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Maintenance Solutions for Bleeding and Flushed Pavements Surfaced with a Seal Coat or Surface Treatment

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Abstract: This report summarizes the findings of research directed at identifying maintenance solutions for bleeding and flushed asphalt pavements surfaced with seal coats or surface treatments. Although the basic mechanism associated with both bleeding and flushing has to do with excess asphalt binder filling the voids between aggregate particles, the terms *are* different — "flushed" is past tense; whereas, "bleeding" is an active verb. Factors that contribute to bleeding and flushed pavements include aggregate issues, binder issues, traffic issues, environmental issues, and construction issues. There is no better advice for dealing with bleeding and flushed pavements than to avoid the problem from the outset. Bleeding is an immediate maintenance problem that must be addressed using corrective or in some cases, emergency, maintenance. The basic approaches used to treat bleeding either (a) bridge over the liquid asphalt by applying aggregate of various types and gradations, (b) cool off the pavement surface by applying water with or without additives, or (c) remove the bleeding asphalt and rebuild the pavement seal. Flushed asphalt pavement, in contrast to bleeding, is typically *not* a maintenance problem that must be addressed immediately. The basic approaches used to treat flushed pavements either (a) retexture the existing flushed pavement surface or (b) add a new textured surface over the flushed pavement. Our research suggests that the use of polymer modified and other binders has improved seal coat and surface treatment performance such that bleeding and flushing problems are becoming less common. Three promising areas for further research and implementation relative to bleeding/flushing solutions include (a) use of lime water, (b) ultra high pressure water cutting, and (c) use of the racked-in seal at intersections.

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Acknowledgement

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The researchers also thank two members of this research team, Douglas Hughes who spent many hours compiling the survey data, and Wickrama Galagoda who assisted with the binder quality analysis, for their valuable help.

Implementation Statement

The primary objective of this research has been to identify maintenance solutions for bleeding and flushed asphalt pavements surfaced with seal coats or surface treatments. The researchers believe this objective has been met. From an implementation perspective, we prepared Product P1, a booklet entitled, *Maintenance Solutions for Bleeding and Flushed Pavements*. Wide dissemination of this booklet at the maintenance section level, both in print and online, will be a key implementation activity. In addition to sharing this knowledge, we have outlined three promising areas for further study for maintenance solutions which deserve further consideration relative to treating bleeding and flushed pavements. These are: (a) use of lime water, (b) ultra high pressure water cutting, and (c) use of the racked-in seal at intersections. Follow-up implementation research in these areas will help to leverage TxDOT's investment in this study.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate

(Revised September 1993)

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CHAPTER 1
INTRODUCTION

1.1 The Research Problem

This report summarizes the findings of research sponsored by the Texas Department of Transportation (TxDOT) directed at identifying maintenance solutions to the problem of bleeding and flushed asphalt pavements with seal coats or surface treatments. The research focused on documenting typical manifestations of bleeding and flushing, discovering the cause(s) and underlying factors that contribute to bleeding/flushing, and identifying cost-effective treatment approaches.

In addressing these challenges, the research synthesized literature and related information from sources outside TxDOT and also attempted to capture the wealth of institutional knowledge and expertise resident within the agency, both at the Division and District levels. The research challenge was to boil everything down to a manageable number of definable practices for treating (or preventing) the bleeding/flushing problem.

Expressed within the broader context of seal coat design and construction, addressing the flushing/bleeding problem will help TxDOT better maintain their pavements in order to provide for the safe, effective and efficient movement of people and goods.

1.2 The Research Approach

The project was comprised of five tasks which were designed to achieve the primary research goal; namely, to establish best practices (maintenance solutions) for treating bleeding and flushed asphalt pavement surfaces. The research relied on insights and lessons learned from previous TxDOT research, in particular, the Seal Coat Constructability Review project [1], the Pavement Edge Maintenance project [2], the Constructability Review of Surface Treatments Constructed on Base Courses project [3], and our Binder Quality Assurance [4] project.

We began with a Literature Review, Task 1, which provided a solid theoretical as well as practical basis for the assessment of TxDOT's practices and procedures for identifying and treating bleeding and flushed asphalt pavements. We first searched the transportation databases, but also searched databases of other public and private agencies, as applicable. The results of the literature review are not presented separately but are incorporated within discussions of various aspects of the bleeding/flushing problem.

Task 2 consisted of interviewing knowledgeable persons outside TxDOT. Here we conducted brief interviews, either by telephone, by email correspondence, or in person, with subject matter experts throughout the United States. Interviewees included researchers who have studied the bleeding asphalt pavement problem, representatives from other State DOTs, and other public and private industry contacts.

We followed this up with TxDOT Division and District site visits (Task 3) where we conducted face-to-face interviews to clarify the data and to gain additional, more subjective information not amenable to questionnaire responses. The breadth of the international literature review and the nationwide interviews complements the depth of the TxDOT face-to-face interviews, and together these form a complete data-gathering process. Based on past TxDOT research experience in the maintenance area we attempted to visit all 25 TxDOT Districts, which not only strengthened the data-gathering aspect but also will pay rich dividends during the implementation phase.

In Task 4, the results of the literature review and the data-gathering efforts were tabulated, summarized, and synthesized. We also attempted to analyze selected bleeding asphalt case studies identified in the District interviews relative to TxDOT's Binder Quality Assurance Database. The outcome of this work (Task 5) has been presented in two forms. One is Product 0-5230-P1, which is a booklet entitled "Maintenance Solutions for Bleeding and Flushed Pavements" [5]. The other is this research report, which summarizes the material in the Maintenance Solutions booklet as well as other research findings.

1.3 Overview of this Report

This report is organized into ten chapters. This introductory first chapter is followed by a comprehensive discussion of the research method in Chapter 2. The remainder of the report presents our research findings.

In Chapter 3, we address the fact that more than a little confusion exists, both in published academic literature and in the roadway maintenance community, about the differences between bleeding versus flushed pavements. To this end, we begin with a brief discussion of maintenance definitions for bleeding and flushed pavements. We also discuss results of our screening questionnaire on bleeding and flushing, the goal being to present a statewide maintenance perspective on this problem.

Chapter 4 – on causes – provides insight into the main factors that contribute to bleeding and flushing. The maintenance supervisor looking for solutions to bleeding and flushing problems will do well to recognize and understand these causes, since in many cases the best solution is to not get into the problem in the first place.

Treatment of bleeding and flushed pavements is considered corrective as opposed to preventive maintenance. However, the preventive maintenance mindset is nevertheless very useful, and this is the topic of Chapter 5. This is for the simple reason that the preventive mindset is by far the most cost-effective maintenance solution discussed herein. "You show me a maintenance leader who approaches seal coat/surface treatment design and construction from the perspective of how to achieve high quality and avoid bleeding and flushing, and I'll show you a maintenance crew that is relatively unbothered by the bleeding/flushing problem."

The next three chapters – Chapter 6, Chapter 7 and Chapter 8 – present maintenance solutions for three specific contexts: bleeding pavements, flushed pavements, and intersections. The introduction to each section provides an overview and a broad comparison of the treatment methods. The discussions of the individual solutions begin with a brief description of the treatment method, followed by a discussion of its applicability and effectiveness, materials and equipment, procedures, helpful tips, and concerns.

Chapter 9 summarizes our analysis of selected bleeding asphalt case studies identified in the District interviews relative to TxDOT's Binder Quality Assurance Database. The report closes (Chapter 10) with a summary of key research findings and with recommendations for both additional research and implementation.

CHAPTER 2
RESEARCH METHOD

2.1 Overview

Unlike a "typical" research project where the problem statement attempts to describe the relationship between selected independent and dependent variables; for example, the effect of binder content on aggregate adhesion, here the problem statement is *descriptive* and very open-ended; namely, to define maintenance practices (solutions) for treatment of bleeding and flushed pavements with seal coats and surface treatments. This non-typical problem required a non-typical research method. As briefly stated in the introduction, we approached the problem as one of gathering, synthesizing, and reconstituting a tremendous volume of data. This work was accomplished in five tasks for this one-year research project.

2.2 Research Tasks

2.2.1 Task 1. Literature Review (International Scope)

We began the project with a comprehensive review of the literature on the problem of bleeding and flushed asphalt surfaces. This was to provide a solid theoretical as well as practical basis for the assessment of TxDOT repair procedures and practices for treating this problem. We searched the transportation databases, including those represented by the TxDOT RTI Library at the Center for Transportation Research. We also did a systematic search of the Internet for selected key words. In addition to this literature, we attempted to identify and review work by public agencies including other state departments of transportation and federal agencies such as the Federal Highway Administration (FHWA).

International in scope, the primary focus of the literature review was to identify and characterize bleeding asphalt pavement diagnosis, prevention and treatment strategies so we could meaningfully evaluate TxDOT's practices and procedures in this area. This information provided a framework from which we could inventory the design, construction, maintenance and related aspects of the problem.

We have reported the results of the literature review as part of the discussions of the various bleeding and flushed pavement topics. That is, rather than develop a single chapter in this report that summarizes the literature, we have cited relevant literature on the topics as they are discussed.

