MC-30 and AE-P binders. The typical spray prime binder application rate is 0.2 gal/sy, which may be adjusted depending on the tightness of base finish and if construction traffic has to be allowed on the primed surface. When construction of a spray prime coat is done under traffic, blotting sand may be spread on the prime coat binder within minutes after the binder is sprayed, and traffic can be allowed on the primed base within a fraction of an hour. Some districts use worked-in (or cut-in) prime where a diluted emulsified asphalt is sprayed on the finished base, which is then covered with a thin coating of fine base material dust by working the windrow with the motor grader. This process is usually repeated 2-3 times to achieve the desired residual binder rate. The emulsions commonly used for this purpose are SS-1, CSS-1h and MS-2. A covered (or inverted) prime is also used where RC-250 cutback is first applied on the finished base, which is covered by spreading Grade 5 rock. This ‘priming’ technique is particularly useful when traffic has to be allowed on the primed surface before the other half of the roadway is primed. The fourth priming method is to scarify the top couple of inches of compacted base and mix it with emulsified asphalt before re-compacting. This technique has not worked well in some projects where it has been tried.

The constructability review revealed that two-course surface treatment is the most widely used surface treatment type in the state. However, underseals (one-course surface treatments) and three-course surface treatments are also used effectively by many districts. The selection of surface treatment materials is an issue that generates a lot of discussion. The most common practice is to use a grade 3 rock in the first course followed by a grade 4 rock in a two-course surface treatment. The binders used in each of the courses depend on the construction sequence and the climate during which the construction is done.

Even the most effective design may not ensure a satisfactory surface treatment due to the strong influence construction practices have on performance. Similar to the preventive maintenance seal coat operations, the surface treatment process is not that complicated. However, they both consist of systems whose satisfactory functioning depends heavily on the conditions under which they are constructed. Therefore, the designers of both these systems are constrained by not knowing the field conditions for which to design for. This puts a tremendous burden on the field project manager to make critical adjustments and decisions in the field. Most practitioners call seal coat and surface treatment work more of an “art” than a science for this reason. However, this research team firmly believes that there is more to the science of surface treatments and seal coats than it appears to be.

Construction of surface treatments, unlike seal coat projects, comprise of a small part in a larger construction contract. The surface treatment in such projects could either be an underseal or a wearing course which is the culmination of a larger project. This sometimes creates a situation where a prime contractor may not have the skilled personnel required to complete the surface treatment work at a satisfactory quality level. For example, the motor grader operator and other surface treatment equipment operators need to be skilled in operating such equipment which are crucial to project quality. In some cases, the prime contractor may subcontract the work to a surface treatment specialist, and this practice should always be encouraged.

The design and construction of surface treatments require careful consideration of several factors. These include sound project selection for ST work, required ride quality and how to achieve it, number of courses in the ST and their construction sequence, prime coating method, and constructability and material selection application rates.

The selection of projects for surface treatments should be judiciously made. An underseal must be recommended practice for most HMAC surfacing projects in the state due to inherent benefits gained from their application. It protects the base from moisture, and ensures satisfactory bonding of the hot mix to the base below. This will in turn reduce the stresses generated in the HMAC layer and is likely to provide longer fatigue life. Surface treatments can be used as wearing courses in pavements that may carry traffic as high as 5000 ADT. The researchers came across a few instances where STs have bee effectively used as wearing courses in ADT levels as high as 12,000. Overlays applied on cracked pavement surfaces may not be suitable candidates for surface treatments because of the likelihood of crack reflection. However, some surface treatments such as hot rubber seals have proven to be satisfactory crack arresters. A two- or three-course surface treatment, when properly constructed, may be as effective if not more effective that HMAC wearing courses at lower traffic levels.

Tire-pavement noise is often a concern with surface treatments, but proper selection of aggregate grades and application rates combined with low-noise asphalts such as tire rubber asphalt can reduce these noise levels significantly. Another important area of application of surface treatment wearing courses is in pavements that are built on moving subgrade. The investments made on HMAC may not be justified under such conditions where the HMAC may not last very long due to excessive stresses caused by subgrade movements. A surface treatment, particularly hot rubber asphalt or multiple-course surface treatment can be both cost effective and easily replaceable.

The industry has been moving towards better control of ride quality for surface treated pavements. The use of IRI is a very effective way to control the ride quality. The IRI can be calculated using profilograph measurements on the finished base, first course or the final course of the surface treatment. Some districts tried IRI specifications of 120 on finished base, but experience suggest that these values can be reduced much further for the finished base. The question then arises as to how these ride quality values can be achieved. Many districts have allowed contractors to use the practice of slush rolling for the purpose of achieving ride quality. Even though this can provide good ride quality, when excessive amount of water is used, slush rolling can be a recipe for premature base failure. Slush rolling drives the fines in the base material to the top, thus creating voids in the flexible base and destroying its integrity. Therefore, the researchers recommend that other methods such as 'blade-and-roll' and the use of base lay-down machine be adopted for this purpose. The 'blade-and-roll' technique requires a very good blade operator and most districts insist that it is becoming harder and harder to find contractors with good blade operators. A base lay-down machine can be a good substitute for this scenario. These factors make it imperative that control mechanisms be adopted by districts to ensure that contractors have appropriate methods in place to achieve the required ride quality without compromising the integrity of the pavement.

The prime coating method is another important aspect of surface treatment. All prime coating methods indicated earlier are capable of providing good bonding between the prime coat and the finished base. One important factor is to ensure that the prime coat binder is sprayed at the appropriate base moisture content. The 2004 TxDOT specification calls for a base moisture content 2 percentage points below the optimum moisture content as appropriate for good prime penetration and adhesion. Even though different base material-binder combinations may have different optimum moisture levels, the specification value appears to be a good rule-of-thumb to adopt. The researchers observed a couple of surface treatment projects that failed during construction because the prime coat was applied too wet.

The material rate design for surface treatments begins with the rate design for seal coats. Even though seal coat binder rate design can be used to guide the binder rate design for multiple-course surface treatments, some key adjustments need to be made to account for the design and construction sequence of the surface treatment. If successive courses are applied quickly one after the other, allowances must be made for drain-down of binder (i.e. use a lighter rate for lower course, and heavier for the upper course). This may be achieved by considering the existing surface to be highly textured (coarse). If upper course is applied months later, use of a heavier rate at the bottom and a lighter rate at the top are recommended.

One of the most critical issues for the immediate future in surface treatment practice is the role of project management and inspection. TxDOT is becoming increasingly dependent on inspectors and project managers with little experience. This is caused by the high rate of turnover of experienced inspectors and project managers over the past several years. This appears to be leading towards an era of surface treatment practices at construction sites dictated to a significant extent by the contractors. Good contractors have a lot of experience and wisdom that TxDOT projects can benefit from. However, the time is right for TxDOT to re-evaluate the inspection process. With a booming construction market and an expanding economy, it is unlikely that TxDOT will have experienced inspectors and project managers in sufficient numbers in the foreseeable future. The alternatives for TxDOT to consider may be either to invest in accelerated inspector training programs or to become innovative and creative in the way specifications are written and designs are done. Innovative contracting methods could also be a possibility.

This constructability review was conducted to evaluate the surface treatment process within TxDOT. The surface treatment process was broken down into its smaller parts and each part was picked apart and analyzed to assess its appropriateness and to find ways to improve them if needed. Some recommendations are made for areas where the researchers felt that improvements are warranted. Based on the findings of this constructability review, a design and construction guide will be developed for possible adoption by TxDOT.

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Appendix A

State DOT Interview Questionnaire

State DOT Interview Questionnaire

TxDOT Research Project 0-5169

<u>Constructability Review of Surface Treatments Constructed over Base Courses</u>

Texas Tech is conducting a comprehensive constructability review of **surface treatments applied directly over a base layer <u>NOT chip seals or seal coats applied to existing asphalt pavement</u>**. This questionnaire is intended to study the best practices on surface treatment construction for each DOT.

1. Can you give me an idea as to the extent (%) to which **<u>surface treatments</u>** are constructed over base courses in your state?
   A. Undercourse
   B. Wearing Courses
      1. 1-Course ______
      2. 2-Course ______
      3. 3-Course ______

2. What criteria are used when selecting roadway sections for surface treatments or underseals on base?
   A. Roadway classification
   B. Functional Classification
   C. ADT
   D. % Truck Traffic
   E. Location (urban, rural)
   F. Road noise
   G. Type of Base
   H. Other______________

3. Do you specify different ride qualities for finished surface treatment wearing courses on different types of highways?

   A. What are these qualities?

4. Who does your actual surface treatment construction? (indicate % against each)
      1. Prime Contractor
      2. Prime Contractor subcontract
      3. Separate (specialty) contractor
      4. Surface treatment using in-house (DOT) crews

5. What specification type(s) do you use for **surface treatment** work?
   A. Method Specification
   B. Performance-based Specification

6. What are the performance-based criteria used?

A. Skid Resistance
B. Ride Quality
C. Other (specify)
D. Warranty Specification
   1. What are the details? (i.e. warranty period, acceptance criteria, etc.)

7. What are typical unit costs bids for **surface treatment** work by contractors in your state?
   (a) 1-course wearing___________
   (b) 2-course wearing___________
   (c) 3-course wearing___________
   (d) Underseal__________

8. Do you use *pre-coated aggregates* in **surface treatments**?

9. What are some typical precoating practices?

   Prompt-*(i.e. what aggregate types are precoated, what are the precoating binder types/grades?, binder contents used, why precoating?, etc.)*

10. What binder types and grades do you use in surface treatment?
   A. 1-Course (cold)___________ (warm)___________
   B. 2-Course (cold)___________ (warm)___________

11. What aggregate gradation do you use in surface treatments?
   A. Max Rock Size_________
   B. Single Size (uniform)________
   C. Distributed-size gradation________

12. What are your base pre-treatment practices?
   A. gravel, crushed stone
   B. cement stabilized base
   C. lime-fly ash stabilized base
   D. other

13. What do you treat the base with before applying the surface treatment?
   A. Prime Coat
   B. Mixed Base-cut a layer and spray emulsion then re-roll and smooth
   C. Other

14. What factors are used in deciding whether to use a prime coat?
   A. Type of Base
   B. Traffic (ADT)
   C. Binder
   D. Other

15. Do you apply surface treatments without a prime coat?

16. Describe the finishing methods you use for different base materials before prime coat or surface treatment is applied?
    A. What type of roller?
    B. How many passes?
    C. Do you slush the base (soak with water) before rolling?

17. How soon after the base is finished do you treat the base?

18. How soon after the base pre-treatment do you apply the binder for surface treatment?

19. Do you allow temporary traffic on the following surfaces?
    A. Finished Base Surface
    B. Prime Coated Base

20. What are your thoughts on allowing temporary traffic on the partially finished surfaces?
    A. In your opinion, does this affect the quality of surface treatment?

21. Do you at any time open the surface treatment to traffic prior to brooming?
    A. Do you open the road at reduced speed?
    B. What is the typical maximum reduced speed?
    C. What is the typical time span between final rolling and opening to full speed traffic?

22. What is the time lag between successive layers in a multiple-course surface treatment?

23. Who inspects the surface treatment work for you?
    A. Team (how many, roles, etc.), Individual?
    B. In-house
    C. Contracted
        1. Is this a separate contract?

24. What field /lab test methods do you think best represent (reflect) quality surface treatment construction?
    A. Bonding with base
    B. Ride Quality
    C. Aesthetics
    D. Other

25. What are the most common surface treatment distresses?
    A. Raveling-(rock loss)
    B. Flushing-(too much binder)
    C. Peeling of ST
    D. Peeling of prime coat

26. If money is not an issue, how would you do surface treatment design and construction?

Appendix B

District Interview Questionnaire

Structured Interview Questionnaire

TxDOT Research Project 0-5169

Constructability Review of Surface Treatments Constructed over Base Courses

This research project is conducting a comprehensive constructability review of surface treatments (ST) applied directly over a base layer. This questionnaire is intended to study the best practices on surface treatment construction of this type. The researchers will visit each district to interview TxDOT personnel involved in surface treatment work and this questionnaire is expected to provide a basis for these interviews. The researchers will also visit construction projects in selected districts to collect additional data, and wherever possible, these project visits and district interviews will be conducted during one trip. The researchers appreciate the district's efforts to collect answers to our questions before the interview date, and if the district personnel wish to fill out the questionnaire on the computer, completed questionnaires may be e-mailed directly to the researchers.

Information on the Respondent:

Name: ____ Title: ______________________

District: __________________________ Office Location: _________________________________

Telephone: ________________________ E-mail: ______________________________________

Mailing Address: ____

General:

1. Provide information on the extent to which surface treatments are used directly over base in your district.

Road Classification	**Total Lane Miles in District**	**% Lanes Miles with Surface Treatment as**	
		Wearing Course	**Underseals**
Rural FM			
Urban FM			
Rural State			
Urban State			
Rural US			
Urban US			
Interstate			
Other ________			
All highways			

Rural-Urban separation based on a population of 5000

2. What types of surface treatments on base courses are used in your district? (indicate % for each; total add up to 100%)
   1-Course_____________ 2-Course_____________ 3-Course_____________

3. What is the typical life span of a surface treatment wearing course (placed on base course) in your district?
   1-Course_____________ 2-Course_____________ 3-Course_____________

4. In the case of surface treatment underseals, what wearing courses are typically used to cover the underseals?

____

5. How do you rate your district experience (results) with surface treatments?
1-Course ST ____
2-Course ST ____
3-Course ST ____
Underseals ____

Planning and Design:

6. What criteria are used when selecting roadway sections for surface treatments or underseals placed on base courses?

Treatment	**Selection Criteria (Roadway Classification, ADT, Location, Base, etc.)**
1-Course ST	
2-Course ST	
3-Course ST	
Underseal	

7. Is roadway noise a consideration when deciding whether or not to use a surface treatment wearing course?

8. Briefly describe your surface treatment design procedure and the design criteria used.

9. How long has the current design procedure been in use?

10. What are the typical asphalt and aggregate rates used in surface treatments? Please indicate separately, the rates used in multiple course surface treatments
Asphalt Rate: ____
Aggregate Rate: ____

11. Would the surface treatment designs be different between main lanes and shoulders?

12. Do you take the subgrade type into consideration when selecting a project for surface treatment or in the design of surface treatments?

Contract:

13. (a) In your district, who does the construction of surface treatment on base courses? Assign a percentage where applicable.
□ Prime contractor _______ □ Subcontractor _______
(b) In your experience, is there a difference in the surface treatment construction process and its quality when the work is done by the prime contractor as compared to a subcontractor?