2.2.2 Task 2. Interview Knowledgeable Persons Outside TxDOT (National Scope)

In this task, we conducted phone and face-to-face interviews with subject matter experts outside TxDOT, nationwide, discussing the causes, background factors, and treatment of the bleeding asphalt pavement problem. We used a concise interview questionnaire to facilitate structured discussion and systematic data gathering, the goal being to elicit the broader, open-ended concerns that need discussing relative to treatment of bleeding asphalt pavements. We also used this opportunity to identify additional literature and printed resources.

These interviews helped to broaden and deepen our understanding of bleeding asphalt pavement issues and helped to provide a national perspective for addressing the problem. This set the stage to conduct more in-depth, face-to-face interviews with knowledgeable persons at TxDOT.

From a reporting perspective, we have archived the handwritten notes of our conversations and interviews, as well as various manuals, photographs, reports, proceedings, and other materials we obtained as part of our inquiry. In selected cases, for example interviews with maintenance representatives from other State DOTs and our interviews with representatives from the Binder Supplier firms, we prepared summary notes of our conversations. We maintain archived copies of these notes in our files, but have also presented an electronic copy of these working notes (not edited for formal reporting) on a Data CD as described in Section 2.3 of this report.

2.2.2.1 Researchers/Academia

We conducted phone interviews with researchers who have previously studied the bleeding asphalt pavement problem.

- Charles T. Jahren, P.E., Ph.D.
  Professor-in-Charge
  Construction Engineering
  Department of Civil, Construction, and Environmental Engineering
  Iowa State University
  Ames, Iowa 50011
  chahren@iastate.edu

- Roger E. Smith, Ph.D, P.E.
  Herbert D. Kelleher Professor in Transportation
  Department of Civil Engineering
  Texas A&M University
  College Station, Texas 77843
  Roger-smith@tamu.edu

- Douglas D. Gransberg, Ph.D., P.E.
  Associate Professor
  Construction Science Division
  College of Architecture
  The University of Oklahoma
  Norman, Oklahoma 73019
  dgransberg@ou.edu

2.2.2.2 Pavement Preservation Centers

Treatment of bleeding and flushed pavements is frequently viewed within the context of pavement preservation efforts. We contacted and had both phone and face-to-face interviews with directors of these Pavement Preservation Centers.

- Larry Galehouse, PE, PS
  Director
  The National Center for Pavement Preservation
  2857 Jolly Road
  Okemos, Michigan 48864
  www.pavementpreservation.org
  T. 517.432.8220
  E. nccp@egr.msu.edu

- William O'Leary
  Director
  Foundation for Pavement Preservation
  8613 Cross Park Drive
  Austin, Texas 78754
  www.fp2.org
  T. 866.862.4857
  E. fpexdir@aol.com

2.2.2.3 Private Industry Experts

We conducted phone interviews with experts/leaders in private industry who were willing to share their knowledge and expertise about the bleeding/flushing problem.

- David G. Peshkin, P.E.
  Vice President
  Applied Pavement Technologies
  115 W. Main Street, Suite 400
  Urbana, Illinois 61801
  www.pavementsolutions.com
  T. 630.434.9210
  E. dpeshkin@pavementsolutions.com

- Kevin King
  Highway Sales & Marketing Lightweight Aggregate
  TXI Expanded Shale & Clay
  PO Box 10110
  Tyler, Texas 75711
  www.txi.com
  T. 903.894.4520
  E. kking@txi.com

- Barry Dunn
  Viking Construction, Inc.
  2592 Shell Road
  Georgetown, Texas 78628
  T. 512.930.5777
  E. barrydunn@covad.net

2.2.2.4 Regional and National (International) Conferences on Pavement Preservation

We attended the following regional and national conferences having to do with pavement preservation. We made a brief presentation on our bleeding/flushing research at both of the Transportation Research Board meetings.

- Pavement Preservation Seminar
  First Annual Meeting
  Foundation for Pavement Preservation
  Austin Convention Center
  Austin, Texas
  October 4, 2005

- TRB Task Force AF020T
  Roadway Pavement Preservation
  85th Annual Meeting
  Transportation Research Board
  Washington, DC
  January 23, 2006

- TRB Committee AHD20
  Pavement Maintenance
  85th Annual Meeting
  Transportation Research Board
  Washington, DC
  January 23, 2006

2.2.2.5 Binder Supplier Firms

Given the close relationship between problems with bleeding/flushing and the type and application of asphalt binder, we contacted representatives from various binder supplier firms to obtain their perspective on the problem. A list of our contacts to Binder Supplier firms is as follows:

Table 2.1 - Asphalt Binder Supplier Contact List, Bleeding Asphalt Pavements

Binder Supplier or Organization	Contact Name	Contact Title or Position	Contacted/ Telephone Interview?
Alon USA Big Spring, TX	Kevin Armstrong	Heavy Oil Coordinator	No
Chevron Asphalt El Paso, TX	Margo Joiner	TxDOT Contact Lab QC/QA	No
Cleveland Asphalt Products Shepherd, TX	Murray C. Moore	Owner	Yes
Ergon Asphalt & Emulsions Pleasanton, TX	Ken Mogensen	Operations Manager	Face to Face Interview
Prime Materials Houston, TX	Bill O'Leary	Owner	Yes
SemMaterials Saginaw, TX	Chuck Danheim	Sales & Marketing	Yes
SemMaterials Saginaw, TX	Shelly Cowley	Southern Region Technical Support (TX/OK)	No
Total Petrochemical Pt Arthur, TX	Jerry Parsley	TxDOT Contact	No
TxDOT Construction Division (CST) Cedar Park, TX	Darren Hazlett	Director, Bituminous Materials Group	Yes
Valero Galveston, TX	Cleve Forward	Technical Service Manager Gulf Coast Asphalt	No
Valero Sunray, TX	Ann Ferry	Lab QC/QA	Referral to Kevin Hile
Valero Catoosa, OK	Kevin Hile	Sales Manager Mid-Continent Region	Yes
Wright Asphalt Channelview, TX	Ted Flanagan	Manager (Owner) QC/QA	Yes

The Data CD (see Section 2.3 of this report) presents a detailed record of these binder supplier interviews. To summarize, the basic view is that binder properties do vary and the proper selection of binder does matter; however, bleeding and flushing seldom results solely from a problem with the binder quality. Typically, bleeding/flushing results from other factors – or combinations of factors – such as overapplication of binder, poor quality/dirty aggregate, poor surface preparation prior to placing the seal coat, construction during periods of cool/inclement weather, inexperienced contractors, inexperienced inspection personnel, traffic considerations, and the like.

2.2.2.6 Other State Departments of Transportation (DOTs)

We contacted maintenance representatives from a sample of the other State DOTs to identify their typical procedures and practices for treating the bleeding asphalt pavement problem.   A list of our contacts is as follows (Table 2.2):

Table 2.2 - State DOT Contact List, Bleeding Asphalt Pavements

	State DOT	**No Response**	**Email Response**	**Telephone Interview**
1.	Alabama	✓		
2.	Arizona			✓
3.	Arkansas	✓		
4.	California			✓
5.	Colorado			✓
6.	Florida		✓	
7.	Georgia		✓	
8.	Hawaii			✓
9.	Idaho		✓	
10.	Illinois			✓
11.	Indiana	✓		
12.	Iowa		✓	
13.	Kentucky	✓		
14.	Louisiana		✓	
15.	Mississippi			✓
16.	Missouri	✓		
17.	Montana			✓
18.	Nevada			✓
19.	New Mexico		✓	
20.	New York		✓	

Table 2.2, continued

	State DOT	No Response	Email Response	Telephone Interview
21.	North Carolina	✓		
22.	Oklahoma	✓		
23.	Pennsylvania	✓		
24.	South Carolina		✓	
25.	Tennessee	✓		
26.	Virginia		✓	
27.	Washington		✓	
Totals		**9**	**10**	**8**

The Data CD (see Section 2.3 of this report) provides a detailed summary of the findings of these DOT interviews. Apart from certain unique observations specific to each state, the dominant finding from these conversations is that other DOTs do not use seal coats (which they refer to as "chip seals") to the extent that Texas does. Thus, most of their experience with bleeding has to do with asphaltic concrete pavements, and when these pavements do experience bleeding, their typical maintenance strategy is to mill out the bleeding area and repair/replace it with more hot mix. The basic view is that Texas leads the nation in seal coat use, so when it comes to questions about how to address problems with bleeding and flushing on pavements with seal coats or surface treatments, the best place to look for expertise is within Texas.

2.2.3 Task 3: Interview Knowledgeable TxDOT Personnel (Divisions & Districts)

Whereas Tasks 1 and 2 primarily were intended to yield *breadth* of information about the treatment of bleeding asphalt pavements from available sources including non-TxDOT experts, Task 3 was about *depth* – as in deepening our understanding and knowledge of the issues. Specifically, our goal in Task 3 was to capture the wealth of institutional knowledge resident within the agency at both the Division and District levels.

Based on past TxDOT research experience in the maintenance area, we contacted all 25 TxDOT Districts to set up site visits/interviews (see Figure 2.1). While the case could be made that District maintenance practices relative to the diagnosis, prevention, and treatment of bleeding asphalt pavements are regionalized and we could probably learn what we need by visiting only a sampling of the TxDOT districts, our experience has shown otherwise.