14. List the names of prime/sub contractors who typically do your surface treatment work. In the last column, provide contact information for those contractors that you recommend to us to obtain additional information for this research.

Contractor	**Prime or Sub**	**Recommend Contact by Researchers**	**Contact Info (Name/Tel/E-mail)**

15. Do you feel that you have a good pool of quality contractors for surface treatment work?

16. Are you satisfied with the quality of your surface treatment work?

17. Do you have any issues, concerns or problems with contractors that could be addressed in this research?

18. Do you require different finish quality levels for surface treatment wearing courses and underseals for different types of highways (e.g. ride quality of finished surface)?

19. In your opinion, is the quality of surface treatment related to the bid unit price?

20. Do you think surface treatments are good candidates for a performance-based specification (some related factors may include bonuses, penalties and acceptance criteria)?

21. What is the maximum length of a surface treatment job in your district in lane miles?

22. What general notes would you typically include in your district surface treatment plans? May we have a copy of a set of general notes?

23. What are the typical unit costs bid for surface treatment work by contractors?
1-Course ST ______________ 2-Course ST ______________ 3-Course ST ______________

Materials:

24. What aggregate specification(s) do you use in surface treatments (Grade 3, 4, 4S, etc.)?

Type of Surface Treatment	**Layer 1**	**Layer 2**	**Layer 3**
1-Course ST			
2-Course ST			
3-Course ST			
Underseals			

25. What are the most commonly used aggregate sources in surface treatments and their corresponding percentages?

Company	Pit	Aggregate Type (Limestone, Sandstone, etc.)	% Use from each Pit

26. (a) Do you use precoated aggregates in surface treatments? ☐ Yes ☐ No
    (b) If Yes, what are your reasons for using precoated aggregate?
    ____
    (c) How do you select a precoating binder?
    ____

27. (a) List the surface treatment binder grades with which precoated aggregate is used.
    Hot Asphalt____
    Emulsion____

28. Provide the following additional information on aggregate precoating.

ST Aggregate Type	Precoating Binder(s)	Precoating Binder Content	Other Remarks

29. What binder types do you use in surface treatments?

<u>Binders used in warm weather construction</u> (Temperature Range ____________________)

Type of Surface Treatment	Layer 1	Layer 2	Layer 3
1-Course ST			
2-Course ST			
3-Course ST			
Underseals			

<u>Binders used in cool weather construction</u> (Temperature Range _______________)

Type of Surface Treatment	Layer 1	Layer 2	Layer 3
1-Course ST			
2-Course ST			
3-Course ST			
Underseals			

30. How do you select the binder type and grade for use in surface treatments?

31. Do you use any tests other than standard test methods to evaluate the suitability of materials used in surface treatments?

Base Courses and Preparation:

32. What are the types of base courses and/or base materials over which surface treatments are applied?

33. Do you use surface treatments without a base pretreatment such as a prime coat?
    ◻ Yes ◻ No

34. What factors are used in the decision to use a base pretreatment?

Factor	**Rank**	**Remarks**
Type of Base		
Traffic (ADT, etc.)		
Compatibility with Surface Treatment Binder		
Whether traffic is allowed on base or not?		
Other (specify) _______		

35. In the following Table, provide information regarding the pretreatment of base layer before the surface treatment is applied. Pretreatments (PT) may include prime coat and emulsified asphalt treatment.

Base Course Type/Material	**Type of Pretreatment**	**PT Binder**	**PT Binder Rate**	**% Use in District/Area**	**Other Remarks**

36. Describe the finishing methods you use for different base materials before prime coat or surface treatment is applied.

37. What roller type(s) is used to finish the base?

38. How do you clean the finished base before prime coat or surface treatment is applied?
    ◻ Rotary Broom ◻ Compressed Air ◻ Other (specify) ___________________

39. Do you clean the primed surface before surface treatment is applied, and if so, how?

40. How soon after finishing the base layer do you apply the prime coat?

41. When the base layer is in place, if a climatic condition such as a rainstorm occurs, what steps would you take to make sure that the base layer is in a state desirable for the application of prime coat and/or surface treatment?

42. How soon after the base pretreatment do you apply the binder for surface treatment?
    Prime coat pretreatment: ____
    Emulsified asphalt treatment: ____

43. If you apply the surface treatment without a prime coat, what is the typical time delay between finishing the base and application of surface treatment binder?

44. Indicate if you allow temporary traffic on the following surfaces, and under what conditions.
(a) Finished base surface: ☐ as a general practice ☐ only when necessary
(b) Prime coated base: ☐ as a general practice ☐ only when necessary
(c) Emulsion treated (cut-in) base: ☐ as a general practice ☐ only when necessary
Comments:____
____

45. What are your thoughts on allowing temporary traffic on the partially finished surfaces as in (44) above? Does the traffic level (ADT) influence your decision to allow temporary traffic?

46. What are your impressions about the old (1993) and new (2004) specifications on base layer preparation for surface treatments? For example, what do you think about the optimum moisture content (OMC) minus 2% moisture content requirement in the new specification?

Construction of Surface Treatment:

47. What is your construction season for surface treatment work placed on base courses?

48. What is the typical binder temperature at the time of spraying?
AC _________°F Emulsion __________°F

49. What is the time delay (in minutes) between the binder spray and aggregate spread for surface treatments?

Layer #	**Hot Asphalt**	**Emulsion**
Layer 1 of ST		
Layer 2 of ST		
Layer 3 of ST		

50. How do you decide on the timing of aggregate spread on emulsions?
☐ As soon as practically possible ☐ When emulsion starts to break
☐ While emulsion is breaking ☐ After emulsion breaks (emulsion turns black)

51. Provide information about rolling in the following Table.

Layer in ST	**Roller Used**	**Roller Passes**	**Time Delay between Aggregate Placement and Rolling**
#1			
#2			
#3			

52. Do you broom the first layer(s) of a multiple-course ST before next seal layer is applied?

53. Do you at any time open the surface treatment to traffic prior to brooming?

54. What is the typical time span between final rolling and brooming?
Asphalt Cement: ____
Emulsion: ____

55. What is the typical number of broom passes?

56. What is the time lag between successive layers in a multiple-course surface treatment placed on base courses?

ST Type	Time Delay between	
	Layer 1 – Layer 2	Layer 2 – Layer 3
1-Course		
2-Course		
3-Course		

57. After the surface treatment is placed, do you open the road to reduced speed traffic first?

58. What is the typical maximum reduced speed allowed?

59. What is the typical time span between final rolling and opening to reduced speed traffic?
Asphalt Cement:______________________________
Emulsion:______________________________

60. What is the typical time span between final rolling and opening to full speed traffic?
Asphalt Cement:______________________________
Emulsion:______________________________

Quality Control:

61. Who does the inspection of surface treatments constructed on base courses for TxDOT, a team or an individual?

62. What records are kept of the field inspections? May we have a sample of such records?

63. Who archives the field records and in what form?

64. What mechanisms do you have to control the quality of the aggregate in the field?

65. How do you monitor the quality of the binder used?

66. Indicate information related to binder sampling in the field (sampling location(s), frequency of sampling, sample size, where are they tested, etc.).
Asphalt Cement:______________________________
Emulsion:______________________________

67. What verification methods are used to check material application rates?

68. For computerized distribution methods, do you strap the distributor to check flow rate, and if yes, how often?

69. What tolerances are allowed for binder spray and aggregate spread rates?
Binder Spray Tolerance:______________________________
Aggregate Spread Rate Tolerance:______________________________

70. Which field/lab tests (on the surface treatment or its materials) do you think best represent (reflect) quality surface treatment construction?

71. Which field/lab tests are <u>critical</u> to quality surface treatment construction?

72. Do you use any procedures/tests to control the quality of surface treatments placed on base courses that are unique to your district or area?

Equipment:

73. Provide any special notes/comments regarding surface treatment equipment used in your district.

Type of Equipment	Special Notes/Comments
Base Construction and Finishing Equipment	
Asphalt distributor	
Chip spreader	
Roller	
Broom	

Performance:

74. In the Table below, provide information on the common surface treatment distresses.

Distress	Rank	When do you first see the distress?	How do you rectify the distress?	Other Remarks
Raveling/rock loss				
Flushing/bleeding				
Peeling of ST				
Peeling prime coat				
Other (specify) _______________				

75. Do you think there is a difference in performance between preventive maintenance seal coats and surface treatments?

76. How often do you inspect the performance of surface treatments constructed on base courses?

77. Who does this inspection, and is the inspection documented?

Continuous Improvement (CI) of Surface Treatment Practices:

78. What (CI) methods are used (or planned) to improve the quality of surface treatments?

79. If money is not a problem, how would you do your surface treatment design and construction?

80. Do you have any comments, suggestions or recommendations for improvement of the surface treatment design and construction process?

81. Is there anything you do differently when you place surface treatments on base courses as compared to other surface treatments such as seal coats?

82. When the district training seminars are conducted later in this research project, are there specific issues or topics you would like us to cover?

83. Do you have any surface treatment projects scheduled for construction during the spring and summer of 2005 for the researchers to observe construction operations, talk to your field inspectors and sample materials? If yes, please identify those projects along with possible construction dates.

Appendix C

District General Notes

Abilene District

302 – AGGREGATES FOR SURFACE TREATMENT
The Engineer reserves the right to test all sources even if the source is listed in the Bituminous Source Rated Quality Catalog.

(Optional, May be Used on Low Volume FM Roads)
Furnish aggregate for final surfaces with a surface aggregate classification of "C". Provide aggregates with a minimum magnesium sulfate soundness loss value of 30%.

(Optional, Note for Underseals)
Provide subsurface aggregates with a maximum magnesium sulfate soundness loss value of 30%.

Flakiness index for aggregates will not be required on this project.

316 – SURFACE TREATMENTS
Unless authorized in writing by the Engineer, the open season for the application of asphalt is May 15 to Septembe.

(Required note for underseals and @CST)
When cutback asphalt is used, delay the second surface treatment course or ACP overlay 90 days. When cool season emulsion asphalt is used, delay the second surface treatment course or AC P overlay 7 days.

(Optional)
Seal driveways, mailbox turnouts, and intersections prior to sealing the roadway, unless otherwise approved.

(Pick one)
Furnish three light pneumatic-tire rollers in accordance with item 210, "Rolling".

OR

Furnish two medium pneumatic-tire rollers in accordance with item 210, "Rolling.

(Required note for all projects with precoated aggregate)
Pre-coat aggregate with **PG 64-16.**

316 – HOT ASPHALT-RUBBER SURFACE TREATMENTS
Unless authorized in writing by the Engineer, the open season for the application of asphalt is May 15 to September 1.

Use type II asphalt rubber binder and grade B crumb rubber modifier in accordance with item 300.
Seal driveways, mailbox turnouts, and intersections prior to sealing the roadway, unless otherwise approved.

(Required note for all projects with precoated aggregate)
Pre-coat aggregate with **PG 64-16.**

Atlanta District

Notes Set 1

316 –

For final surfaces furnish aggregate with minimum “A” surface aggregate classification.

Transverse variance rate of _____ (**10% suggested)** is required. **(District seal coat)**

Asphalt season starts May 1 and ends September 1. Obtain written approval before placing asphaltic materials between September 1 and May 1.

Deliver asphaltic material to each control section by the ton as measured at the point of origin.
(Dist Seal Coat)

Seal intersections and driveways before sealing the main lanes. Seal all existing roadway surfaces, including extra widths, crossovers, roadside parks, picnic areas, mailbox turnouts, public road intersections, and public driveways, within the limits of each project. Do not seal intersections or driveways surfaced with ACP or constructed of concrete.
(Dist Seal Coat)

The Department may require the use of emulsion instead of AC if conditions so dictate. Apply AC unless otherwise directed.

Cure the surface treatment under traffic a minimum of 14 days before placement of any subsequent surface courses.

Precoat aggregate with an AC.

316 & 662:

Patch, repair, clean up and apply work zone pavement markings to each individual project within two working days after sealing the project before conducting further sealing operations. **(Dist Seal Coat)**

Notes Set 2

316 –

The open season for application of asphalt is from May 1, to September 1.

The latest roadway-start-work date for the level-up and seal coat operations is June 01, 2005.

No asphalt shall be applied when rain chances are 40% or greater.

No asphalt shall be applied when overnight temperatures are expected to fall below 65 degrees F.

No asphalt shall be applied later than one and one-half hours before sunset.

If the Contractor measures the asphalt shots or rock lands with the use of a distance measuring instrument (DMI), then the Contractor shall verify the accuracy of this equipment with the Engineer.

Coarse aggregates to be used in the surface courses shall have a minimum surface aggregate classification shown on the plans (basis of estimate). The surface aggregate classifications for sources on the aggregate quality monitoring program (AQMP) are listed in the rated source quality catalog (RSQC) along with the criteria used to determine surface aggregate classifications.

In accordance with Item 302.4 the aggregate shall have 99.5 to 100% by weight retained on the no. 200 sieve. The testing will be done immediately prior to shipment from the producer to the jobsite. It will be the Contractor's responsibility to notify the Engineer sufficiently in advance so that the testing can be performed.

Brooming operations will require up to three flashing arrow boards. A lead vehicle will be required and shall be equipped with one forward and one rear facing arrow board, on four lane individual highways. A trailing vehicle will be required and shall be equipped with the third flashing arrow board, on two lane and four lane undivided highways. The positioning of these vehicles shall be directed by the Engineer.

Loose and surplus aggregate shall be broomed off the surface as directed by the Engineer. This work shall be considered subsidiary to the various bid items.

All surfacing shall include transitions, tapers, climbing lanes, mailbox turnouts, intersections, roadside parks, and any other paved surfaces to the limits as directed by the Engineer.

Brooming will be required before opening to traffic on all roadways.

Asphalt used to precoat aggregate will be ionically compatible to the asphalt specified.

The asphalt distributor spraybar shall be equipped so that nozzles not over the wheel paths of the through lanes will have the capability of an increase of up to 25% or as directed by the Engineer. The Contractor will be required to furnish new nozzles at the beginning of this project. These nozzles shall be installed in the spray bar as directed by the Engineer prior to shooting.

Asphaltic material will be delivered to each control section by the ton as measured at the point of origin. The use of storage tanks will be permitted only with the prior approval of the Engineer.

The Engineer, as his discretion, may spot check transport loading, weighing and unloading.

340 –
Due to small quantity of ACP level-up, density requirements will be waived.

Depth of ACP level-up shall be as directed by the Engineer.

A minimum of 30 days cure time will be required between the level-up operation and the seal coat operation.

502 –
After completion of the level-up and permanent striping, the Contractor shall remove the barricades from the Right-of-Way and shall be replaced prior to the seal coat operation. This shall be done per roadway as directed by the Engineer.

Notes Set 3

247 –

Obtain TY E GR 4 flex base from the stockpiles at the following locations or other locations of approximately equal haul distance as directed:

NW quadrant of FM 2517 and FM 10 Intersection. Deplete this stockpile first.
On FM 999, 3.3 miles east of FM 1971.

Contractor is responsible for preparing these sites as approved.

The following pertains to Type "A" flex base only:

Notify Engineer in writing before stockpiling operations begin at the source or sources of base material. Keep Engineer informed on progress of stockpiling operations. A minimum of 14 days is required for testing after stockpiling of material is completed.

Obtain a price schedule for additional sampling and testing from Engineer.

Specific requirements for a crushed iron ore source:

Stockpile a minimum of 10,000 cubic yards or estimated volume from the plan quantity.

Place a maximum of 10 layers. Maximum size of stockpile is 15,000 cubic yards.

Engineer tests each stockpile.

Target grading is required for TY A flex base (See Special Provision 247-001)

The Department will accept lane smoothness on the basis of an IRI profile of less than or equal to 125.0 inches per mile. The Department will measure the profile prior to the application of a surface treatment.

275 –

There are no strength requirements.
Use TY 1 cement.
Multiple full depth ACP patches will be encountered during treating operations. Pulverize and incorporate into cement treated layer. Payment for this work will be subsidiary to this bid item.

316 –

For final surfaces furnish aggregate with a minimum “A” surface aggregate classification.

Asphalt season starts May 1 and ends September 1. Obtain written approval before placing asphaltic materials between September 1 and May 1.

Seal intersections, driveways and mailbox turnouts before sealing the main lanes.

The Department may require the use of emulsion instead of AC if conditions so dictate. Apply AC unless otherwise directed.

Cure the OCST GR 3 under traffic a minimum of 14 days before placement of OCST GR 4.

Beaumont District

Notes Set 1

316 –
Coarse aggregate to be used in surface courses shall have a minimum surface aggregate Classification of “B”. The surface aggregate classifications or sources on the aggregate quality monitoring program (AQMP) are listed in the rated source quality catalog (RSQC). When aggregates are supplied from a source which is not on the AQMP, the aggregate will be sampled and tested prior to use. The procedure will be in accordance with the AQMP.

The seal coat shall be cured a minimum of 3 days before placing the asphaltic concrete pavement.

Rolling for this item shall meet the requirements of item 213 “Rolling (Pneumatic Tire)” – Medium Pneumatic Tire Roller (TY B).

No asphalt shall be placed between October 1 and May 1 unless otherwise directed by the Engineer in writing.

Notes Set 2

316 – Surface Treatments
the seal coat shall be cured a minimum of 7 days or as directed by the Engineer before placing the asphaltic stabilized base.

Rolling for this item shall meet the requirements of item 213 “Rolling (Pneumatic Tire)” – Medium pneumatic tire Roller (TY B). a minimum of two (2) rollers in good order will be required at all times.

Notes Set 3

300 –
the emulsion shall meet the requirements of both ductility and elastic recovery.

316 –
prior to beginning aggregate stockpiling operations, the contractor shall contact the TxDOT maintenance supervisor in each maintenance section to review the potential stockpile locations. The contractor shall secure the approval of the respective maintenance supervisor in writing on a “stockpile information sheet” for each stockpile location to be used. The Engineer shall be provided with a copy of the “stockpile information sheet” for each stockpile. This information sheet shall include the location and limits of the stockpile area, the reference number(s) where the stockpiled material will be used, the maintenance section where the stockpile is location, and the approval signature of the respective maintenance supervisor.

Aggregate stockpiled for this project shall be placed in locations that will not interfere with TxDOT maintenance activities or the safe passage of traffic. Those stockpile that are within 15 feet of the pavement edge shall be marked with a Type 2 or Type 3 object marker and shall be subsidiary to various bid items.

No asphalt material shall be placed between October 1st and May 1st unless otherwise directed by the Engineer in writing.

No asphalt emulsion shall be used with the pre-coated aggregate on this project.

For these projects, a minimum of six (6) rollers (light pneumatic tire) in good working order will be required at all times. Rolling should be staggered pattern making a minimum of five passes per mat for asphalt cement and a minimum of three passes for emulsion.

When ordered by the Engineer, aggregate stockpiled for surface treatment shall be flushed with water to remove excessive dust particles. This work shall be done in such sequence that will permit free water to drain from the stockpiled aggregate prior to surfacing operations. This work will be considered subsidiary to various bid items. Application of asphalt shall cease two (2) hours before sunset unless otherwise directed by the Engineer.

The asphalt shall be CRS-2P unless otherwise approved by the Engineer. All emulsion delivered to the projects shall come from the same supply source.

Brownwood District

247 – Flexible Base

The stockpiled flexible base material shall not be greater than 16 feet in height.

275 – Portland Cement Treated Materials (Road Mixed)

If the Contractor excavates beyond normal structural excavation, the Contractor shall place Portland cement materials at hi/her own expense.

310 – Prime Coat

If AE-P is used for prime, sanding may be required at intersections, drives and other areas as directed by the Engineer.

314 – Emulsified Asphalt Treatment

The emulsified asphalt shall be SS-1 unless otherwise directed by the Engineer.

The approximate top 1 in of all base material to be finished for final surfacing shall be processed with emulsified asphalt to conformity with a typical sections shown on the plans and to the established lines and grades as directed by the Engineer.

The percent of emulsified asphalt in the mixture of asphalt and water shall be from 1% to 25% as directed by the Engineer.

316 – Surface Treatment

The precoating asphaltic material for Item 316 aggregate shall be PG 64-22 or CSS-1H emulsion.

Asphalt material for final surface shall be placed between May 1 and October 1 unless otherwise directed by the Engineer.

MC-2400 will be used for wintertime applications unless otherwise directed by the Engineer. If MC-2400 is used a curing time of 90 days will be required before the next surface course may be applied.

State personnel will run an asphalt transverse distribution check on the Contractor's distributor prior to its use on surfacing items, unless otherwise directed by the Engineer.

The asphalt rates shown hereon are for average conditions. The rate may be varied as determined by the Engineer to obtain proper embedment of aggregate.

Light pneumatic rolling, in accordance with Item 213 "Rolling (Pneumatic Tire)" at the rate directed by the Engineer, will be required under this item.

Childress District

Notes Set 1

300 – ASPHALTS, OILS AND EMULSIONS
State personnel will check the calibrations and perform an asphalt transverse distribution check on the contractor's distributor prior to its use on surfacing items, unless otherwise directed by the Engineer.

This calibration shall insure that the distributor meets or exceeds the requirements listed below:

1) Extended spray bars should not be permitted until a check has been made using the bucket test. The percent variation from the mean should be random when comparing nozzle output along the bar. The percent variation from the mean of any individual nozzle should not be greater than +/- 10 percent.
2) Distribution nozzles should be checked using the bucket test and the percent variation from the mean of any nozzle should not be greater than +/- 10 percent.

The differential in the spray bar height shall not be greater than ½" between a full tank and an empty tank.

Each load of asphalt shall be sampled by the contractor and delivered to the Engineer within 24 hours.

302 – AGGREGATES FOR SURFACE TREATMENT

The Engineer prior to stockpiling aggregates will approve stockpile locations.

The contractor may, at his option, use ASTM DD448 size No. 7 in lieu of TY B, Gr. 4 aggregate.

SIEVE	GRADE 4 (MOD) ASTM D448 SIZE NO. 7% RETAINED.
¾"	0
5/8"	….
½"	0-10
3/8"	30-60
No. 4	85-100
No. 8	95-100
No. 10	….
No. 200	98.5-100

316 – SURFACE TREATMENTS

A stringline shall be visible to the distributor operator on all applications. All stringlines shall be removed and disposed of by the contractor upon completion of the operation.

The asphalt for use in precoating the aggregate shall be treated with an adhesion modifier (AKZO NOBEL REDICOTE CS-329S or equivalent) at a percentage between 1% and 2% as determined by the Engineer. The addition of adhesion modifier to the asphalt will not be paid for directly but will be considered subsidiary to this bid item. Light weight aggregate does not require an adhesion modifier.

Open season for the application AC asphalt shall be from May 1st to September 15th unless authorized by the Engineer.

Stockpiling of aggregates may begin at any time after issuance of the work order for this project. However, prior to stockpiling activities the contractor shall contact the maintenance supervisor in each county to verify each roadway's ability to withstand haul truck traffic and stockpile locations.

If the wind exceeds 20mph, no asphalt surface treatment shall be applied unless authorized by the Engineer. The wind velocity is to be determined by the Engineer using a wind meter.

100% of item 213 "Rolling (Med Penumatic tire)" shall be performed immediately after the application of the asphalt and aggregate and completed prior to the next application of asphalt and aggregate.

The Engineer at his discretion may check transport loading, weighing and unloading.

SPECIAL PROVISION 316---XXX for Surface Treatments

For this project, Item 316, "**Error! No text of specified style in document.**," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Article 316.6 Payment. Asphalt that is incorporated into the work and has been tested and found defective will be paid for as indicated in the chart below.

PAY ADJUSTMENT FACTORS FOR VISCOSITY AT 275 F POISE TEST PROCEDURE T202

AC-5 w/2% SBR	**AC-15P**	**AC-20 5TR**
7.1 -7.5: 0.95 of Bid Price	8.1 – 8.5: 0.95 of Bid Price	10.1 – 10.5 .95 of Bid Price
7.6 – 8.0: 0.90 of Bid Price	8.6 – 9.0: 0.90 of Bid Price	10.6 – 11.0 .90 of Bid Price
8.1 and above: 0.85 of Bid Price	9.1 and above: 0.85 of Bid Price	11.1 and above .85 of Bid Price

PAY ADJUSTMENT FACTORS FOR PENETRATION TEST PROCEDURE T 49

AC-5 w/2% SBR	**AC-15P**	**AC-20 5TR**
119 – 115: 0.95 of Bid Price	99 – 95: 0.95 of Bid Price	74 – 70: 0.95 of Bid Price
114 – 110: 0.90 of Bid Price	94 – 90: 0.90 of Bid Price	69 – 65: 0.90 of Bid Price
109 and below: 0.85 of Bid Price	89 and below: 0.85 of Bid Price	64 and below: 0.85 of Bid Price

PAY ADJUSTMENT FACTORS FOR ELASTIC RECOVERY TEST PROCEDURE TEX-539-C

AC-5 w/2% SBR	**AC-15P**	**AC-20 5TR**
NA	54 – 50: 0.95 of Bid Price	54 – 50: 0.95 of Bid Price
	49 – 45: 0.90 of Bid Price	49 – 45: 0.90 of Bid Price
	44 – 40: 0.85 of Bid Price	44 – 40: 0.85 of Bid Price

The Pay adjustment factors above will be applied to individual loads of Asphalt. The pay adjustment factors will be cumulative for each failing property. Example AC 15 P that has Penetration of 92 and a elastic recovery of 52 would have a 15% pay reduction.

Comment: I intend to have a excel program that would calculate the payment similar to the hot mix pay adjustment factors. The User would input the 2 or three test results above along with the quantity of asphalt to determine payment.

Dallas District

Notes Set 1

310 –

The use of cut back asphalts other than MC-30 for printing base courses will be prohibited between April 16 and September 15 unless approved in writing by the Engineer.

The Contractor shall allow the prime coat to penetrate the finished flexible base course. After priming operations have been completed, the Contractor shall remove any excess prime coat from the roadway. This work shall be done by a method approved by the Engineer, and will be considered as subsidiary to this bid item.

The Contractor shall furnish flaggers, signs, or other traffic control devices, as necessary, to direct and keep traffic off the prime coat, until it has had sufficient time to penetrate the base course.

310 and 316 –

No asphalt material shall be placed between September 1 and May 1, except by written permission of the Engineer.

316 –

Surface Treatment Data

Prime coat application rate: (MC-30)	0.25 gal per sq yd
1^{st} course asph. Appl. Rate: (AC-15P)	0.32 gal per sq yd
1^{st} course aggr. Appl. Rate: (TY B GR 4)	1 cy per 105 sq yd
2^{nd} course aggr. Appl. Rate: (AC-15P)	0.38 gal per sq yd
2^{nd} course aggr. Appl. Rate: (TY PB GR 3)	1 cy per 95 sq yd

Rolling shall conform to the requirements of medium pneumatic tire roller (type B), and will be performed, as directed by the Engineer. A minimum of two (2) rollers for the two course surface treatment applications shall be required. The Contractor may be required to use steel wheel rollers if deemed necessary by the Engineer.

The precoating asphaltic material shall be PG 64-22.

The Contractor shall furnish flaggers, signs, or other traffic control devices, as necessary, to direct and keep traffic off the prime coat, until it has had sufficient time to penetrate the base course.

Notes Set 2

310 and 316 –

Surface Treatment Data

Prime coat application rate: (MC-30 or SS-1)	0.25 gal per sq yd
1^{st} course asph. Appl. Rate: (CRS-1P)	0.45 gal per sq yd
1^{st} course aggr. Appl. Rate: (TY B GR 4)	1 cy per 105 sq yd
2^{nd} course aggr. Appl. Rate: (AC-15P)	0.38 gal per sq yd
2^{nd} course aggr. Appl. Rate: (TY PB GR 3)	1 cy per 95 sq yd

Rolling shall conform to the requirements of medium pneumatic tire roller (type B), and will be performed, as directed by the Engineer. A minimum of two (2) rollers for the two course surface treatment applications shall be required. The Contractor may be required to use steel wheel rollers if deemed necessary by the Engineer.

The precoating asphaltic material shall be PG 64-22.

The aggregate will be evaluated for moisture susceptibility (test method TEX-530-C) following the precoat process. A minimum one (1) percent antistrip, by weight of asphalt that conforms to the requirements of Item 301 will be required to improve the overall quality of the aggregate.

Five cycle magnesium sulfate soundness loss (test method TEX-411-A) shall be no greater than 20 percent.

The aggregate for surface treatment of the travel lanes shall be a minimum class of B as published in the aggregate quality monitoring program rated source quality catalogue.

No work under this item shall be conducted later than one (1) hour before sunset, unless otherwise approved by the engineer.

The Contractor shall schedule and control his work so that mineral aggregate is applied immediately after asphalt application.