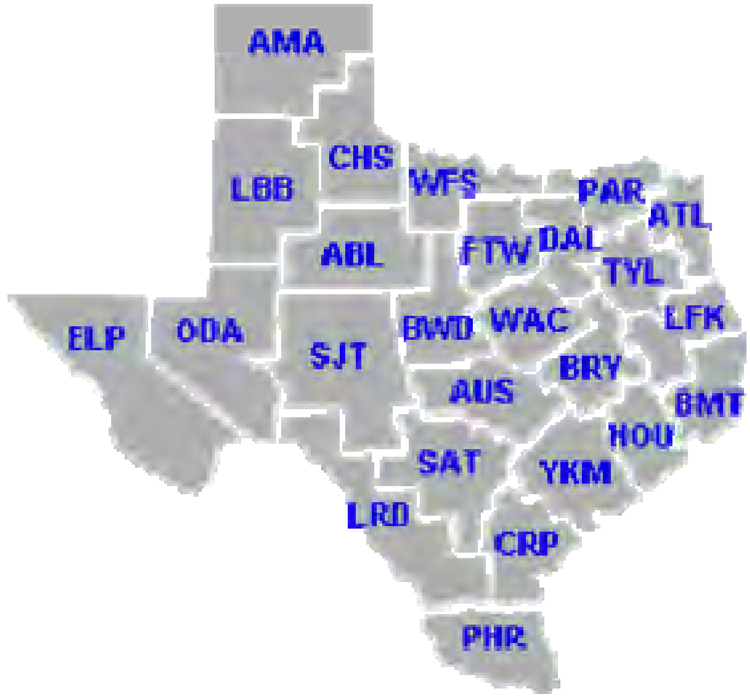

Figure 2.1 TxDOT Operational/ Geographic Districts (*Source:* TxDOT [6])

Further, even if diagnostic and treatment practices for bleeding asphalt pavements were not diverse, data-gathering was not the only research goal. One key benefit in visiting all the Districts concerned research implementation. Since implementation starts with listening, we felt that the best way to gain "buy-in" from the Districts was to make the effort to personally listen to TxDOT construction and maintenance staff from each and every District.

Twenty-three of the districts – all but Houston and Pharr – accepted our request. The reason maintenance directors in these two districts declined was because they do not use an appreciable amount of seal coats and surface treatments, and thus they did not feel they would have much to contribute.

2.2.3.1 The Screening Survey

Prior to commencing the District interviews, we developed and submitted a "Screening Survey" to maintenance directors across the State, the goal being to obtain a broad picture of the types of practices and procedures that were being used to treat bleeding pavements. This screening survey (Appendix A) was intended to assess issues such as frequency and severity of bleeding, the causes of bleeding, the frequency with which various solutions to bleeding are used, and the perceived effectiveness of those solutions.

Results from the Screening Survey provide some insight at the State level and these results are discussed in subsequent chapters of this report, as applicable. Further, the screening survey data did assist in clarifying our understanding of maintenance terminology and the kinds of questions that needed further elaboration in the District Interview Questionnaire.

2.2.3.2 The Interview Questionnaire

Appendix B of this report presents our interview questionnaire. We developed a draft of this questionnaire and submitted it to our TxDOT Project Monitoring Committee for review and comment, and then finalized it for use in the research. We provided the questionnaire to District maintenance personnel at least one month in advance of our site visits, the idea being to help District personnel understand the type of information we wanted to talk about in the interview.

The final version of the questionnaire contains 18 questions with numerous sub-questions. This level of detail provided for a very fine-grained and structured conversation about bleeding and flushing. Ultimately, the interview questionnaire best served as advance notice to District maintenance personnel about the topic for discussion, and as a guide for the conversation once we arrived on site. The three primary issues addressed in the questionnaire were:

- Characterization of the flushing and bleeding problem
- Causes of flushing and bleeding
- Solutions to the flushing and bleeding problem

In sum, we felt we had accomplished our research objective if we left the district with an understanding of how flushing and bleeding were identified in that particular district, what the typical causes were, and how that district addressed those problems from a maintenance perspective.

2.2.3.3 District Site Visits

The key data-gathering aspect of this research was accomplished by making site visits to 23 of TxDOT's operational/ geographic Districts. We scheduled the visits in January through March of 2006, and made the site visits from March through June, 2006. The standard procedure for the site visits was as follows:

- Typically one or two members of the research team visited each TxDOT District to conduct the interview and observe District practices and procedures for addressing the problem of bleeding asphalt in seal coats and surface treatments.
- The planned duration of the visit was one day, with the interview in the morning and field observations in the afternoon. The researchers documented District practices and procedures by means of notes, photographs, video, and audio recordings, as applicable.
- Each District convened appropriate representatives for the interview. We initiated contact through the District Director of Maintenance/Director of Operations (DOM/DOO). In addition to the DOM/DOO, we specifically requested attendance at the interview by the District Director of Construction and the District Seal Coat Program Manager. Beyond this minimum core, we encouraged the DOM/DOO to invite other interested persons to attend, for example, Roadway Maintenance Supervisors with special

insight and experience. The interview typically took place at the District office but was arranged wherever it was most convenient and effective.

- In advance of our visit, we submitted the questions we intended to cover in the interview to the local District personnel. In this way, District personnel would be more prepared to discuss their own practices and procedures for addressing the bleeding asphalt pavement problem. District personnel were encouraged to demonstrate any specialized equipment or procedures they use.

Table 2.3 summarizes the District demographics as they relate to our site visits and interviews. Whereas comprehensive TxDOT statistics are available on-line, this table conveniently illustrates the number of counties and lane miles, and the number of personnel who participated in our interview, along with their years of experience. It is significant to note that 120 TxDOT personnel with a combined total of 2,494 years of construction/maintenance experience participated in this research, offering us the benefit of their knowledge and expertise. The findings we gathered are theirs.

Table 2.3 District Demographics Summary, Bleeding/Flushing Interview

District No./ Designation	District Name	No. of Counties	No. of Lane Miles	No. of Personnel Interviewed	Years of Maintenance Experience
01/ PAR	Paris	9	7,126	3	47
02/ FTW	Ft. Worth	9	8,470	1	20
03/ WFS	Wichita Falls	9	6,316	6	133
04/ AMA	Amarillo	17	9,284	6	147
05/ LBB	Lubbock	17	12,004	6	149
06/ ODA	Odessa	12	7,928	4	76
07/ SJT	San Angelo	15	7,113	8	126
08/ ABL	Abilene	13	8,376	5	130
09/ WAC	Waco	8	7,705	6	134
10/ TYL	Tyler	8	8,624	2	37
11/ LFK	Lufkin	9	6,352	2	36
12/ HOU	Houston	6	9,683	--	--
13/ YKM	Yoakum	11	7,904	8	170
14/ AUS	Austin	11	8,549	3	58
15/ SAT	San Antonio	12	10,387	9	171
16/ CRP	Corpus Christi	10	6,936	11	219
17/ BRY	Bryan	10	6,898	2	45
18/ DAL	Dallas	7	9,928	2	55
19/ ATL	Atlanta	9	6,372	5	112
20/ BMT	Beaumont	8	5,643	6	115
21/ PHR	Pharr	8	5,613	--	--
22/ LRD	Laredo	8	4,920	11	215
23/ BWD	Brownwood	9	5,860	3	72
24/ ELP	El Paso	6	4,720	2	38
25/ CHS	Childress	13	5,411	9	189
TOTALS		254	188,122	120	2494

The goal of these site visits was to obtain a shared understanding of District perspectives, practices, and procedures on bleeding and flushing during the morning interview, and then to physically observe and document illustrative examples of these same conditions and practices in the field in the afternoon. This proved to be a very effective method for gathering information and yielded a large volume of data – over three linear feet of shelf space for documentation. These data are archived in our files and selected items are included in a Data CD (see Section 2.3 of this report).

2.2.3.4 Data Gathering – Selected Bleeding/Flushing Projects

The District site visits include provisions for detailed data gathering on selected recent maintenance/construction projects where bleeding/flushing had been a problem. Prior to our site visit, we requested that District personnel identify a manageable number of recent projects – say, two to four – which we could observe in the field. In addition to discussing the significance of the bleeding/flushing problems at these sites, and the types of corrective solutions employed, we requested detailed information from the construction records of the selected projects. Such information included the dates of construction, the binder source and application rate, the condition of the pavement prior to placement of the seal coat or surface treatment, and the like. With this background information, we attempted to investigate possible links between the bleeding/flushing performance issues and TxDOT Binder Quality Assurance data (see Section 2.2.4, and Chapter 9).

2.2.3.5 Interviews with TxDOT Division Maintenance Personnel

We conducted interviews with TxDOT subject matter experts in the Divisions – Mr. Zane Webb, P.E., Director of Maintenance, and Mr. Joe Graff, P.E., Deputy Director of Maintenance. In addition to being very knowledgeable about maintenance and construction issues, these leaders also discussed the policy implications of various activities, considerations which could play a large part in uniformly implementing best practices.