The use of cut back asphalts other than MC-30 for priming base courses will be prohibited between April 16 and September 15 unless approved in writing by the Engineer.

The Contractor shall allow the prime coat to penetrate the finished flexible base course. After priming operations have been completed, the Contractor shall remove any excess prime coat from the roadway. This work shall be done by a method approved by the Engineer, and will be considered as subsidiary to this bid item.

The Contractor shall furnish flaggers, signs, or other traffic control devices, as necessary, to direct and keep traffic off the prime coat, until it has had sufficient time to penetrate the base course.

Notes Set 3

316 –

Surface Treatment Data

Prime coat application rate: (MC-30)	0.25 gallons per square yd
1st course asph. Appl. Rate: (CRS-1P)	0.45 gallons per square yd
1st course aggr. Appl. Rate: (TY B GR 4)	1 cu. yd. per 105 sq. yd
2nd course aggr. Appl. Rate: (AC-15P)	0.38 gallons per square yard
2nd course aggr. Appl. Rate: (TY PB GR 3)	1 cu. yd. per 95 sq. yd

Roll in conformance to the requirements of a medium pneumatic tire roller (Type B), and as directed. Provide a minimum of 2 rollers for the two course surface treatment applications. Use steel wheel rollers if directed.

Use PG 64-22 precoating asphaltic material.

The Department will evaluate the aggregate for moisture susceptibility, using Test Method Tex-530-C, following the precoat process. A minimum of 1% antistrip, by weight of asphalt in conformance with the requirements of Item 301, is required to improve the overall quality of the aggregate.

Five cycle magnesium sulfate soundness loss (Test Method TEX-411-A) must be less than or equal to 20%.

Do not conduct work under this item later than 1 hr. before sunset, unless otherwise approved.

Schedule and control work so that mineral aggregate is applied immediately after asphalt application.

Notes Set 4

301 –
All requirements of Item 301 for testing of the mixture during mix design and production are applicable. Plant produced mixture will be tested in accordance with test method TEX 530-C and a maximum stripping of 5 percent is allowed. Effectiveness of the antistripping agent will be evaluated at the following rate: Lime in slurry form at 1.0%, 1.5%, or 2% by dry weight of aggregate. Liquid agents at 0.5%, 0.75%, or 1% by weight of the asphalt in the mixture but shall not exceed the amount recommended by the manufacturer.

This test procedure is subjective where a percent is determined according to a visual inspection of the test sample. It is preferred to allow 0% or no evidence of stripping.

316 –
When wind velocities are sufficient to produce noticeable distortion of the spray from the distributor bar, asphaltic materials cannot be placed.

After completion of any section of surface treatment, aggregate will be properly rolled and swept off as soon as practical prior to opening for traffic. All surface treatment operation will be planned so that rolling and sweeping of excess aggregate will be accomplished before the end of each day's operation.

Notes Set 5

301 –
All requirements of Item 301for testing of the mixture during mix design and production are applicable. Plant produced mixture will be tested in accordance with test method TEX 530-C and a maximum stripping of 5 percent is allowed. Effectiveness of the antistripping agent will be evaluated at the following rate: Lime in slurry form at 1.0%, 1.5%, or 2% by dry weight of aggregate. Liquid agents at 0.5%, 0.75%, or 1% by weight of the asphalt in the mixture but shall not exceed the amount recommended by the manufacturer.

The test procedure is subjective where a percent is determined according to a visual inspection of the test sample. It is preferred to allow 0% or no evidence of stripping.

316 –
When wind velocities are sufficient to produce noticeable distortion of the spray from the distributor bar, asphaltic materials cannot be placed.

After completion of any section of surface treatment, aggregate will be properly rolled and swept off as soon as practical prior to opening for traffic. All surface treatment operation will be planned so that rolling and sweeping of excess aggregate will be accomplished before the end of each day's operation.

El Paso District

247 – Flexible Base
Tolerances as outlined under article 247.2(%)(A) and 247.2(%)(B) for gradation and plasticity index, under section 247.3(F) subsection (I) for density will be allowed.

All flexible base shall be crushed limestone and have a minimum triaxial class of 3 as determined using TEX-11-E (part 1).

The base edge tapers shown on the typical section shall not be included for measurement and payment, but shall be considered subsidiary to item 247.

275 – Portland Cement Treated Materials (Road Mixed)
All flex base material shall have a sulfate content of less than 2000 ppm as determined using TEX-620-J.

314 – Emulsified Asphalt Treatment
Emulsified asphalt treatment shall be applied as a dust preventative as directed by the Engineer.

Emulsified asphalt to be placed as prime material on flexible base shall be applied as a mixture of 5%-10% emulsified asphalt to 95%-90% water. Emulsified asphalt shall be placed in various applications and incorporated into the top one inch of the flexible base during finishing operations.

Emulsified asphalt shall be applied as fog seal at rates and at locations as directed by the Engineer. This work will me measured and paid for under this item.

316 – Surface Treatments
Asphalt anti-stripping agent (liquid) shall be used only in the asphalt precoating the aggregate and shall be used in accordance with item 301.

AC-20 shall be used for precoating Gr 3 PB and Gr 4 PB aggregate.

The Engineer prior to application shall specify the rate of asphalt application. Different rates of application may be specified by the Engineer. The rates of application, shown in the bases of estimate, are for estimating purposes.

Two rollers shall be required and shall conform to the medium pneumatic roller of item 213.

Flat-wheel rollers described in article 210.2(2) for surface treatments shall be used when directed by the Engineer.

Before opening any roadway to traffic, all surplus aggregate shall be broomed from the roadway surface.

The flakiness index for the aggregate, as determined by test method TEX-224-F, shall not exceed 14.

The minimum surface aggregate classification for this item shall be “A”.

All material stockpiles for this item “aggregate for surface treatments” shall be located in such a manner which complies with the traffic control details.

Asphaltic material shall not be placed from October 1 to April 15 unless otherwise authorized, in writing, by the Engineer.

Houston District

Notes Set 1

247 – Flexible Base
Flexible base shall be placed in courses not to exceed eight (8) inches loose measurement or as directed by the Engineer. Flexible base requiring two or more mixtures of material shall be mixed in an approved stationary mixer of the pugmill type. Material passing the No. 40 sieve shall be known as soil binder.

Tolerances with respect to specified gradation and Plasticity Index provided under this specification are permitted when approved by the Engineer.

All base material furnished shall be of one type unless authorized by the Engineer.

All courses shall be compacted to a minimum density of ninety-five (95) percent of the maximum density as determined by test method TEX-113-E.

Sandstone will not be permitted.

310 – Prime Coat (Cutback Asphaltic Material)
Asphaltic material (MC-30 or PCE) shall be used for new flexible base and salvaged flexible base to be surfaced and shall be placed as directed by the Engineer.

316 – Surface Treatment
The asphalt cement used for this Item shall be modified with either latex of SBS (Styrene-Butadiene Styrene) additives. If a latex modified asphalt is selected it shall consist of AC-55 or AC-10 asphalt cement to which has been added a minimum of 2.0 percent by weight styrene-butadiene rubber latex. If an SBS modified asphalt is selected it shall consist of an asphalt cement to which has been added a minimum of three (3) percent by weight of the SBS additive, to achieve the properties meting the requirements for AC-15P.

Placement of one course surface treatment shall be limited to the period of April 1 to October 31, inclusive, except that if in the opinion of the Engineer weather conditions warrant an extension of the placement period, such extension will be permitted when approved in writing by the Engineer.

Rolling under Item 213 will be limited to light pneumatic type.

The rate of asphalt application shown on the “Basis of Estimate” is an average rate for calculating asphalt quantities; this rate shall be varied as deemed necessary based on pavement conditions and other factors such as type and grade of aggregate used, weather, traffic, etc.

Notes Set 2

247 – Flexible Base
Place the flexible base of the thickness indicated on the plans. Mix flexible base that requires two or more mixtures of material, in an approved stationary pugmill type mixer. Material passing the No. 40 sieve is known as soil binder.

Tolerances relating to a specified gradation and to a plasticity index under this specification are permitted.

Furnish one type of the base material unless authorized.

Compact the courses to a minimum density of 95 percent of the maximum density as determined using test method TEX-113-E.

292 - Asphalt Treatment (Plant-Mixed)
341 – Dense-Graded Hot Mix Asphalt (QCQA)

Rap materials salvaged from within this project (or other approved state projects) may be used to compose up to 10 percent of the bas course. RAP stockpiles intended for this use must be approved by the Area Engineer prior to their use.

292 - Asphalt Treatment (Plant-Mixed)

Compact the courses to a minimum density of 95 percent of the maximum density as determined using test method TEX-126-E.

Meet grade 2 requirements.

Use the following asphalt binder to manufacture the asphalt treatment under this item:

PG 64-22

Provide asphalt treatment with a laboratory molded density of 96 percent plus or minus 1.5 percent. The minimum stability is 30 percent. For nominal aggregate size less than 0.5 in., design the mix in accordance with test method TEX 204-F.

Assume responsibility for proportioning the materials entering the asphalt mixture, regardless of the type of plant used.

Furnish the mix designs for approval.

Dilution of tack coat is not allowed.

302 – Aggregates for Surface Treatments
Provide coarse aggregates in surface courses with a minimum surface aggregate classification of Class A, as listed in the Rated Source Quality Catalog of the Aggregate Quality Monitoring Program. No blending is allowed for this project.

Notes Set 3

247 – Flexible Base
Place the flexible base in courses a maximum of 8 in. thick (loose measurement). Mix flexible base that requires two or more mixtures of material, in an approved stationary pugmill type mixer. Material passing the No. 40 sieve is known as soil binder.

Tolerances relating to a specified gradation and to a plasticity index under this specification are permitted.

Furnish one type of the base material unless authorized.

Compact the courses to a minimum density of 95 percent of the maximum density as determined using test method TEX-113-E.

Sandstone aggregate is not permitted.

302 – Aggregates for Surface Treatments
303 – Aggregates for Surface Treatments (Lightweight)

Provide coarse aggregates in surface courses with a minimum surface aggregate classification of Class A, as listed in the Rated Source Quality Catalog of the Aggregate Quality Monitoring Program.

310 – Prime Coat (Cutback Asphalt Material)
Use asphalt material (MC-30) for new flexible base and for salvaged flexible base to be surfaced and place as

directed.

316 – Surface Treatments
Placing one course surface treatment is limited to the period of April 1 to October 31, inclusive. Obtain written approval if weather conditions warrant an extension of the placement period.

Limit rolling to the light pneumatic type, as specified in Item 213.

The asphalt application rate shown on the "Bases of Estimate" is an average rate for calculating asphalt quantities. This rate may vary based on the pavement conditions and other factors such as the type and grade of aggregate used, weather, and traffic.

Lufkin District

302 – Aggregates for Surface Treatments

Type E, Grade 4 aggregate shall be aggregate consisting of basalt. Type PE, Grade 3 and Type PE, Grade 4 shall be precoated aggregate consisting of crushed stone or natural limestone rock asphalt.

316 – Surface Treatments

When ordered by the Engineer, aggregate stockpiled for surface treatment shall be flushed with water to remove excessive dust particles. This work shall be done in such sequence that will permit free water to drain the stockpiled aggregate prior to surfacing operations. This work will be considered subsidiary to various bid items.

The uniformity and rate of distribution of asphaltic material will be checked periodically during construction as directed by the Engineer. The seal coat shall be applied in lane widths unless otherwise directed by the Engineer. Where extra width of surfacing has been provided in transitions and climbing lanes, the entire width of surface shall be sealed.

The rates of application of asphalt and aggregate shown hereon are for estimating purposes only. The actual rates to be used during construction will be as directed by the Engineer and may vary from lane to lane and at intersections.

The limits of each seal coat reference may be varied by the Engineer. The seal coat limits at each intersection shall be field verified prior to placement of seal coat at the intersection. Payment will be made by actual quantities used.

The Contractor will be required to resurface turnouts, cross-overs, and county road and connecting highway intersections, as directed by the Engineer. These areas will be paid under a separate bid item and are summarized elsewhere in the plans. The sequence of work shall provide for surfacing of these areas prior to surfacing of the roadway.

The Contractor shall be responsible for marking off the length of each shot.

Application of asphalt shall cease two (2) hours before sunset unless otherwise directed by the Engineer.

AC-20-5TR asphalt material shall meet the requirements of ASTM Test 5546 with a minimum solubility of 98%.

Minimum AC-20-5TR asphalt temperature shall be 330 degrees F.

Medium pneumatic tire rollers shall be used for surface treatment work and shall conform to Item 213, “Rolling (Pneumatic Tire)”. A minimum of four (4) operational rollers shall be in use at all times. A minimum of three (3) roller passes shall be performed on each project. The Contractor shall furnish one back up medium pneumatic roller which will be available for use at each project site.

The Contractor may use both lightweight and hard rock aggregate on this project; except where shown otherwise in the plans, but shall not mix rock types on the same road.

Excess aggregate on the roadway surface shall be broomed as directed by the Engineer.

It is the Contractor’s responsibility to order and deliver enough aggregate to allow for loss at the stockpile.

Surplus stockpile aggregate will be measured and paid for under Item 316-817 “AGGR (STKPL) (TY PE, GR 3 OR TY PL, GR 3)”, or Item 316-537 “AGGR (STKPL) (TY PE, GR 4, OR TY PL, GR 4)” or item 316-895 “AGGR (TY E, GR 4) (STKPL)”. The maximum combined total quantity for payment for all types of aggregate shall be 400 CY, unless otherwise approved by the Engineer in writing. Each type of aggregate shall be pushed up into one pile at each location.

Material shall be pushed up into one pile at each stockpile location, when directed by the Engineer. Upon completion of each project reference all stockpile sites shall be clear of debris and dressed up in a manner approved by the Engineer.

Aggregate stockpile locations proposed by the Contractor shall meet the approval of the Area Engineer prior to stockpiling.

All stockpile locations shall be cleaned by the Contractor prior to placement of the aggregate. The site can be cleaned either by mowing or scraping. Cleaning or stockpile sites will be considered subsidiary to various items.

Any change in stockpile locations shall be approved by the Engineer prior to placement of the aggregate.

When asphalt is being transferred from the transport to the asphalt distributor, precautions shall be taken to prevent asphalt from spilling during this operation. If asphalt is spilled during seal coat operations it shall be cleaned up and properly disposed of.

All roadways shall be cleaned with a broom prior to and after the placement of the surface treatment to remove any loose or excess material debris. A vacuum broom shall be required on all roadway sections having curb and gutter and all roadway sections within the city limits of any city. All other locations shall be cleaned with a rotary type broom.

247 – Flexible Base

Stockpiling of base material will not be required if testing has been performed and the material has been approved at the source. The Contractor shall be responsible for delivering approved specified materials to the project.

260 – Lime Treatment for Materials Used As Subgrade (Road Mixed)

Limits of lime treated subgrade may be varied as directed by the Engineer.

275 – Portland Cement Treated Materials (Road Mixed)

Removal and disposal of excess material form the pulverizing, mixing and finishing operations shall be the responsibility of the Contractor. The excess material shall be deposited at a site approved by the Engineer. This work will be considered subsidiary to Item 275.

Stabilized sections shall be compacted and sprinkled for dust control as directed by the Engineer for traffic use.

Prior to adding cement, the existing pulverized material shall be at least two (2) percent below optimum moisture and then dry mixed with the cement.

302 – Aggregates For Surface Treatments

Type E aggregate shall consist of crushed stone, or natural limestone rock asphalt.

Type PE aggregate shall be precoated aggregate consisting of crushed stone, or natural limestone rock asphalt.

316 – Surface Treatments

Aggregate stockpile locations proposed by the Contractor shall meet the approval of the Engineer prior to stockpiling.

When ordered by the Engineer, aggregate stockpiled for surface treatment shall be flushed with water to remove excessive dust particles. This work shall be done in such sequence that will permit free water to drain from the stockpiled aggregate prior to surfacing operations. This work will be considered subsidiary to various bid items.

Coarse aggregates for the surfaces of travel lanes shall be a minimum class of B as published in the “Aggregate Quality Monitoring Program Rated Source Quality Catalogue”.

Asphalt shall not be placed from October 1 through May 1 without the Engineer’s written approval.

The rates of application of asphalt and aggregate shown hereon are for estimating purposes only. The actual rates to be used during construction will be as directed by the Engineer and may be from lane to lane and at intersections.

The sequence of work shall provide for surfacing of driveways and road turnouts prior to final surfacing of the roadway.

Application of asphalt shall cease two (2) hours before sunset unless otherwise directed by the Engineer.

The second course of the two-course surface treatment shall not be placed until the first course has adequately cured to the satisfaction of the Engineer.

AC-20-5TR material shall meet the requirements of ASTM Test 5546 with a minimum solubility of 98%.

Te desired asphalt will be determined and selected by the Engineer from the following:		
Primecoat	Anytime when needed for traffic	RC 250
First Course	May 1 through October 1 October 1 through may 1	AC-15P CRS-1P
Second Course	May 1 through October 1	AC-20-5TR

The Contractor shall use the following schedule for aggregate:		
Primecoat	With RC 250 under traffic	Type E or L Grade 5
First Course	When AC-15P used When CRS-1P is used	Type PE or PL Grade 3 Type E or L Grade 3
Second Course		Type PE or PL Grade 4

The closed season for asphalts may be eliminated, with written permission of the Engineer, for surface treatments that will not carry traffic.

Medium pneumatic rollers shall be used for surface treatment work and shall conform to Item 213, “Rolling (Pneumatic Tire)”. The Contractor shall provide enough rollers to perform the work to the satisfaction of the Engineer.

The roadway shall be cleaned with a rotary type broom prior to and after the placement of the surface treatment to remove any loose or excess material or debris, unless otherwise directed by the Engineer.

Lubbock District

302 – Aggregates for Surface Treatment
Precoat aggregate with asphalt of the type and grade approved by the Engineer. Use an anti-stripping agent, of the type and at a rate approved by the Engineer. The use of flux oil is not permitted.

Cure precoated aggregate a minimum of 72 hours before applying the aggregate to the roadway surface.

NOTE 3 required for Grade 5
The Engineer reserves the right to waive flakiness index testing (Test Method TEX 224-F).

District Soundness Chart for designer's information only

Current ADT	*Surface Treatment*
0-750	*25*
750-2000	*25*
2000-5000	*20*
>5000	*18*

NOTE 4 required: replace xx with correct value from district soundness chart, no note is required if using default of 25.
Aggregate will be subjected to five cycles of the magnesium sulfate soundness test in accordance with Test Method TEX-411-A. The loss shall not be greater than XX percent.

NOTE 5 <u>FOR MAINTENANCE CONTRACTS, OR LOW ADT, ONLY.</u> This note is required for Type "E".
Use crushed gravel, crushed slag, or crushed stone for Type E aggregate, with a minimum 70 percent of the particles retained on the #4 sieve having at least one mechanically induced crushed face.

310 – Prime Coat
Apply a prime coat to all finished flexible and salvage base due to receive asphaltic concrete pavement or surface treatments.

Cure the prime coat for a minimum of 72 hours before placing any asphaltic material on the primed surface, unless authorized by the Engineer.

316 – Surface Treatments
Do not place AC asphalt between September 1 and April 30, unless authorized by the Engineer. Cure CRS-1P asphalt for 30 days before applying the second course or hot mix, if it is used on the first course.

Remove all excess aggregate by brooming after sufficient curing has occurred but no later than the end of the day, as directed by the Engineer. Remove all excess aggregate from the project in curb and gutter sections, and other areas as directed by the Engineer.

Schedule the placement width for all asphalt surfaces in a manner such all joints will coincide with proposed lane lines (+/- 6 inches).

Cover or protect any sealed expansion joints or rail on bridges and any railroad tracks encountered on this project, as directed by the Engineer. Clean any of these items not properly protected. This work will not be paid for directly but will considered subsidiary to Item 316.

Leave signs and barricades in place until all brooming and the application of the center stripe is completed, unless otherwise directed by the Engineer/

Set a string line for all surface treatment operations, unless authorized by the Engineer. Remove the string line daily.

NOTE 7 Optional *(Light is default)*
Use Medium pneumatic tire rollers, as directed by the Engineer.

NOTE 7B optional
Do not use flat wheel rollers.

Apply lime water as directed, if in the opinion of the Engineer the pavement temperatures are becoming, or are expected to be, so elevated that the pavement surface could begin picking up under traffic. Failure to do so will be cause for rejection and re-work of sections of roadway damaged by traffic at the Contractor's expense. Payment will be made for the application of lime water as provided for in Articles 4.2 and/or 9.5 in the Standard Specifications.

Asphalt storage tanks may be used.

Paris District

247 – Flexible Base

Grading Requirements
TESTS TO BE IN ACCORDANCE WITH TXDOT STANDARD TEST METHODS

	SOIL CONSTANTS		
ITEM DESCRIPTION	LINEAR SHRINKAGE MAX	LL MAX	WET BALL MAX
247 FLEX BASE	6.0	40	40

SIEVE	PERCENT RETAINED
1-3/4"	0
7/8"	10-35
3/8"	30-50
NO. 4	45-60
NO. 40	70-85

The standard wet ball mill test, test method TEX-116-E, shall be used to test the base material. The increase in soil binder shall not be greater than 20 percent.

The base material shall be subjected to the 5 cycle soundness test in accordance with the Test Method TEX-411-A. The loss shall not be greater than 35 percent when magnesium sulfate is used.

Material under this item shall contain not more than one (1) percent by weight, clay balls and shall be practically free of soil, loam or vegetative matter. Percent clay balls shall be determined from a representative sample of base material at approximate compaction ration moisture. The base material shall be separated into the plus No. 4 and the minus No. 4 material by use of a No. 4 sieve. The clay balls shall be removed manually from the Plus No. 4 material and then clay balls and the remainder of the sample shall be dried to constant weight. Any aggregate or binder embedded in the clay balls shall be considered as part of the clay balls. The percent clay balls shall be computed by dividing the dry weight of the clay balls by the dry weight of the total and multiplying by 100.

251 – Reworking Base Material
Existing asphalt surface material shall be broken down to a maximum size of two (2) inches, removed from the roadbed and stockpiled. Salvaged base material (RAP shall be temporarily stockpiled on State right of way. Contact the Rains County Maintenance Supervisor at (903) 473-2682 at least one (1) week prior to this operation so he may designate the location to place the material. This work will not be paid for directly, but shall be subsidiary to this bid item. Reworking of the existing base will be paid for only once, regardless of the number of the manipulations involved.

The Contractor will be required to maintain a grade book of elevations for this project. At each 100-foot station, this will consist of:

1) Elevations of original centerline;
2) Centerline and edge of reworked base elevations, after the reworked base is graded to a smooth profile, and has been approved by the Engineer;
3) Alignment and elevation hubs for centerline and outside edge of cement treated subgrade elevations; and
4) Alignment and elevation hubs of new base at the centerline and proposed edge of pavement.

The field book of elevations shall be copied after each land operation and provided to the Engineer. The Engineer will then spot check and any elevation discrepancy of 0.04 feet or greater will be just cause for non-approval of that land. The Contractor will make necessary corrections to the satisfaction of the Engineer before subsequent operations are allowed.

Although plan vertical profile data is provided, the intent is to construct this project as a typical roadway rehabilitation project using conventional methods, except within the limits labeled as “Grade Control” on the roadway plan and profile sheets. At these “Grade Control” locations, vertical grade control will be required. This work shall not be paid for directly, but shall be considered subsidiary to the various bid items.

At each end of the project and adjacent to bridge decks or other fixed objects (where finished elevations are committed to tying into an existing elevation), a 100-ft vertical transition must occur. In this transition, the existing base must be salvaged off and adequate subgrade discarded to accommodate the construction of the proposed typical section within these limits. This work is shown on the “Vertical Transition Detail” sheet in the plans and will not be aid for directly, but will be considered as subsidiary to the various contract items.

275 – Portland Cement Treated Materials (Road Mixed)
For this project, 16” cement treated salvage and flexible base shall be processed in two layers. This first layer shall consist of approximately 6” salvage base material. The second layer shall be 10” of flexible base.

Trucks furnishing cement with weights certified on public scales shall be selected at random and weighed on public scales in the vicinity of the project, under the supervision of the Engineer. The number of trucks selected for weighing will be based on approximately ten percent of either the number of trucks or the total weight of cement that will be required for the completion of this project. The net load shown on the supplier’s weight ticket will be acceptable, if the observed net weight is within two (2) percent of the weight. All loads shall be weighed until three consecutive loads are within two (2) percent and then from that point on, the random weighing, as described above, will be resumed.

310 – Prime Coat (Cutback Asphaltic Material)
The Contractor shall allow the prime to penetrate the finished flexible base course (either virgin flex base or rap material). After priming operations have been completed, the Contractor shall remove any excess prime from the roadway. This shall be done by a method approved by the Engineer, and will not be paid for directly, but shall be considered subsidiary to this item.

The Contractor shall furnish flaggers, signs, or other traffic control devices, as necessary, to direct and keep traffic off the prime coat, until it has had sufficient time to penetrate the base course.

If the Contractor elects to prime with SS-1, it will be mixed with the top ¼ inch of flexible base during finishing operations.

In the curb and gutter section, the Contractor shall prime the finished cement treated subgrade prior to placement of the asphalt stabilized base course.

316 – Surface Treatments
Asphalt for one course surface treatment and for the second course of the two course surface treatment will be AC-20-%TR, or as directed by the Engineer, based on weather and field conditions.

Rolling shall conform to the requirements of medium pneumatic tire roller (Type B), and will be performed, as directed by the Engineer. A minimum of two (2) rollers for the two course surface treatment applications shall be required and a flat wheel roller shall be available for use, as deemed necessary by the Engineer.

The precoated asphaltic material used on the second course shall be PG 64-22.

The aggregate will be evaluated for moisture susceptibility (Test Method TEX-530-C) following the precoat process. A minimum one (1) percent, by weight of the asphalt, antistrip, that conforms to the requirements of Item 301, “Asphalt Antistripping Agents,” will be required to improve the overall quality of the aggregate. There shall be no evidence of stripping when tested by the Test Method TEX 530-C.

Five-cycle magnesium sulfate soundness loss (Test Method TEX-411-A) shall be no greater than 20 percent.

The aggregate for surface treatment of the travel lanes shall be a minimum Class A, as published in the Aggregate Quality Monitoring Program Rated Source Quality Catalogue.

No work under this item shall be conducted later than one (1) hours before sunset, unless otherwise approved by the Engineer.

The Contractor shall schedule and control his work so that mineral aggregate is applied immediately after asphalt application.

Asphalt rates shown may be adjusted by the engineer, depending on conditions encountered.

After completion of any section of surface treatment, aggregate will be properly rolled and swept off as soon as practical prior to opening for traffic. All surface treatment operations will be planned so that rolling and sweeping of excess aggregate will be accomplished before the end of each day’s operation.

When wind velocities are sufficient to produce noticeable distortion of the spray from the distributor bar, asphaltic materials cannot be placed.

San Angelo District

302 – Aggregates for Surface Treatment

Stockpile aggregates separately and label stockpiles with project number, material type, and grade.

316 – Surface Treatment

Furnish similar color aggregate from a common source for individual roadways.

Cure the first surface treatment course a minimum of __ days before placing the second course.

If cutback asphalt is used for the first surface treatment course, a minimum of __ days curing time shall be required before placing the second course. The Department will assume interim maintenance of the first course during the period provided that other items of work including clean-up have been completed as directed.

Asphalt application season is from __ to __ *(Insert dates).*

Keep concrete curbs and railing clean and free of asphalt and other stains during construction.

Do not place wet aggregate.

Use medium pneumatic rollers that meet the requirements of Item 210, “Rolling.”

Tyler District

316C) – Use on projects requiring surface treatment
Perform rolling as directed with equipment complying with Sections 210.2.D.2, "Medium Penumatic Tire." This work will not be paid for directly, but will be subsidiary to pertinent items.

316D) – Use on surface treatments to be overlaid.
For each project, complete surface treatment and allow surface to cure for 10 days before placing asphaltic concrete pavement unless authorized or directed.

316E) – Use on all surface treatment projects
Do not apply asphalt later than 1 hour before sunset unless otherwise approved.

316F) - Use on District surface treatment & other applicable projects
The Engineer will approve stockpile sites for materials. Locate stockpile site a minimum of 30 ft. from the roadway unless otherwise authorized. Place stockpiles in a manner that will not interfere with access from abutting property and will not obstruct traffic or sight distance. Avoid stockpiling at intersections. Notify the Engineer at least 5 working days prior to stockpiling material to secure approval of the site. The Engineer may approve stockpiling of materials closer than 30 ft. from the travelway if adequate barricades and devices are furnished and approved. Keep stockpile clear of debris and vegetative growth as approved.