2.2.4 <u>Task 4: Data Analysis</u>

The "top down" research approach utilized for this project began with identifying solutions from international, national, and statewide sources. The wealth of information gathered from Tasks 1, 2 and 3 was cataloged, sorted, evaluated and organized, the goal being to distill the best practices for diagnosis, prevention, and treatment of bleeding and flushed asphalt pavements.

2.2.4.1 Maintenance Solutions for Bleeding and Flushed Pavements

Product 0-5230-P1 from this research [5]; that is, a booklet entitled, *Maintenance Solutions for Bleeding and Flushed Pavements*, summarizes TxDOT maintenance practices for treatment of bleeding and flushing in seal coats and surface treatments. These maintenance solutions represent the best practices for treatment of bleeding and flushing – those maintenance practices that are the most safe, effective, and efficient. In particular, the District interviews and site visits enabled us to identify the types of maintenance that are being done, what does and does not work, why particular approaches work, and under what conditions. Chapters 3 through 8 of this report present those findings.

Our experience with best practices research suggests that because the bleeding/flushing problem derives from different causes, it is counter-productive to think strictly in terms of identifying "the best practice" or to force-rank solutions. Rather, we identified many different practices which we characterized in terms of their usefulness and applicability in certain contexts. The goal is to empower maintenance personnel to select the solutions that are "best" for a particular application.

The results of the District interviews, both the interview record and the documentation of selected maintenance practices and procedures, were initially intended to be tabulated and statistically analyzed for trends in the data. However, because of the open-ended nature of the interviews and variation in the discussions, the data were not readily amenable to formal statistical analysis. While broad themes exist which we note and discuss in this report, we did not attempt to characterize potential trends with the language of mathematical rigor nor did we ground our observations with statistical confidence factors.

We emphasize that one of the reasons "best practices" have not existed for treatment of bleeding and flushed pavements is that this type of maintenance is typically done using local (District) forces without the benefit of a broader view of the problem. We see this research project as a means to take what is best from local practices and share this information with all the Districts, thereby strengthening TxDOT's entire pavement maintenance program.

2.2.4.2 TxDOT's Binder Quality Assurance Database

Part of the data analysis consisted of attempting to link bleeding/flushing performance concerns for selected projects with data from the TxDOT binder quality assurance database. We requested project-specific data as part of our District interview process. This effort yielded information on 30 roadway projects, 10 of which could be considered for further analysis.

From the TxDOT binder quality assurance research project 0-4681 [4] currently being done at TechMRT, we obtained access to TxDOT's asphalt binder test data, and we explored possible correlations between the binders used in bleeding seal coats and their laboratory test properties. Our goal was to look into factors that influence bleeding, in particular, binder temperature susceptibility. Chapter 9 of this report presents the results of this analysis.

2.2.5 Task 5: Project Meetings and Reports

Three reports have been/ are being prepared for this project. The first consisted of the booklet entitled, *Maintenance Solutions for Bleeding and Flushed Pavements,* which summarizes TxDOT maintenance practices for treatment of bleeding and flushing in seal coats and surface treatments. The second is this Research Report presenting the findings of research Tasks 1 through 5. The third report is TxDOT's 2-page Project Summary Report.

2.3 Archive/Publication of Research Data

2.3.1 Overview

As already noted, the research data gathered from the literature review, interviews, and site visits (Tasks 1, 2 and 3) has been cataloged, sorted, evaluated and organized, the goal being to distill the best practices for diagnosis, prevention, and treatment of bleeding and flushed asphalt pavements. This research report presents those findings as a comprehensive stand-alone summary document.

2.3.2 Archive of Bleeding Asphalt Research Data

We have taken an alternative approach toward archiving the hundreds of pages of supplementary materials – data gathered from the interviews, site visits and the like. That paperwork is voluminous and there is a need to balance the desire for an archived copy of data versus the effort and cost associated with publishing it. With the approval of the Research Sponsor [7] and consistent with accepted research practice, we have proceeded as follows:

- TechMRT will maintain hard copies of the supplementary interview-related materials in our research files; these are archived working documents which are not in final report format.
- We have prepared selected data files for inclusion in this report as Appendices.
- We have scanned selected working documents, copied these files onto a Data CD, and provided the Data CD to TxDOT for archive purposes.

2.3.3 The Bleeding Asphalt Data CD

The files on the Data CD primarily consist of notes, photographs, and other records – *not in final report format* – from our interviews. Specifically, the Data CD contains the following files:

Task 1: Literature Review

- *No files* for Task 1 are included on the Data CD.

Task 2: Interview Knowledgeable Persons Outside TxDOT

- Interview records for conversations with representatives from Binder Supplier firms
- Interview records for conversations/correspondence with representatives from State DOTs

Task 3: Interview Knowledgeable TxDOT Personnel

- Interview records for conversations with representatives from 23 of the 25 TxDOT Districts. These records summarize the results of the interview and site visits and are the primary data upon which this report is based. The typical interview record consists of a summary of the interview plus photographs and other documents provided by the District. The Data CD contains only the interview summary plus selected photographs.
- Summary descriptions of Bleeding/Flushing projects in selected Districts

Task 4: Data Analysis

- Project-level analysis for three separate projects investigating the effect of seal coat binder quality on flushing/bleeding

The Data CD contains much of the data upon which the report findings are based. It is here the reader will find detailed information about District conditions. The working files also present first-hand information about maintenance practices and procedures for bleeding and flushing conditions for a specific region of Texas, including annotated photographs, contact names, and phone numbers for further information (current as of the date they were obtained).

2.4 Research Focus and Limitations

Bleeding/flushing represents a multi-faceted problem that has been explored from design, construction, maintenance, and other perspectives — but we have intentionally focused our research from the *maintenance* perspective. It is appropriate to identify other boundaries and limitations of this research.

First, it must be emphasized that this report addresses maintenance solutions for both bleeding and flushing. Although published literature does not always distinguish between these two phenomena, TxDOT maintenance forces *do* distinguish between bleeding and flushing – they are different problems with different causes and different solutions. Therefore, this report treats bleeding and flushing as separate problems and discusses solutions for both.

Second, this report specifically focuses on solutions for bleeding/flushed pavements that are surfaced with a seal coat or a surface treatment. We acknowledge that bleeding/flushing problems also occur in hot mix asphaltic concrete pavements, but these bleeding/flushing scenarios have been intentionally *excluded* from this research. This is not to say that they are not important, but that we have limited our research to considerations for seal coats/surface treatments such as would be typically encountered by TxDOT maintenance personnel.

Third, we did not limit our research to "short term" solutions. Although the original research problem statement specifically addressed short-term solutions to bleeding, it became apparent that the range of effectiveness for maintenance solutions varies from short term to long term. In fact, the same solution can be either or short term or long term, depending on its application and the details of the bleeding or flushing problem.

Fourth, and related to the above, the maintenance practices and procedures discussed herein are intended for use in Texas, for roads within the TxDOT system. The physiographic make-up of Texas includes mountains, beaches, deserts, high-rainfall areas, grasslands, and forests. Traffic conditions range from rural countryside to metropolitan cities, with everything in between. This makes for a highly diverse range of conditions for which the practices and procedures discussed herein will apply. But Texas is obviously located in the southern part of the United States and thus does not experience severe winter weather like northern states do, so the bleeding/flushing maintenance practices and procedures discussed herein do not heavily get into freeze-thaw and cold-weather issues.

CHAPTER 3

TEXAS MAINTENANCE PERSPECTIVES ON BLEEDING AND FLUSHED PAVEMENTS

3.1 Overview

Pavement maintenance literature discusses bleeding and flushing as a roadway surface defect, the typical definition being “excess asphalt binder occurring on the pavement surface” [8]. “Bleeding” is the term most commonly-used to describe this type of distress, although “flushing” is also used. While some definitions distinguish between the terms bleeding and flushing [9], *by far* most pavement maintenance publications – both academic and operations-oriented – treat the terms more or less interchangeably [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29]. Even the TxDOT *Seal Coat and Surface Treatment Manual* [34] does this. Some definitions explicitly equate bleeding and flushing, and some definitions view bleeding as a more severe manifestation of flushing. The problem is exacerbated by definitions which are restricted to asphaltic concrete pavements but do not indicate this. Thus some confusion exists, both in academic literature and in the practice-oriented publications of the roadway maintenance community, about the differences between bleeding versus flushed pavements. To dispel confusion about these terms, we begin with a brief discussion of maintenance definitions for bleeding and flushed pavements for roads surfaced with a seal coat or surface treatment.

3.2 Mechanism Responsible for Bleeding/Flushed Pavement

General agreement exists in the research and roadway maintenance communities that the basic mechanism associated with both bleeding and flushing has to do with excess asphalt binder filling the voids between the aggregate particles (cover stone). Figure 3.1(a) illustrates a situation where adequate voids exist between the aggregate particles. The binder performs its function of protecting and sealing the roadway surface against moisture infiltration and other environmental effects; whereas, the aggregate particles perform their function of creating a skid-resistant surface and keeping vehicle tires out of the asphalt. From a systems perspective, the asphalt binder protects the road, and the aggregate particles protect the binder.

(a) Seal Coat Aggregate Particles Embedded in Asphalt Binder with Sufficient Voids Between Particles

(b) Asphalt Binder Migrated to the Surface of Seal Coat Aggregate Causing Insufficient Voids Between Particles

Figure 3.1 Relationship Between Aggregate Voids and Bleeding/Flushing

However for various reasons, the binder may migrate to the surface of the aggregate, filling the voids, as indicated by Figure 3.1 (b). Here the binder continues to perform its function of sealing the roadway surface; however, the aggregate no longer serves to protect the binder from direct contact with tires. This situation – inadequate voids between the aggregate particles – can manifest itself as either bleeding or flushing. The terms *are* different even though the origin of the problem is the same in both cases.

The following sections discuss the functional differences between bleeding and flushing. This discussion is a synthesis of information obtained from our District interviews and generally represents the perspective of the TxDOT maintenance community.

3.3 Bleeding Pavement – A Maintenance Definition

As used in this document, bleeding is the upward movement of asphalt in a seal coat or surface treatment resulting in the formation of a film of asphalt on the roadway surface (Figure 3.2). Bleeding occurs when excess asphalt binder fills the voids in the aggregate mat and then moves upward to the pavement surface under traffic and with heat expansion in a non-reversible, cumulative process.

Figure 3.2 Bleeding Asphalt Caused by Excessive, Heavy Truck Traffic and Hot Weather

3.3.1 Visual Identification

Maintenance personnel have described bleeding as the rapid onset of live (liquid), excess asphalt on the pavement surface which rises above the aggregate. The appearance of the pavement surface goes from dull black to glossy, shiny, and glass-like. Traffic through a bleeding pavement makes a “smacking" sound, like "driving through rain” — sometimes termed “singing.” The key factor is that the asphalt binder is in liquid form.

3.3.2 Why Bleeding Is A Problem

Bleeding asphalt sticks to aggregate and tires and causes tracking. Left unattended, bleeding can result in the seal coat or surface treatment aggregate rolling over and being picked up. This can lead to “pitting out” or pulling up chunks of pavement — “slinging” as opposed to “singing.” With reference to Figure 3.3, both the asphalt *and* the aggregate are picked up, effectively ruining the seal.

Figure 3.3 Pavement Damage – Picking Up of Seal Coat – Caused by Bleeding

Bleeding typically occurs during seal coat/surface treatment construction process when the pavement is first opened to traffic, before the binder has fully cured. Functionally, bleeding is considered a failure and it must be addressed using corrective or reactive (in some cases, emergency) maintenance.

3.3.3 Maintenance Concerns

Factors that lead to bleeding include but are not limited to binder issues (too much binder, wrong binder type), environmental conditions (temperature, humidity), traffic effects (heavy traffic, high volume traffic), and construction deficiencies. Bleeding is an immediate maintenance problem that must be repaired. Repair response is time-critical to prevent picking up a fresh seal coat or surface treatment.

3.4 Flushed Pavement – A Maintenance Definition

Like bleeding, flushing describes a pavement condition where excess asphalt binder occurs on the roadway surface. Many pavement maintenance definitions use the terms “bleeding” and “flushing” interchangeably; they do not distinguish between the two. However, for the purposes of this document, flushing differs from bleeding in certain key ways.

3.4.1 Flushed Pavement: Not Necessarily A Bad Thing

First and foremost, flushing is typically not an immediate maintenance problem and may not be a maintenance problem at all. In a flushed pavement, asphalt fills the voids in the aggregate mat and comes up flush with top of rock, but the binder is not liquid — it is solid or semi-solid. A flushed pavement is still holding its seal, so in a very real sense, the seal coat is still performing at least one critical aspect of its function (Figure 3.4).

Figure 3.4 Flushed Pavement

Second, flushing occurs on pavements where the asphalt has already cured; whereas, bleeding typically occurs during the seal coat or surface treatment construction period while the binder is still tender. In contrast, flushed pavements have typically been through at least one full winter/summer season. Progressive flushing due to wearing down of aggregate is common during the typical life cycle of a properly-constructed seal coat.

One of the more helpful descriptions we heard in the Districts is that "flushed" is past tense; whereas, "bleeding" is an active verb.

3.4.2 <u>Visual Identification</u>

Depending on the degree of severity, flushed areas of the pavement surface may be discolored/darker (low severity), experience a loss of surface texture (moderate severity), or have a shiny, glossy appearance showing tire marks in warm weather (high severity – see Figure 3.5). Flushed pavements can track and bubble, eventually going to bleeding. The excess asphalt associated with flushing frequently appears in the wheel paths.

Figure 3.5 Heavily Flushed Pavement

3.4.3 <u>Maintenance Concerns</u>

The maintenance threshold for flushed pavements is a slick roadway surface with low skid resistance. Flushed areas become very slippery, especially in wet weather conditions, which is a safety concern. The condition becomes particularly severe when flushing coincides with rutting and water accumulation in the wheel paths.

3.5 Screening Survey Results – Views on Bleeding/Flushing from a "Statewide" Perspective

3.5.1 Survey Respondent Demographics

Prior to commencing the District interviews, we developed and submitted a "Screening Survey" to maintenance personnel across the State, the goal being to obtain a broad picture of the types of practices and procedures that were being used to evaluate and to treat bleeding and flushed pavements. This screening survey was not a random sample *per se*, but was intended to elicit statewide perceptions about the bleeding/flushing problem.

We sent surveys to the Directors of Maintenance in all 25 Districts, asking them to complete the survey themselves and also forward the survey to other persons in the District (5 max, 3 min) whom they thought would be most knowledgeable about the bleeding asphalt issue. We received a total of 56 completed surveys from 23 of the 25 districts, with responses per District varying from 1 person to 6 persons, average 2 persons. Respondents were mostly senior maintenance personnel (Table 3.1), most of whom had 21 to 25 or more years of experience (Table 3.2).

Table 3.1 Screening Survey Respondent Job Function (N=56)

Job Function	No. of Respondents	Percentage of Respondents
Director of Maintenance/ Director of Operations	19	34
Maintenance Supervisor/ Assistant Supervisor	14	25
District Seal Coat Manager	7	13
Area Engineer	4	7
Maintenance Administrator	3	5
Director of Construction	3	5
Maintenance Engineer	2	4
Chief Inspector/ Inspector	2	4
Special Jobs Supervisor	1	2
District Pavement Engineer	1	2

Table 3.2 Screening Survey Respondent Total Years Work Experience (N=55)

Total Years Work Experience	No. of Respondents	Percentage of Respondents
5 or fewer	0	0
6-10	2	4
11-15	5	9
16-20	17	31
21-25	16	29
26-30	7	13
31-35	7	13
More than 35	1	2

3.5.2 Screening Survey Results

Appendix A presents the Screening Survey Questionnaire. Findings from this survey can be presented in terms of four categories of questions; namely:

- The general conditions relative to bleeding problems for seal coats/surface treatments
- The extent to which various factors cause bleeding on pavements with seal coats/surface treatments
- The frequency with which various solutions are used to treat bleeding
- The perceived effectiveness of the various solutions (how well the treatments work)

For the purposes of the survey, it is important to note that all questions were about "bleeding" and bleeding was defined as "…excess asphalt binder occurring on the pavement surface." Arguably, a more carefully-worded survey that distinguished between bleeding and flushing (as per the previous section) could have been developed upon completion of the research, but it is important to remember that the findings presented herein are from the screening survey, done at the beginning of the project. In all cases, we used a 7-point scale (range equal 1 to 7) with "1" representing the low end and "7" representing the high end of the response spectrum.

3.5.2.1 General Conditions

The initial four questions were directed at identifying the general conditions relative to bleeding conditions. Of these, only Question 2 yielded reliable answers. In particular, Questions 3 and 4 were interpreted in different ways by the respondents and thus the results were not consistent. Table 3.3 presents the results for Question 1.

Table 3.3 Extent of the Bleeding Problem in the Districts (N=56)

Survey Item/Description	Percentage of Respondents Who Say…								Weighted Average
	NEVER HAPPENS 1	2	3	4	5	6	VERY COMMON 7	Don't Know	
2. How common is it for the roads with seal coats/surface treatments in your District to have problems with bleeding?	4	29	52	9	2	2	4	0	2.96/7

The data in Table 3.3 show that only 8 percent of respondents (summation of top three response percentages) believe that bleeding is very common in Texas. Most respondents (85%) indicate that bleeding is not common.

3.5.2.2 Causes of Bleeding

The next section of the screening survey concerned the causes of bleeding. Here, respondents were asked to indicate the extent to which various factors cause bleeding in their particular district. The stated factors were identified from the literature review and initial conversations with the Project Monitoring Committee and include aggregate issues (Item 5), binder issues (Item 6, 11 and 12), environmental issues (10, 15), and predominantly, construction issues (Item 7, 8, 9, 13, 14, and 16). Table 3.4 presents the results from these survey items.