316G) – Use on all surface treatment projects with pre-coated aggregates
Furnish aggregate pre-coated with an approved asphaltic material that covers over 90% of each aggregate. The aggregate should have a minimum 1% asphaltic pre-coating.

316H) – Use on all applicable projects
Provide aggregate for shoulders and mainlanes from the same source unless otherwise authorized or directed.

316I) – Use on projects that don't use latest start work date
Place surface treatment between May 1 and October 1 unless otherwise authorized or directed.

316J) – Use on all projects requiring surface treatment
The rates shown on the plans for asphalt and aggregate are for estimating purposes only. The rates may be varied as directed.

316K) – Use when using emulsions 31 days in summer and 90 days in winter
Two-course surface treatment should have a _ day minimum curing time in between application of the first and second course unless otherwise directed.

316L) – Comment: Use when allowing CRSP
The Contractor may use CRS-1P between October 1 and May 1, as directed, provided the air temperature does not exceed 60 degrees F during time of placement.

Waco District

Notes Set 1

SPECIFICATION DATA

(PERCENT RETAINED-SIEVE)

DESCRIPTION	2”	1 1/2”	#4	#40	PI MAX	PI MIN
FLEXIBLE BASE (TYPE A, GRADE 4)	0	0-10	45-75	70-85	12	4

1. This material shall be produced from a source which when tested in accordance with test method TEX-117-E, PART 1, shall meet the requirements of class material.

2. This material shall be produced from a source which when tested in accordance with test method TEX-116-E, the maximum wet ball mill value shall not exceed 45 and the maximum increase of material passing the No. 40 sieve shall not exceed 20 percent.

3. Job control samples for gradation and P.I. testing will be taken from the windrow after blade mixing.

(PERCENT RETAINED-SIEVE)

DESCRIPTION	2”	1 1/2”	#4	#40	PI MAX
FLEXIBLE BASE (TYPE E, GRADE 4)	0	0-10	45-75	65-85	18

1. This material shall be produced from a source which when tested in accordance with test method TEX-117-E, PART 1, shall meet the requirements of class 3.5 material.

2. This material shall be produced from a source which when tested in accordance with test method TEX-116-E, the maximum wet ball mill value shall not exceed 50 and the maximum increase of material passing the No. 40 sieve shall not exceed 20 percent.

3. Job control samples for gradation and P.I. testing will be taken from the windrow after blade mixing.

(PERCENT RETAINED-SIEVE)

DESCRIPTION	2”	1 1/2”	5/8”	#4	#40	PI MAX
ASPHALT TREATMENT (PLANT-MIXED) (GRADE 4)	0	0-10	10-45	40-65	70-80	10

The material passing the No. 200 mesh sieve shall generally be limited to 1/3 of the material passing the No. 40 mesh sieve.

ITEM 247: FLEXIBLE BASE

After the existing pavement is scarified and spread evenly over the proposed subgrade, incorporate additional flexible base into the scarified material. Spread the resulting mixture and compact to the required density as required for **ITEM 247** and to the lines and grades set forth in the plans and as directed by the Engineer.

Place the material in approximately equal courses not to exceed inches in depth per course. During mixing and laying operations, sufficient water shall be added to the material to insure that the moisture content is not less than optimum moisture as determined by test method **TEX-114-E**.

ITEM 251: REWORKING BASE MATERIAL

Salvaged material shall remain the property of the state and shall be stockpiled at the location designated on the title sheet.

Compact the reworked base material using Density Control method as directed in Item 251.

Some patches of cement or stabilized base may be encountered while reconditioning the existing base. If such material is encountered, it will be removed and disposed of as directed by the Engineer. This work will not be paid for directly but will be subsidiary to Item 251.

Indicated quantities of flexible base to be salvaged are for estimating purposes only. Salvage all acceptable base material encountered in the existing base, including intersection areas, as directed by the Engineer regardless of quantities involved. This work shall be paid for as specified in Item 251.

The flexible base used in the detour shall become the property of the state once the detour is no longer needed. Salvage this material and stockpile at a location approved by the Engineer. This work will be paid for under Item 251.

ITEM 260: LIME TREATMENT (ROAD-MIXED)

Weigh approximately five (5) percent of all truckloads or shipments of lime, which are eligible for payment on the project. Perform the weighing on certified public scales located at or near the project site in the presence of department personnel. Select the truckloads or shipments of lime, which are to be weighed, in a random manner as determined by the Engineer. Documentation from the certified public scales must show gross, tare and net weights. The producer’s delivery ticket must also show gross, tare and net weights. The contractor shall make every reasonable effort to see that the lime trailers are completely emptied at the project site. The cost of this operation will not be paid for directly, but will be considered subsidiary to this item.

ITEM 275: CEMENT TREATMENT (ROAD-MIXED)

Break the existing asphalt surface, if present, by scarifying or other approved methods as directed by the Engineer (and new base shall be added) prior to grading and shaping as specified in ARTICLE 275.4.A. Breaking up existing asphalt surfaces will not be paid for directly but will be considered subsidiary to Item 275.

This material must meet a minimum 7-day unconfined compressive strength of 175 psi.

Cure the cement treated material with an application of MS-2 or an emulsion approved by the Engineer at a rate of 0.2 gal/sy. The application of this material will not be paid for directly but will be considered subsidiary to Item 275.

ITEM 276: CEMENT TREATMENT (PLANT-MIXED)

Wet construction joints between new base and base previously placed and coat with dry cement prior to the addition of new base.

Strength class required for this material will be Class M.

Cure the cement treated material with an application of MS-2 or an emulsion approved by the Engineer at a rate of 0.2 gal/sy. The application of this material will not be paid for directly but will be considered subsidiary to Item 276.

ITEM 292: ASPHALT TREATMENT (PLANT-MIXED)

That part of the mineral aggregate retained on the No. 10 sieve shall be tested in accordance with test method TEX-406-A and the loss by decantation shall not exceed 2% when sampled from the hot bin or 3% when sampled from the cold feed or stockpile.

Evaluate the mixture proposed for use for moisture susceptibility in the mixture design stage by test method TEX-531-C, unless otherwise directed by the Engineer. For production testing and monitoring, test method TEX-530-C will be used to evaluate the mixture for moisture susceptibility. Maximum stripping of 0% is required. If more than 0% stripping occurs, additional anti-stripping agent may be required.

The minimum slow strength will be 40 PSI.

In place compaction control will be by ordinary compaction.

Use aggregates that meet the quality requirements shown in TABLE 1 as specified in ARTICLE 292.2(A).

ITEM 300: ASPHALTS, OILS & EMULSIONS

AC-20-5TR material shall meet ASTM TEST-D-5546 with minimum solubility of 98%.

Latex modifiers will not be allowed to acquire the specified PG grade.

ITEM 302: AGGREGATES FOR SURFACE TREATMENTS

Material produced by test method TEX-217-F PART II, passing the No. 40 sieve, is restricted to no more than 1% by weight.

The course aggregates to be used in surface courses shall have a minimum surface aggregate classification requirement of class for all travel lanes.

The pre-coated aggregate target value for residual bitumen shall be determined by the Engineer. This value shall be in the range of 0.5 to 1.5 % by weight of residual bitumen from a pre-coating material.

ITEM 310: PRIME COAT

When cutback asphalt is used, a minimum curing time of 7 days shall be required before application of item 316 unless otherwise authorized or directed by the Engineer in writing.

ITEM 314: EMULSIFIED ASPHALT TREATMENT

Apply emulsified asphalt treatment to areas as directed by the Engineer.

Prior to application, emulsion may be diluted with water up to a maximum dilution of one part emulsion to six parts water (14% diluted emulsion mixture) as directed by the Engineer.

Prior to application, PCE emulsion shall be diluted with water up to maximum dilution of one part PCE with seven parts water (12% diluted emulsion mixture) as specified and as directed by the Engineer.

ITEM 316: SURFACE TREATMENTS

The Engineer will select the asphalt for surface treatments from the types and grades shown on the plans.

No asphalt for surface treatment items will be placed between October 1 and May 1 for AC unless approved by the Engineer in writing.

No asphalt for surface treatment items will be placed between October 1 and April 1 for emulsions unless approved by the Engineer in writing.

All trucks hauling materials to be paid for by truck measurement shall be “struck off” prior to delivery to the project.

Protect all existing bridges, curbs, and other exposed concrete surfaces within the limits of these projects as much as practicable from asphalt materials by any method that is acceptable by the Engineer. Remove any excessive asphalt materials deposited on these surfaces in a manner approved by the Engineer at the contractor’s expense.

During application of the surface treatment, if existing conditions warrant, the lane widths, transitions, and intersection areas may be varied as directed by the Engineer.

Use a medium pneumatic roller meeting the requirements of Item 210 as directed by the Engineer. This work will be subsidiary to the various bid items.

All aggregate for each project shall come from the same source or blended sources.

Cure surface treatment for 4 days prior to placement of asphalt concrete pavement unless otherwise authorized or directed by the Engineer.

Remove dirt and debris that has accumulated in the curb and gutter sections prior to beginning paving. This work will be subsidiary to other items.

Notes Set 2

302 –
Material produced by test method TEX-217-F Part II, passing the No. 40 sieve, is restricted to no more than 1% by weight.

The course aggregates to be used in surface courses shall have a minimum surface aggregate classification requirement of class B for all travel lanes and shoulders.

316 –
No asphalt for surface treatment items will be places between October 1 and May 1 for Emulsion seal coat unless approved by the Engineer in writing.

Rates of application and quantities shown on the plans of surface treatment are for estimating purposes only. It shall be the contractor’s responsibility to verify all quantities prior to ordering and delivering materials. The asphalt rates will be adjusted as necessary to fit existing field conditions as agreed upon by the contractor’s designated project superintendent and the department’s designated project manager.

The asphalt distributor spray bar shall be equipped so that nozzles outside the wheel paths will, have an output of upto 30% more than the wheel paths. The nozzle configuration may be changed from project to project as directed by the Engineer. Nozzles will be furnished by the contractor.

For this contract, wind velocities in excess of 18mph shall be construed as inclement weather and work will be suspended. Wind velocities will be determined at the nearest airport to the area.

Excess surface material shall be broomed using a vacuum broom in curb and gutter sections and a rotary broom in all other sections. Brooming will not be paid for directly, but shall be considered subsidiary to the various bid items of the contract.

Used medium pneumatic roller meeting requirements of Item 210 as directed by the Engineer. This work will be subsidiary to the various bid items.

Stockpile sites for material shall be approved by the Engineer and shall be located as far as possible from the travelway and in no instance closer than 30 FT unless otherwise authorized by the Engineer. They shall be kept clear of improved abutting property and, in general, locations at intersections shall be avoided in order than sight distance will not be impaired. The contractor shall notify the Engineer at least 5 days prior to stockpiling of materials closer than 30FT from the travelway provided that adequate barricades and warning signs and devices are provided by the contractor and approved by the Engineer. Stockpile sites for material shall be leveled and cleared of all vegetation prior to materials being stockpiled. Stockpile sites shall be kept clear of debris and vegetative growth in a manner approved by the Engineer.

Stockpile locations shall be cleared and sites shall be revegetated prior to partial acceptance of individual projects. This work will not be paid for directly, but shall be considered subsidiary to the various bid items of the contract.

All trucks hauling materials to be paid for by the truck measurement shall be “struck off” prior to delivery to the project.

A patch truck and crew will be required behind the aggregate spreader box as directed by the Engineer.

All aggregate for each project shall come from the same source.

Notes Set 3

300 – Asphalts, Oils, & Emulsions
AC-20-5TR material shall meet ASTM TEST-D-5546 with minimum solubility of 98%.

AC-20-5TR shall be tested for elastic recovery, in lieu for ductility, in accordance with ASTM D-5892-96 (REF. 6.2). The percent recovery shall be 55 minimum.

Latex additives or modifiers will not be allowed on this project.

302 – Aggregates for Surface Treatments
Material produced by test method TEX-217-F PART II, passing the No. 40 sieve is restricted to no more than 1% by weight.

The course aggregates to be used in surface courses shall have a minimum surface aggregate classification requirement of class B for all travel lanes and shoulders. No gravel will be permitted unless otherwise approved by the Engineer.

The pre-coated aggregate target value for residual bitumen shall be determined by the Engineer. This value shall be in the range of 0.5 to 1.5% by weight of residual bitumen from a pre-coating material.

316 – Surface Treatment
No asphalt for surface treatment items will be placed between October 1 and May 1 for AC unless approved by the Engineer in writing.

For this contract, wind velocities in excess of 18 mph shall be construed as inclement weather and work will be suspended. Wind velocities will be determined at the nearest airport to the area.

Excess surface material shall be broomed using a vacuum broom in curb and gutter sections and a rotary broom in all other sections. Brooming will not be paid for directly, but shall be considered subsidiary to the various bid items of the contract.

Use a medium pneumatic roller meeting the requirements of Item 210 as directed by the Engineer. This work will be subsidiary to the various bid items.

Yoakum District

All manipulation of roadway delivered material prior to cement or lime treatment, including spreading, rolling and maintaining an acceptable riding surface, will be subsidiary to this item.

247-08
Stakes set by contr @ 50' (Req'd on jobs w/247, OCST, & <2" ACP) stake grade control for base courses using a spacing of at most 50 FT. At centerline, edge of travel lane, grade control breaks, and/or the outside crown point as approved. Reduce stake spacing as necessary to provide an acceptable ride for superelevated sections.

247-09a –
Minimum compaction requirements for Type E Base Course <REQD> COMPACT THE TYPE E BASE TO AT LEAST 98.0% OF THE MAXIMUM DENSITY DETERMINED BY TEX-113-E.

247-09b –
Minimum compaction requirements for Type B Base Course <REQD> COMPACT THE TYPE B BASE TO AT LEAST 95.0% OF THE MAXIMUM DENSITY DETERMINED BY TEX-113-E.

247-09c –
Compact the Type B Base by Ordinary Compact <REQD – Off-Sys Brg> COMPACT THE TYPE E BASE BY ORDINARY COMPACTION.

247-10 –
Ride Qual of Bs Crs <Req'd for base course without ACP overlay> measure the ride quality of the base course for acceptance with a high speed or lightweight inertial profiler certified at the Texas Transportation Institute located at the Riverside campus near Bryan, Texas. Provide equipment and personnel certifications in accordance with Item 585. this work will not be paid for directly but will be subsidiary to pertinent bid items.

Measure the ride quality of the base course after placement of the prime coat (See plans for Type of prime coat). Ride quality will be accepted on a IRI value of 125 in per mile or less for each wheel path for each 0.1 mile section of travel lane. Correct any individual 0.1 mile section meeting the specified value by approved methods until the ride quality requirement is met. Provide all profile measurements to the Engineer within 3 days after placement of the prime coat in electronic data files using the format specified in TEX-1001-S.