Table 3.4 Extent to Which Various Factors Cause Bleeding (N=56)

Survey Item/Description	Percentage of Respondents Who Say… NOT A PROBLEM 1	2	3	4	5	6	MAJOR PROBLEM 7	Don't Know	Weighted Average
14 Pre-existing bleeding of existing pavement surface	5	14	16	21	11	14	14	4	4.22 /7
5 Loss of aggregate	5	18	22	13	20	15	7	0	3.96 /7
6 Too much asphalt	5	25	16	15	16	16	5	0	3.82 /7
13 Inadequate curing time of patching materials prior to seal coating	14	14	16	23	13	11	7	2	3.67 /7
15 Climatic conditions (cold/wet) during and immediately after construction	18	16	18	16	11	11	7	4	3.48 /7
12 Poor binder quality	18	23	13	9	9	7	5	16	3.13 /7
16 Seal coat was constructed outside the seal coat season	32	25	13	5	7	9	7	2	2.85 /7
8 Inadequate curing of seal coat before road is opened to traffic	27	25	16	9	9	11	0	4	2.80 /7
7 Excessive delay between application of asphalt and aggregate placement	30	30	11	14	5	2	0	7	2.35 /7
11 Improper binder type	30	30	9	2	7	4	0	18	2.22 /7
9 Improper or inadequate rolling of aggregate	33	27	18	5	2	2	0	13	2.10 /7
10 Water vapor pressure from the base or subgrade (stripping)	35	28	11	2	2	0	0	22	1.81 /7

The data in Table 3.4 show that the dominant cause of bleeding is perceived to be pre-existing bleeding of the pavement surface, with a significance rating of 39 percent. This suggests that bleeding problems perpetuate themselves and are difficult to solve. Additional significant causes of bleeding are aggregate loss (which could arise for a number of reasons), too much asphalt (ostensibly a binder problem, but likely a construction issue), and inadequate curing time (also a construction issue). The bottom half of the table – all items below "Inadequate Curing of Seal Coat" – most of which are construction issues – have significance ratings of 20 percent or lower and are typically not a problem. Stripping is hardly ever a problem.

3.5.2.3 Solutions to Bleeding Ranked by Frequency of Use

The next section of the screening survey concerned solutions to bleeding and their frequency of use. Here, respondents were asked to indicate the frequency with which they use various solutions to address bleeding in their particular district. The stated solutions were identified from the literature review and initial conversations with the Project Monitoring Committee, prior to conducting the District interviews. Thus, these solutions were not ordered and classified in the same way as we have presented the solutions in Chapter 6 (Bleeding), Chapter 7 (Flushing), and Chapter 8 (Intersections). Review of the solutions indicate that eight solutions apply to bleeding (Items, 17, 18, 19, 20, 21, 24, 28, 29). Four solutions apply only to flushing (22, 25, 26, 27), and two solutions could apply to either bleeding or flushing (23, 30). Table 3.5 presents the results from these survey items.

Table 3.5 Frequency With Which Various Solutions Are Used to Treat Bleeding (N=56)

Survey Item/Description	Percentage of Respondents Who Say…								Weighted Average
	NEVER 1	2	3	4	5	6	VERY OFTEN 7	Don't Know	
17 Apply layer of small size (grade 5) aggregate	5	7	9	20	14	18	23	4	4.83 /7
28 Apply lime water to cool and crust over the bleeding pavement surface	13	5	11	21	13	16	21	0	4.50 /7
19 Apply blotter material (coarse sand/stone screenings) to blot up excess asphalt	20	20	16	7	14	7	16	0	3.63 /7
30 Apply a thin asphaltic concrete overlay	27	27	14	11	11	4	5	2	2.84 /7
23 Apply new seal coat over bleeding pavement surface	35	24	16	7	9	4	4	2	2.57 /7
25 Apply microsurface (application of a thin layer – or layers – of dense-graded aggregate, polymer-modified asphalt emulsion, water and mineral fillers)	35	25	16	5	4	4	7	4	2.57 /7

Table 3.5 continued

27	Cold milling to remove bleeding asphalt layer, with or without replacement materials	31	31	22	2	7	7	0	0	2.45 /7
29	Apply water to cool the pavement surface	36	29	14	13	4	2	2	2	2.31 /7
24	Remove bleeding pavement surface and replace with new seal coat	55	25	9	2	0	5	2	2	1.87 /7
18	Apply layer of larger size (grade 3) aggregate	59	21	4	4	2	0	5	5	1.83 /7
26	Apply slurry seal (application of slow setting emulsified asphalt, well-graded fine aggregate, mineral filler or other additives, and water)	75	14	0	4	2	2	0	4	1.43 /7
20	Sandwich Seal (apply layer of coarse aggregate directly on the bleeding pavement surface, shoot a layer of asphalt, and then apply a wearing course of smaller rock)	80	5	4	2	2	2	0	5	1.37 /7
21	Apply very clean, hot aggregate directly to the bleeding pavement surface	79	11	5	2	0	0	0	4	1.28 /7
22	High pressure water treatment to remove excess asphalt and restore texture (water blaster, water cutter)	96	2	0	0	0	0	0	2	1.02 /7

The data in Table 3.5 show that in reality, only three solutions are frequently used to treat bleeding – application of small size (grade 5) aggregate, application of lime water, and application of blotter material. Of these, the first two dominate with frequency ratings of 50 percent or better. The remaining solutions are not used very often, with frequency ratings of less than 20 percent.

3.5.2.4 Solutions to Bleeding Ranked by Perceived Effectiveness

The final section of the screening survey concerned solutions to bleeding and their perceived effectiveness. Here, respondents were asked to indicate how well a particular solution works in their district. As with the frequency items, the stated solutions were identified prior to conducting the District interviews and thus are not ordered and classified in the same way as we have presented the solutions in Chapter 6 (Bleeding), Chapter 7 (Flushing), and Chapter 8 (Intersections). Table 3.6 presents the results from these survey items.

Table 3.6 Perceived Effectiveness of Various Solutions Used to Treat Bleeding (N=56)

Survey Item/Description	Percentage of Respondents Who Say…							Don't Know	Weighted Average
	NOT EFFECTIVE 1	2	3	4	5	6	**HIGHLY EFFECTIVE** 7		
39 Apply microsurface (application of a thin layer – or layers – of dense-graded aggregate, polymer-modified asphalt emulsion, water and mineral fillers)	5	2	2	7	9	15	24	35	5.44 /7
44 Apply a thin hot mix asphaltic concrete overlay	4	2	7	7	9	22	25	24	5.40 /7
41 Cold milling to remove bleeding asphalt layer, with or without replacement materials	7	11	7	7	13	13	22	20	4.66 /7
42 Apply lime water to cool and crust over the pavement surface	2	11	13	21	16	16	14	7	4.56 /7
31 Apply layer of small size (grade 5) aggregate	5	7	11	20	25	13	13	7	4.50 /7
38 Remove bleeding pavement surface and replace with new seal coat	13	6	9	7	6	13	11	33	4.19 /7
33 Apply blotter material (coarse sand/stone screenings) to blot up excess asphalt	11	14	20	18	13	7	4	14	3.50 /7

Table 3.6 continued

40 Apply slurry seal (application of slow setting emulsified asphalt, well-graded fine aggregate, mineral filler or other additives, and water)	9	7	0	2	4	0	7	70	3.44 /7
37 Apply new seal coat over bleeding pavement surface	13	16	20	13	16	7	0	15	3.30 /7
32 Apply layer of larger size (grade 3) aggregate	20	5	7	5	0	7	7	47	3.21 /7
34 Sandwich Seal (apply layer of coarse aggregate directly on the bleeding pavement surface, shoot a layer of asphalt, and then apply a wearing course of smaller rock)	13	0	4	2	4	4	2	73	3.07 /7
43 Apply water to cool the bleeding pavement surface	7	27	20	5	7	7	0	25	3.00 /7
35 Apply very clean, hot aggregate directly to the bleeding pavement surface	13	5	0	4	4	0	0	75	2.21 /7
36 High pressure water treatment to remove excess asphalt and restore texture (water blaster, water cutter)	15	0	2	0	0	0	0	84	1.22 /7

The data in Table 3.6 show that five solutions are perceived to be effective for treatment of bleeding –microsurfacing, application of a thin hot mix overlay, cold milling, application of lime water, and application of small size aggregate – each of these having confidence ratings of 45 percent or better. Of these, the first three are actually solutions for flushed pavements rather than bleeding. The next two – lime water and application of small size aggregate – apply to bleeding and as far as bleeding solutions go, they are not only among the more effective but are also the most frequently used. The remaining solutions are not used very often, with frequency ratings typically lower than 20 percent.

It is significant to note that much uncertainty exists about the perceived effectiveness of these solutions. For example, seven of the solutions had “Don’t Know” responses of greater than 33 percent, and four had “Don’t Know” responses of greater than 70 percent. Ambiguity about the effectiveness of these solutions suggests that while maintenance forces use what is available, they do not always feel good about it.

Also, the findings of the screening survey do not necessarily indicate that a particular solution is a poor choice, even when it is not used much. For example, few if any of the respondents knew anything about the ultra high pressure water cutter, and this is borne out by the survey results which show low frequency of use and low perceived effectiveness. However, when this method was explained during our interviews, most maintenance personnel expressed interest in learning more about it.

CHAPTER 4
CAUSES OF BLEEDING AND FLUSHED PAVEMENTS

4.1 Overview

This section of this report provides insight into the main factors that contribute to bleeding and flushed pavements. These include aggregate issues, binder issues, traffic issues, environmental issues, and construction issues. The maintenance supervisor looking for solutions to bleeding/flushing will do well to recognize and understand these causes, since in many cases the best solution is to not get into the problem in the first place [13].

4.2 Aggregate Issues

When a seal coat or surface treatment loses its rock, flushing and/or bleeding will be the result (Figure 4.1). Aggregate issues include rock loss, application of too much rock, use of dirty rock, use of soft rock, and judicious use of modified aggregate grades.

Figure 4.1 Flushing in Wheel Paths

4.2.1 Rock Loss

Loss of aggregate, also known as rock loss, or shelling, ranks high as one of the major causes of flushing and bleeding for pavements with seal coats and surface treatments. Rock loss problems frequently occur when a seal coat is placed outside the established seal coat season, either late or early.

Rock loss problems tend to happen when abnormally cool or cold temperatures (or rain/snow) occur during or after the placement of a seal coat before the aggregate/asphalt bond has had a chance to fully develop. Rock loss problems can also occur when:

- The binder is too stiff for a particular weather condition.
- The asphalt rate is too light.
- Too much time elapses between the asphalt shot and rock placement.

Rock loss can also occur when water (moisture) is trapped in an existing pavement and then sealed. The water will turn into a vapor and rise when heated resulting in possible rock loss problems or delamination of the seal coat [30] [31].

4.2.2 Too Much Rock

The wrong aggregate rate — typically too much aggregate — can cause bleeding and flushing. Where the rock rate is too high, the rock is too crowded resulting in a solid mat/rocks stacked on top of each other. Here the rock will crush and create more fines, further displacing the asphalt.

The aggregate must have an adequate quantity of voids to accommodate volume changes of the asphalt with changes in temperature, and at the same time keep the vehicle tires out of the asphalt. If the rocks are too close together, they cannot “roll over” and get the proper embedment in the asphalt. Additionally, if the cover stone is too dense (insufficient voids in the mat), the asphalt will have a tendency to rise above the level of the rock when temperatures rise and the asphalt starts to expand.

Seal coat aggregate should be placed so that rock particles do not touch each other but are close enough so that a rock will not fit in the space between the rocks. District personnel like to see 15-20% voids between the rocks. The freshly placed mat typically looks “light” until the rocks go to their final position. It normally takes a few days under traffic before this occurs.

4.2.3 Dirty and/or Soft Rock

Use of dirty seal coat aggregate leads to rock loss. Dirty aggregate causes loss of adhesion/bond between aggregate and asphalt binder (Figure 4.2).

Softer aggregates tend to abrade and wear down (polish out flat) more quickly under traffic. This can lead to a loss of traction (skid resistance) as well as a flushed condition and possible subsequent bleeding. This is especially true when the rock rate is too high. When the seal coat aggregate crushes, this creates more fines, and the excess fines displace the asphalt (push the oil up) resulting in less void depth to keep tires out of the asphalt.

Figure 4.2 Dirty Seal Coat Aggregate

Whereas Grade 3 rock – TxDOT Standard Specification Item 302 [32] – is generally more forgiving than the smaller Grade 4 rock with regard to asphalt rates, lightweight rock (usually Grade 3) is very susceptible to abrasion and wearing down under traffic, especially for high traffic conditions. Harder rock is recommended for higher volume roads.

4.2.4 Modified Aggregate Grades

Modified aggregate grades (single size rock) have fewer problems with bleeding and flushing [33]. These grades are more predictable, can accommodate a higher and more consistent asphalt rate, and are more forgiving. In contrast, normal gradations have more fines, are more variable, and require a lower asphalt rate. However, aggregate suppliers are reluctant in some instances to produce and supply modified gradations, and they are more expensive.

4.3 Binder Issues

The development and appropriate use of polymer modified and other binders have improved seal coat and surface treatment performance due to their increased cohesion, toughness, and reduced temperature susceptibility. Binder issues relative to bleeding and flushing include binder selection, historically problematic binders, binder application rate, binder curing, and binder quality.

4.3.1 General Issues

General binder-related issues associated with flushing and bleeding include the quality of binder, use of inappropriate (too high or too low) binder application rates, and poor construction practices. Binder properties influence flushing and bleeding of seal coats in two ways. One is when highly temperature-susceptible asphalt binder is used in the layer below the seal coat. This binder can soften at very high pavement service temperatures resulting in the aggregates of the seal coat pressing into the underlying pavement layer. This pushes the asphalt binder upwards causing flushing and bleeding.

A second issue is incompatibility between the seal coat aggregate and the binder, which can cause aggregate loss resulting in a bleeding pavement. This incompatibility may be caused either by problems inherent in the binder, or by binder-related issues that are accentuated by inappropriate construction practices. Examples of such practices include long delays between the binder spray and the aggregate spread in the case of emulsion binders, low binder temperature at the time of aggregate spread for hot asphalt binders, and inappropriate binder spray temperature for all types of binders.

Another major binder-related issue that causes bleeding is inappropriate curing time used for cutback asphalt binders. When cutback asphalts are used either in a prime coat or in the first course of a multiple course surface treatment, short curing time for cutback asphalt will leave volatile oils underneath the seal coat or surface treatment that can significantly soften the surface treatment binder.

4.3.2 Binder Selection

The appropriate asphalt must be used in the appropriate season as defined by the project plans, specifications and experience. Softer binders used in relatively colder climates in the state have been shown to cause more bleeding problems during hot summers in those areas. The use of any asphalt binder outside the recommended temperature conditions (or asphalt season) can lead to problems with bleeding, flushing and/or rock loss. This would be especially true where a cool weather binder is used late in the winter followed by a period of very warm or hot weather before the binder has a chance to fully cure and adhere to the rock. Asphalt binders also should be selected based on the traffic conditions anticipated for the roadway.

4.3.3 Historically Problematic Binders

Some asphalt binders used in the past have since been discontinued or discouraged in certain applications due to problems with flushing and bleeding. Examples of the older, less-frequently used binders include unmodified AC-5 and AC-10. When unmodified, softer binders are contained in underlying layers of pavement or seal coats, they have a tendency to work their way up through the newer layers and continue to create problems with flushing and bleeding.

4.3.4 Binder Application Rate

Asphalt and aggregate shot rates need to be appropriate for the selected type and grade of binder and rock. If the asphalt rate is too light it can lead to rock loss (shelling) and ultimately, flushing. If the asphalt rate is too heavy, it can lead to bleeding and/or flushing.

Special care must be taken in the material rate design phase and most importantly, during construction, to properly adjust the shot rate for pavements where previous flushing or bleeding problems have occurred, in wheel paths, or in other areas rich with asphalt.

Roads that have been shot with too much asphalt can become long-term maintenance problems because the asphalt keeps softening when subsequent layers are added. Such roadway surfaces eventually have to be replaced.

4.3.5 Binder Curing

Seal coat and surface treatment asphalts normally require several months of warm/hot weather before the asphalt gets hard (cured), penetrates well into the aggregates, and becomes less susceptible to material property changes with large increases in temperature.

4.3.6 Binder Quality

Poor quality and/or inconsistent binder quality can lead to problems associated with flushing, bleeding and rock loss. This may be due in part to the quality and variability of the crude (base asphalt) and to binder production processes adopted by the manufacturer. Certain districts have had problems with "out of spec" binders received for field projects. TxDOT's binder quality assurance program is being updated to address this issue.

4.4 Traffic Issues

Certain types of traffic can press aggregate into the seal coat/surface treatment matrix or it can result in aggregate being dislodged or rolled over by turning stresses. Traffic considerations relative to bleeding and flushing include traffic volume, traffic type (heavy trucks), traffic movements (stop & go, turning, etc.), and intersections.

4.4.1 Traffic Volume (Average Daily Traffic – ADT)

Traffic volume and type play a major part in the development of bleeding and flushing problems. Higher traffic volumes will cause flushing and bleeding to manifest sooner than for roadways with lower ADT. This is due in part to the rolling action of the traffic which pushes the rock down into the asphalt or underlying pavement.

4.4.2 Traffic Type (Heavy Trucks)

The amount and percentage of truck traffic (heavy loads) can accelerate aggregate abrasion as well as accelerate the process of embedding rock into the underlying asphalt or existing pavement layers. High volumes of truck traffic and overweight loads over extended periods of time can also create rutting in the wheel paths.

Heavy truck traffic, heavy loads, and overweight loads are especially problematic on steep grades or along sharp (tight) curves where frequent braking is required. These loads are typically associated with certain industries, for example, farming/agriculture, logging, oilfield, and the like. Because of industry exemptions these trucks are often overweight, sometimes by as much as 50 percent. This is particularly damaging to the rural FM roads where such traffic is most prevalent.

4.4.3 Traffic Movements (Stop & Go, Turning, Etc.)

Starting, stopping (braking), turning, and slow-moving traffic tends to aggravate flushing and bleeding problems. Heavy loads associated with truck traffic make bleeding and flushing worse because such traffic has a tendency to shove and move the rock. This is especially the case at turns/horizontal curves.