Sections the Engineer determined to have failed maintain the ride quality after placement of the prime coat (See plans for type of prime coat) will be re-profiled. Correct re-profiled sections that have an IRI value greater than 125 in. per mile for each wheel path for each 0.1 mile section of travel lane. Correct re-profiled sections until the ride quality requirement is met and perform the work at no additional expense to the department.

The above ride quality requirements are in addition to providing the geometric typical section as detailed on the plans.

251/305-04 –
All materials hauled to stockpile by Trucks <OPT> use trucks to haul salvaged base materials from the roadway to the stockpile unless otherwise approved.

260 – Lime Treatment (Road Mixed)
260-02 – Mix Exist pavement with Final Base <OPT> pulverize the existing bituminous surface so that 100% of the material passes a 2 inch sieve and incorporates in into the final base course. This work will not be paid for directly but will be subsidiary to this item.

260-03 – Mix Exist pavement with Lime Treated Base <OPT> pulverize the existing bituminous surface so that 100% of material passes a 2 inch sieve and incorporate it into the lime treated salvage base course. This work will not be paid directly but will be subsidiary to this item.

260-04 – Base and Lime to be mixed @ Central Site before Del to Rdbed (OPT) mix lime and base material at a central mixing site off the roadway prior to delivery to the roadbed.

260-05 – Base Existing Base and Flex Base Ty B, Gr 4 <OPT> use the existing roadway base and flexible base Type B, Grade 4 for this item.

260-06 – Base Scarified/Pulverized Depth 6", Shaped w/ __% Slope <OPT> scarify, pulverize, and thoroughly mix the base for a typical 6 inch depth as shown on the plans or as directed. Provide equipment capable of scarifying, pulverizing, and mixing the material full depth in a single pass.

275 – The _" Base Overlay to be Blend w/Exist Asph Ridng Surf <OPT> pulverize the existing bituminous surface so that 100% of the material passes a 2 inch sieve and incorporate in into the __ Inch base overlay. Provided equipment capable of thoroughly mixing the materials full depth in a single pass.

Division III Surface courses of Pavement Notes to Items 300-368 (302-01)

302 – Aggregates For Surface Treatments

302-02 – Defines Type PE Aggr (Required if Type PE Specified)
Furnish Type PE aggregate consisting of crushed slag, crushed stone or natural limestone rock asphalt.

302-03 – Define Type PE and E Aggr (Reqd if types PE or E specified) Furnish type PE and type E aggregate consisting of crushed slag, crushed stone or natural limestone rock asphalt.

305 – Salvaging, Hauling, and stockpiling Reclaimable Asphalt Pavement

305-02 – Stockpile location <OPT> Haul and stockpile the reclaimed asphaltic material at the following location:
_______________ ___________ ___________
Approximately _____Miles _____ Of the Project.

305-03 Stockpiled in Manner to Prevent Undue Compaction in Stkpil <OPT> Stockpile the material to prevent any undue compaction.

314 – Emulsified Asphalt Treatment

314-02 – SS-1 Asphalt used to Process Top 2 Inches of Base Lift <OPT> Use SS-1 Asphalt to process 2 inches of the final base lift.

314-03 – SS-1 (Limstn)/CSS-1 (Gravl) used to Process Top 2 " of Base Life <OPT> Use SS-1 or CSS-1 Asphalt, as approved, to process 2 inches of the final base lift.

314-04 – SS-1 used to Prcs top 2 " of Base Lift (Not < 2 % of Mix) <OPT> Use SS-1 Asphalt to process 2 inches of the final lift of the flexible base. Use an amount within the percentile limits determined, not less than 2 percent of the total mixture.

316 – Surface Treatments

316-02 – Cold Weather Asphalts (CRS-2P) <REQD> Use CRS-2P instead of AC-15P as approved when surface treatment is placed between November 1 and April 1.

316-03 – Max 1 mi primed base allow befor surfng begin <hi adt rehab> Limit the work area of primed flex base to 1 mile before the one course surface treatment operations begin.

316-04 – Seal coat plac on surf w/in 10 cal day <DSC & MIL/INLAY> Place the seal coat on the planed surface within 10 calendar days or as directed.

316-05 – Excess Aggregate in C&G Sections Rem & Disposed of <OPT> remove excess aggregate in developed or curb and gutter sections and dispose of at an approved site.

316-06 – Calibration tests required for spray bars <Reqd for DSC> Calibrate spray bars in accordance with test method TEX-922-1G Part III prior to beginning seal coat. Furnish one (1) gallon or elliptical buckets for the calibration test and dispose of these buckets after being used.

316-07 – 3 Day Emulsion Cure Time (Reqd w/AC-15P or CRS-2P on 2-crs proj) Cure any seal coat or one course surface treatment placed with an emulsified asphalt a minimum of three days before succeeding courses are placed unless otherwise directed. Cure a cutback asphalt a minimum of seven days unless otherwise directed.

316-08 – RC-250 Curing Time & Subsequent Courses no later than 14 Days <REQD with RC-250> Cure the RC-250 a minimum of seven (7) days prior to placement of the one course surface treatment. Place one course surface treatment no later than fourteen (14) days after placement of the RC-250, unless otherwise directed.

316-09 – Additional rdwy widened areas to be sealed. <Reqd for DSC> Seal additional roadway widened areas at bridges, curves, etc., shoulder tapers, mailbox turnouts, and historical markers. Payment for these quantities will be included with the appropriate items all as directed.

316-10 – Asphalt distr shall be equipped with a spray bar. <Reqd for DSC> Use asphalt distributors equipped with a spray bar that can apply a variable rate along the length of the spray bar. The asphalt rate in the wheel paths will be as directed.

316-11 – Path Truck/Crew reqd behind the Spreader Box. <Reqd for DSC> Use a path truck and crew behind the aggregate spreader box as directed.

Appendix D

District Surface Treatment Profile

TxDOT Research Project 0-5169
Constructability Review of Surface Treatments Constructed on Base Courses
Summary of District Profiles

Category	Sub-Category	Abilene	Amarillo	Atlanta	Austin
Types of ST	1-C	100% Underseal			
	2-C	100% Wearing		100%	60%
	3-C	N/A			40%
Asphalt/Aggr. Rates		Two Shots. 0.70gal/sy or 0.75gal/sy AC or Emulsion	.35-.50 for seals;.35 underseals;approx 100sy/cy for seals/underseals	.36gal/sy-.5gal/sy;GR4 115:1, GR3 100:1	0.32-0.38;0.4-0.46; GR 4 to and bottom 0.3(120),0.36(115)
Aggregate Specs	1-C			3 or 4	
	2-C	GR 3 to 4; or GR 4 to 3		3 and 4	GR 3P:4P
	3-C				GR 3P:4P:4P
	Underseal	GR 4(A or B)	A or B; GR 3 & 4	3 or 4	GR 4P
Warm Weather Binders	1-C				
	2-C	AC20-5TR, some AC 20-XP (experimental)			AC 20 STR: AC 20 STR
	3-C				
	Underseals	Hot Rubber seal on High Volume Roads	AC 5		AC(tread)
	Remarks			No emulsion at the bottom unless out for a while	
Cold Weather Binders	1-C				
	2-C	CRS-1P			CRS 1P;HFRS- 2P
	3-C				
	Underseals	Hot Rubber seal on High Volume Roads	AC 5		
Finsihing Methods before prime		Slush roll, tight blading, brooming followed by light sprinkle of water(may disturb rock in base), Install base 0.1 ft high and "mill to grade" using trimmer machine, not sure what is a good practice.	75% motor grader;25% trimmer	Finish with Motor Grader; Limestone/Sandstone; slushed; Iron Ore no slushing	
Common ST distresses **How soon;what season;**	Raveling/rock loss	2 or 1, First cold and/or wet spell; Fall/Winter or early Spring, Fog seal if caught early or blade patch over ST	1; First cold/wet event	1;Immediate; 2nd Lighter Appl.; fog seal	2;First cold/wet spell;reseal/fog
Correction	Flushing/bleeding	1 or 2;Summer or following summer;Lime water, Ice blades, grooves; Microsurfacing may be best fix if variable nozzles are not used	District used to be #1 in bleeding pavement	2; Next Day; Apply more Aggr.GR 5 or what is used	1;emulsions
	Peeling of ST	Rare, Not a problem with TR		3;Opening lane to traffic; More rock or Sand; Log truck traffic	
	Peeling of Primecoat	Rare			Had trouble rolling up on one job
	Other				

TxDOT Research Project 0-5169
Constructability Review of Surface Treatments Constructed on Base Courses
Summary of District Profiles

Category	Sub-Category	Beaumont	Brownwood	Bryan	Childress
Types of ST	1-C	Underseal More prevalent in Rehab			Doing mostly hot mix now, will do some ST in the future
	2-C	Very Little	100%(maybe upto 1 year later)		
	3-C	None			
Asphalt/Aggr. Rates		0.45 for CRS-2P GR 3 1:110 sy; AC20-STR w/GR 4	for both courses 0.70 gal/sy (AC), 1 gal/sy (emulsion); Typically first course is 0.25-0.30 gal/sy and GR 3 rock; Aggr rates for Lampasas: 115 sy/cy GR 3 PB (delta rock) on AC 5+Latex, 90 sy/cy GR 3 PB (delta rock) on MC 2400+Latex	0.22gal/sy for GR 5 RC250; 0.37 gal/sy GR 3 for AC	0.45gal/sy w/ GR4M w/ SC-15STR or AC 15-P; 1:125 B4M; 1:150 GR 5; 1:110-115 GR3; Recommends anti strip w/ precoated rock for late season job
Aggregate Specs	1-C	3 or 4		GR 5	
	2-C	3 or 4;3 or 4	GR 3:GR4/4M	GR 5:GR 3	
	3-C		GR 3, GR 3, GR 4	GR 5: GR 3: GR 4	
	Underseal	3 or 4	GR 4	GR 4	
Warm Weather Binders	1-C			RC-250	STR, 15P, 15XP, S&L
	2-C		AC20 STR; AC20-P; CRS-2; CRS-2P; AC 10(L)		
	3-C				
	Underseals				
	Remarks				
Cold Weather Binders	1-C				Usually the first course is done in winter
	2-C		CRS-1P; MC 3000; MC 2400(latex)		CRS 1P, MC-2400
	3-C				
	Underseals		AC 5		
Finsihing Methods before prime		Slush Roll on limestone "should not be doing it"; Finish w/ maintainer; smooth roll it	Slush;Roll; Burning;Broom(sometimes)	Slush; Light sprinkle RC-250; MC-30 when wet; after slushing burn it to make sure fines don't stay up	Skeeting with water,one pass with flat wheel;Slushing, need to cure before surface; Fly Ash base, don't roll as much to keep from being smooth
Common ST distresses					
How soon;what season;	Raveling/rock loss	2;upto 1 yr later; reseal	2; 2-3 days after construction or first cold season; fog seal; if not enough binder	1;after a few days; fog seal	1,Cool/Wet storm, Reshoot,Stripseal,Fog seal, First night<50 degreesF
Correction	Flushing/bleeding	1;First heat;complaint; rock chat TXI;sporadic	1;1 day to 1 year (usually in summer);lime water;once stopped, chat	2;can see immedietly and after a few days;lime water, sand	1,Lime water, GR 5 LW, Bottom Ash from Harrington,
	Peeling of ST	rare 3; Redo; Fines at top can do this	3; Summer; Patch with premix	3;can see immedietly and after a few days; sand	2,Fly Ash base
	Peeling of Primecoat	rare 4;	3	4;can see immedietly and after a few days; sand	
	Other				Scabbing, In level ups and occasional problem

Category	Sub-Category	Corpus Christi	Dallas	El Paso	Fort Worth	Houston
Types of ST	1-C				Doing very few ST's, some U/S's(predominetly rural)	100% undseals
	2-C	100%,AEP,CRFS	100%			
	3-C					
Asphalt / Aggr. Rates		Plans	0.30-0.34% 15P for GR 4; Look at plans	MC 2400 L, AC 5(plain);GR 3(not PC) B-1:100 sy; GR 4 PB-1:110 sy; uses asphalt rubber in PM work	Depends on type of asphalt, last ST-long ago	(AC only- AC-20 STR). 0.3gal/sy-estimate only-determine in field. 1:100 cy/sy w/ gr 4
Aggregate Specs	1-C	GR 4 modified				GR 4 or 5
	2-C		GR 3; GR 4	GR 3; GR 4 PB	GR 3 & GR 4 (used to use)	GR 3 or 5
	3-C					
	Underseal		GR 3	GR 4 PB	GR 4	
Warm Weather Binders	1-C					
	2-C		AC 15P or XP; AC 15P,XP, STR	AC-5; AC-5		
	3-C					
	Underseals					
	Remarks					
Cold Weather Binders	1-C				No good cool weather asphalt	
	2-C		CRS 1P, Hot Emulsion	MC 2400-L; AC-5		
	3-C					
	Underseals		CRS 1P			
Finsihing Methods before prime		Balance, get to grade;don't slush, weak area,failure plane;blade and roll; pass density	Slush Rolling with steel wheel roller	Blade and maybe roll	tight blade and sluch rolling; flood water truck-pneumatic roller; gets fines up to help keep wet; more pressure v. cut in	Crushed Concrete Base;Limestone-connect treated from pugmill site by truck;dump with blade;laydown machine;roll
Common ST distresses **How soon;what season;**	Raveling/rock loss	1, Wet on cool nights, more rock, shoot again	2,Strip Seal	2, cold spell, rain,patches I with GR and same binder, late season seals	2, 1st cold night, reshoot area	1,immediately, keep going
Correction	Flushing/bleeding	2,sand, GR 5 rock, very small stick in asphalt well(too much asphalt)	1,Emulsion, First year; AC next year or two, Chatting resurfacing; wheel path	1, within 1 week, sand it (chatting); Lime water	1, 1st hot day, put more rock out, roll in, little rolling	
	Peeling of ST		3			
	Peeling of Primecoat					
	Other					

Category	Sub-Category	Laredo	Lubbock	Lufkin
Types of ST	1-C	85% all underseals		
	2-C	10%	98%(oil field and heavy traffic-2-course won't handle traffic economically compared to 2'' hot mix)	100%; 100% u/s- may be a 2 cour u/s if traffoc is put on
	3-C	5% Rural very low ADT <200	2%	
Asphalt/Aggr. Rates		0.42 for AC 20-5TR, 0.35 for AC 20-5TR, 0.20 for RC 250(smooth penitrates well with GR 5);1/90 for GR 3 mod., 1/100 GR 4 mod, 1/120 GR 5	2cour(.5gal/sy,.45gal/sy); 3cour(.25gal/sy,.55gal/sy,.48gal/sy);2cour(1CY/85SY,1CY/110SY);3cour(1CY/60SY,1CY/85SY,1CY/105SY)	GR 3(0.45-0.48 with AC and 0.55 with emulsion), GR 4(0.33-0.36 with AC and 0.45 with emulsion), GR 5(0.20-0.22 with AC,0.18-0.22 with RC-250, and 0.28-0.32 with emulsion); GR 3(98 SY/CY), GR 4(114 SY/CY), GR 5(120 SY/CY)
Aggregate Specs	1-C	GR3/4 mod		GR3
	2-C	GR3/4 mod,GR3/4 mod	GR 3m, GR 4m	GR 4, GR 3
	3-C	GR3/4 mod,GR3/4 mod, GR 5	GR 1or GR 2 or GR 2m, GR 3m, GR 4m	
	Underseal	GR3/4 mod	GR 4m	GR 5
Warm Weather Binders	1-C	AC 20-5TR		
	2-C		AC 20-5TR, AC 20-5TR	
	3-C	RC 250, AC 20-5TR, AC 20-5TR	AC 20-5TR, AC 20-5TR,AC 20-5TR	
	Underseals	AC 20-5TR	AC 20-5TR, AC 10 w/2% latex, AC 10(hot rubber binder)(17-18%)	
	Remarks			
Cold Weather Binders	1-C			
	2-C		CRS 1P or AC 12-5TR(0.02-0.03 gal/sy higher),AC 12-5TR	
	3-C			
	Underseals	HFRS-2P		
Finsihing Methods before prime		We typically do not use a prime coat. We allow the use of RC 250 and GR 5 as a seal and prime coat. Motor grader finsh, some contractors slush the base to get the fines to the top.	Maintainer blade, Steel wheel roller, pneumatic roller, water truck if necessary. Couple of % points drier than opt. slush rolling not done-skeptical about it	Slush to get smooth finish, steel wheel, Sometimes pneumatic roller after the steel wheel
Common ST distresses				5TR good for both 1 and 2. Stop and go traffic at work zones can peel off
How soon;what season;	Raveling/rock loss	3, occasionally, depends on severity	1, Immediately or first cool weather(and wet weather), shoot emulsion or re-apply ST(Fog Seal-maint. Section)	1. First cold snap, fog seal
Correction	Flushing/bleeding	1, occasionally a couple of months after placement, lime water, depends on severity	2, as soon as traffic hits it,Lime water	2. When weather warms up, chatting 1/2-1'' Type F max
	Peeling of ST	2,occasionally, re-application	3	Occasional
	Peeling of Primecoat		4	Occasional
	Other			

Category	Sub-Category	Odessa	Paris	Pharr	San Angelo
Types of ST	1-C	U/S		100% underseals.any reconstructed project has u/s. Low volume FM Roads-overlain typically	
	2-C	100%; 2 courses spread out	100%, use 1 course in detours and 1 course in winter.(need to do 2-C in some cases)		100%
	3-C				
Asphalt/Aggr. Rates		AC 5/latex .320,second course .353;MC 2400 w/latex .320gal/sy;GR 2 73 sy/cy,GR 3 82 sy/cy, GR 4 114 sy/cy	.38 gal/sy, .45 gal/sy; GR 4 1:110, GR 3 1:100	0.30 gal/SY oil higher 0.33-0.34- ST's;1 CY/120 SY; dependent upon traffic on u/s	GR 3- .42 gal/sy, GR 4-.34 gal/sy; GR 3 85-90 sy/cy, GR 4 110 sy/cy
Aggregate Specs	1-C			GR 4	N/A
	2-C	GR 3 PB; GR 4 PB	GR 3 or GR 4 w/ flakiness and SAC S; same	GR 4, GR 4	GR 3, GR 4
	3-C				N/A
	Underseal	GR 3(too coarse, may impact compaction of mix)	GR 3 or GR 4	GR 4	GR 4
Warm Weather Binders	1-C				N/a
	2-C	AC 5 or AC 5 w/latex	AC 20-5TR, AC 20-5TR		AC 5 w/latex, AC 15P,AC 15; AC 15P or AC 20-5TR
	3-C				N/A
	Underseals	AC 5 or AC 5 w/latex	AC 20-5TR		AC 5 w/latex, AC 15P
	Remarks				
Cold Weather Binders	1-C				N/A
	2-C	MC 2400 w/latex,No winter asph	CRS-1P or 2P, wait till warm weather with AC 20-5TR		MC 2400, AC 3; AC 15P
	3-C				N/A
	Underseals		CRS-1P		AC 3 or AC 5. (AC 12 5TR- Wright FM 915- rock didn't stick at all)
Finsihing Methods before prime		Caontractor compacts to density, to moist let cure until moisture is 2 3% below optimum, then finishing with MS-2 is allowed, work in prime with pneumatic and blade, finish pass with stell wheel, then final shot with MS-2; AEP or MC - 30 allow contractor to finsh with water,sweep excess dust, then light shot of water to keep asphalt from rolling up into little balls leaving bare spots	All base is processed, mixed and compacted. Moist cure and add emulsion prime to finish water. Continue to add prime/water so slush and build fines. Burn off by tight blading, continue to skeet with prime water	Once densities for the base material are met, the contractors usually "shave off" a little to leave a smooth surface. Need to meet blue top elevations.tight blading, very few contractors slush base.	Material is rolled and bladed to grade.(slush rolling). Use pneumatic to finish not a steel wheel. Steel wheel used to repair areas to create fines
Common ST distresses **How soon;what season;**	Raveling/rock loss	2.after first freeze,fog seal; get caught in shower, reshoot area; coming our of spreader box, wet stockpile to reduce the dust	1. sometimes immediately, maybe after first cool rains, increase rates next year,Fog sela as soon as you see rocks come out	2 days, fog seals severe cases stop seals on top	1, 7-10 days, live with it, have milled areas off later
Correction	Flushing/bleeding		2, Lime water/chatting	1,immediately,as soon as traffic hits it	2, 2-3 days (more to do with temp), treat areas with a lime/water mixture, SA AO
	Peeling of ST	1, immediately, wet aggr or too small of aggr for traffic			3, 1 day, spot repair with asphalt/aggr
	Peeling of Primecoat				4, 1 day, freshen up areas with new prime
	Other				

TxDOT Research Project 0-5169
Constructability Review of Surface Treatments Constructed on Base Courses
Summary of District Profiles

Category	Sub-Category	San Antonio	Tyler	Waco	Wichita Falls	Yoakum
Types of ST	1-C	U/S	90% underseals		90%	
	2-C	100%	10%	100%	10%	100%
	3-C	Done some in Uvalde over 8 years ago				
Asphalt / Aggr. Rates		0.2-0.22 for GR 5, 0.3-0.35 for GR 3, 0.3-0.32 for GR 4; 1:110 GR 5, 1:100 GR 4,3	0.36, 0.42; GR 4 100-110 sy/cy; GR 3 90 sy/cy. Adj for gradation	2-C GR 3 then GR 4 (Hot oil AC or 15P- GR 3 0.42 1-C); GR 3 1:90, GR 4 1:120	AC 20-5TR, 0.35-0.40; 90-110 sy/cy 1-C	Preventive Maintenance- depends; 1-C ST (GR 3) 0.30 gal/sy; 2-C ST (GR 4) 0.25 gal/sy; 1-C GR 3 1:90 cy/sy, 2-C GR 4 1:100 cy/sy
Aggregate Specs	1-C			U/S GR 4	GR 4M	
	2-C	GR 3, GR 4; used modified but going back to original grade	GR 3, GR 4	GR 3, GR 4	GR 3, GR 4	TY PE GR 3, Ty PE GR 4
	3-C					
	Underseal		varies, 3 or 4, mostly 3			Ty PE GR 3
Warm Weather Binders	1-C				AC 20-5TR	AC 15P, AC 20-5TR
	2-C	AC 15P, AC 20 5TR	AC 20-5TR, AC 20-5TR	AC 20-5TR, AC 15P		AC 15P, AC 15P
	3-C					
	Underseals	AC 15P, AC 20 5TR	may shoot out of season		CRS 2P	AC 15P, AC 20-5TR
	Remarks					
Cold Weather Binders	1-C				MC 2400	
	2-C	CRS 2P, HFRS 2P; CRS 2P, HFRS 2P	AC 12-5TR			CRS 2P, CRS 2P
	3-C					
	Underseals	CRS 2P, HFRS 2P; CRS 2P, HFRS 2P				CRS 2P
Finsihing Methods before prime		Slush roll(water); pneumatic- may burn if necessary. Also with diluted MS 2 emulsion in several steps	Blade and moisture for 7 days	motor grader; tight blade; Big Creek, laid down base with lay down machine, Slush	Trouble finding blade operators. Slush, roll pneumatic, let it dry, blade. A light shot of water before priming	
Common ST distresses **How soon;what season;**	Raveling/rock loss	1 or 2, first cold, fog seal, more on ST placed in winter	1, rain, end of season, fog seal, cool rain/night	3, not big problem	Cool weather	1, emulsions mostly
Correction	Flushing/bleeding	1, first summer, hot mix, chat(GR 5), rocks pushed to base, turning movement	1, >100 degrees cover w/ HMAC ASAP, fog seal- lime and chat; tried but don't work - blade it off	2, as soon as put down- few days to few weeks, Ice Chat	AC 5 w/ latex	2, rock embeded by lot of trucks/ maint patches, too high asphalt rates
	Peeling of ST	Few state forces work w/ no prime; pockets of dust		1 paving HMAC, go to asphalt that is not as sticky, biggest problem with U/S		4,very seldom
	Peeling of Primecoat			1, go to non-modified like CRS-2	with enviro prime emulsion	3 very seldom
	Other					

Appendix E

District Surface Treatment Rates

Table 1. Aggregate and Binder Rates Used by TxDOT Districts in 2-Course Surface Treatments

1st Course				2nd Course			
Aggregate Grade	Aggregate Rate Sy/Cy	Binder Grade(s)	Binder Rate(s) Gal/Sy	Aggregate Grade	Aggregate Rate Sy/Cy	Binder Grade(s)	Binder Rate(s) Gal/Sy
GR 3-4		AC-20 5TR	0.35-0.375	GR 4-3		AC-20 5TR	0.35-0.375
GR 4-3	100	AC55,10	0.25,0.30	GR 3-4	100	AC-5,10	0.25,0.30
GR 3	100	AC-15P, 20 5TR	0.50	GR 4	115	AC-15P, 20 5TR	0.36
GR 3(P)	120	AC-20 5TR	0.32-0.38	GR 4(P)	115	AC-20 5TR	0.40-0.46
GR 3	110	CRS-2P	0.45	GR 4		AC-20 5TR	
	115		0.25-0.30		115		0.40-0.45
GR 5	130	RC-250	0.22	GR 3	110	AC	0.37
GR 3	110-115	AC-20 5TR	0.55	GR 3	110-115	AC-20 5TR	0.55
GR 4-3		AC-15P	0.30-0.34	GR 4		AC-15P	0.30-0.34
GR 4S(P)	110	AC-5, MC-2400L		GR 3(P)	100	AC-5	
GR 3		AC-20 XP, 5TR, P		GR 4		AC—20 XP, 5TR, P	
GR 3	100	AC-20 5TR	0.42	GR 4	120	AC-20 5TR	0.35
GR 3S	85	AC-20 5TR	0.50	GR 4S	110	AC-20 5TR	0.45
GR 4	114		0.33-0.36, 0.45 w/Emul.	GR 3	98		0.45-0.48, 0.55 w/Emul
GR 3	82	AC-5w/L, MC-2400L	0.32	GR 4	114	AC-5 w/L	0.35
GR 4	110	AC-20 5TR, CRS-1P	0.38	GR 3	100	AC-20 5TR	0.45
GR 3	85-90	AC	0.42	GR 4	110	AC	0.34
GR 3	100	AC-15P, 20 5TR	0.30-0.35	GR 4	100	AC-15P, 20 5TR	0.30-0.32
GR 3	90	AC-20 5TR	0.36	GR 4	100-110	AC-20 5TR	0.42
GR 3	90	AC-15P, 20 5TR	0.42	GR 4	120	AC-15P, 20 5TR	0.32
GR 4	100	AC-15P	0.25	GR 4	100	AC-15P	0.25

Table 2. Aggregate and Binder Rates Used by TxDOT Districts in 1-Course Surface Treatments (Underseals)

Aggregate Grade	Aggregate Rate Sy/Cy	Binder Grade(s)	Binder Rate(s) Gal/Sy
GR 3 or 4	100	AC-5 or 10	0.35
GR 5	130	RC-250	0.22
GR 5	150	AC-5, AC-15 TR AC-20 5TR	0.45
GR 4		AC-20 XP, 5TR, P	
GR 4	100	AC-20 5TR	0.30
GR 3	100	AC-20 5TR	0.42
GR 3	98		0.45-0.48 0.55 w/Emul
GR 4	120		0.30
GR 3	90	AC-20 5TR	0.36
GR 4	120	AC-15P, 20-5TR	0.32
GR 4S	90-100	AC-20 5TR	0.35-0.40
GR 3	90	AC-15P, AC-20 5TR	0.30

Table 3 Aggregate and Binder Rates Used by TxDOT Districts in 3-Course Surface Treatments

1st Course				2nd Course				3rd Course			
Aggregate Grade	Aggregate Rate Sy/Cy	Binder Grade(s)	Binder Rate(s) Gal/Sy	Aggregate Grade	Aggregate Rate Sy/Cy	Binder Grade(s)	Binder Rate(s) Gal/Sy	Aggregate Grade	Aggregate Rate Sy/Cy	Binder Grade(s)	Binder Rate(s) Gal/Sy
GR 5	130	RC-250	0.22	GR 3	110	AC	0.37	GR 4	125	AC	0.32
GR 3	110-115	AC-5	0.45	GR 3	110-115	AC-5	0.55	GR 3	110-115	AC-5	0.55
GR 3	100	AC-20 5TR	0.42	GR 4	120	AC-20 5TR	0.35	GR 5	90	RC-250	0.20
GR 1,2,2S	60	AC-20 5TR	0.25	GR 3S	85	AC-20 5TR	0.55	GR 4S	105	AC-20 5TR	0.48