Braking tends to tip the seal coat rock up, exposing more asphalt binder on the pavement surface. The rock is more prone to being abraded in this situation.

Turning causes the aggregate to mound up and shove. The reason is that, unlike cars and most other vehicles, the rear tandem axles of trucks do not have differentials that allow the rear wheels to turn at different rates as the vehicle makes a turn. This twisting action of tandem axle tires as they essentially slide across the pavement surface is one of the main causes of scrubbing at intersections and curves. The result is a “washboard” effect on the pavement surface (Figure 4.3).

Figure 4.3 Pavement Distress Caused by Starting/Stopping and Turning Maneuvers

Slow moving or stopped traffic contributes to many of the problems associated with bleeding pavements, including the tendency to “roll the rock” — especially for freshly constructed seal coats or surface treatments. This “rolling up” or “picking up” of the seal coat or surface treatment from the base or underlying substrate is especially damaging.

Slow-moving or stopped traffic (with hot tires) directed onto fresh seals as part of the traffic control plan makes an already-difficult problem worse.

4.4.4 Intersections

Intersections are particularly problematic relative to slow-moving traffic, starting, stopping (braking), and turning movements. Oil leaks, diesel leaks, and other solvents tend to be deposited in these areas. Catalytic converters from slow-moving or stopped traffic produce excessive heat, increasing pavement temperatures. Turning movements cause the seal coat to be "shoved sideways" resulting in a very irregular (rough) pavement surface. Thus, flushing and bleeding problems are more prevalent at these areas.

4.5 Environmental Issues

Environmental issues such as temperature and humidity have a profound effect on flushing and bleeding. This section of the report discusses the key environmental factors associated with flushing/bleeding pavements including high temperature, humidity, changing temperatures, and low temperatures.

4.5.1 High Temperature

Temperature and humidity have a profound effect on flushing and bleeding. High temperatures — nearing 100°F or higher — coupled with elevated humidity can turn flushed pavements into bleeding pavements (Figure 4.4). This is particularly the case where these high temperatures persist for several consecutive days, as is common during the summer in most parts of Texas. The severity of bleeding conditions is made worse in combination with traffic and other factors described previously.

While no definitive temperature threshold exists to define bleeding, our interviews suggest that ambient temperatures above the mid-to-upper 90°s can turn flushed pavements into bleeding pavements. Maintenance personnel report that bleeding can occur at air temperatures of 95°F and above. Data from an infrared surface temperature gun indicated a pavement surface temperature of 136°F on a bleeding seal coat. Pavement temperature in the wheel paths can be as high as 150°F with an air temperature of 100°F.

4.5.2 Humidity

Temperature and humidity conditions for bleeding become more critical if there is no wind to cool the pavement. The "heat index" is the key — i.e., the combination of temperature, humidity and wind. High humidity will increase the severity of bleeding at a given temperature.

Humidity essentially reduces the rate at which a pavement can be cooled. High humidity also delays the break and set of a seal coat emulsion, and this can increase the tendency for rock to roll under traffic; traffic has to stay off the fresh seal for a longer period of time. High humidity results in slower curing of asphalt (initial setup), especially with emulsions. This tends to keep asphalt alive longer.

It should be noted that the TxDOT Seal Coat Manual [33] states that "no asphalt should be shot above a relative humidity of 50%." While this would be possible in West Texas, this situation simply will not exist for other parts of the state.

4.5.3 Changing Temperatures

Changing weather conditions can present special problems for seal coats and surface treatments. One example is a series of high temperature days followed by a "cold snap" or cooling rains.

Such unstable weather patterns typically coincide with transition seasons at the beginning and end of the seal coat season — in the spring and fall of the year. Inspection personnel must monitor temperatures closely during construction and shut down seal coat operations completely (or earlier in the day) if cold weather is expected.

Cool weather/rains during or a few days after seal coat construction can create problems with rock loss which in turn can lead to problems with flushing or bleeding. Emulsions are particularly susceptible to this situation.

Figure 4.4 Soft Pavement (Flushing) Resulting From High Temperature/Humidity

4.5.4 Low Temperatures

As noted above, cool/cold weather or rain/snow during or shortly after the placement of a new seal coat can create rock loss problems. This in turn can lead to problems with flushing and/or bleeding.

The tendency for rock loss is especially severe where a hard freeze is experienced for several days in areas where bleeding has occurred before. The result is a loss of rock which exposes more asphalt at the pavement surface.

4.6 Construction Issues

The dominant causes of flushing/bleeding pavements with seal coats and surface treatments fall in the category of construction issues. Most of these causes are preventable with good design and construction practices. Construction issues relative to preventing/avoiding bleeding and flushed pavements include proper assessment of existing pavement conditions, use of good seal coat preparation techniques, treatment of rutting in wheel paths, attention to the special curing needs of new seal coats, use of fog seals to mitigate rock loss problems, and avoidance of poor construction practices.

4.6.1 Existing Pavement Conditions

Many of the older farm roads have received numerous layers of asphalt in the form of multiple seal coats, patches, etc., as well as many different types of asphalt. Asphalt in subsequent seal coats has a tendency to flow into, build up or accumulate in rutted wheel paths, increasing the likelihood of problems associated with flushing and/or bleeding. Special care must be taken on existing pavements where previous flushing or bleeding problems have occurred, where rutting is present, in patched areas, or in areas rich or deficient with asphalt.

4.6.2 Seal Coat Preparation

Existing pavement conditions must be carefully considered in advance of seal coating operations relative to potential bleeding and flushing. Preparation and repairs on an existing pavement must have adequate time to cure before the seal coat is applied. This includes level-up operations, spot repairs and crack sealing. The recommended minimum is 6 months curing time.

Asphalt selection is very important for strip seals and spot seals in advance of seal coat construction. Certain asphalts such as RC-250 (and others) are more prone to being "livened up" when hot seal coat asphalt (350°F) is sprayed on top of them. Asphalt rates must be adjusted to accommodate each change in condition — dry, hungry or rich areas — otherwise problems with bleeding, flushing and/or rock loss could occur.

Patching should be done no later than the fall preceding the summer seal coat season. Fresh hot mix or premix patches have a high demand for seal coat asphalt. If patches are not adequately cured or seal coat asphalt rates are not adjusted, the patches can wick the seal coat asphalt resulting in rock loss which in turn can lead to bleeding and/or flushing. Patches need adequate time to cure and to allow the volatiles to escape before seal coating (1 year preferred, 6 months minimum). If a new seal coat — with hot oil — is shot over a green patch, traffic can pull up both the seal coat and fresh patch.

Crack sealing should be done at least one year in advance of seal coating. The crack sealant material is prone to reflect or bleed through a seal coat if it is not allowed adequate time to cure.

4.6.3 Rutting In Wheel Paths

Asphalt in subsequent seal coats will tend to flow into, build up or accumulate in rutted wheel paths, increasing the probability of problems associated with flushing and/or bleeding. If the wheel paths are already flushed, this should be taken into account when selecting asphalt rates during seal coat design. During construction, asphalt rates can be adjusted in the wheel paths through the use of variable rate nozzles or double spray bars. Significant rutting should be corrected before subsequent seal coats are applied.

4.6.4 New Seal Coats

New seal coats are particularly susceptible to bleeding problems immediately and soon after placement, especially when shot in very hot weather conditions. Construction equipment on the fresh mat can "roll the rock" and "roll up" the new seal coat if tires are allowed to come into contact with the liquid asphalt. The traveling public can intensify the problems when the fresh mat is opened to traffic before the asphalt/aggregate bond has fully developed.

4.6.5 Fog Seals

Fog seals are used to mitigate rock loss problems, and some districts include provisions in the construction plans for this application. Some fog seals contain a rejuvenator which will liven the asphalt and allow the rock to stick. However, if the fog seal is overdone, it can create problems with flushing and bleeding.

4.6.6 Poor Construction Practices

Construction practices which can lead to bleeding and flushed pavements include, but are not limited to:

- Sloppy seal coat work – bad joints, overlapping applications of asphalt and rock, inconsistent asphalt rates.
- Shooting seal coat out of season.
- Premature release of seal coat to traffic.
- Aggregate not spread on the asphalt as soon as possible.
- Poor rolling equipment and methods; construction equipment (spreader box and rollers) getting on the fresh seal too quickly.
- Crack sealants - over application, inadequate curing time and improper selection of materials.
- Use of asphalt distributor wands at intersections and radii – rates cannot be controlled.

CHAPTER 5
PREVENTIVE MAINTENANCE AS A SOLUTION FOR BLEEDING AND FLUSHED PAVEMENTS

5.1 A Preventive Maintenance Approach

There is no better advice for dealing with bleeding and flushed pavements than to avoid the problem from the outset during seal coat/surface treatment design and construction [13]. As in medicine, so in maintenance: “An ounce of prevention is worth a pound of cure.”

Figure 5.1 illustrates the typical pavement life cycle. It shows that speed of deterioration increases rapidly in the latter part of the performance curve. Moreover, the cost of a possible rehabilitation at the late stages in the performance cycle is three to four times more expensive than when applied early in the life of pavement. Therefore, preventive maintenance makes sense provided it is used at the appropriate time.

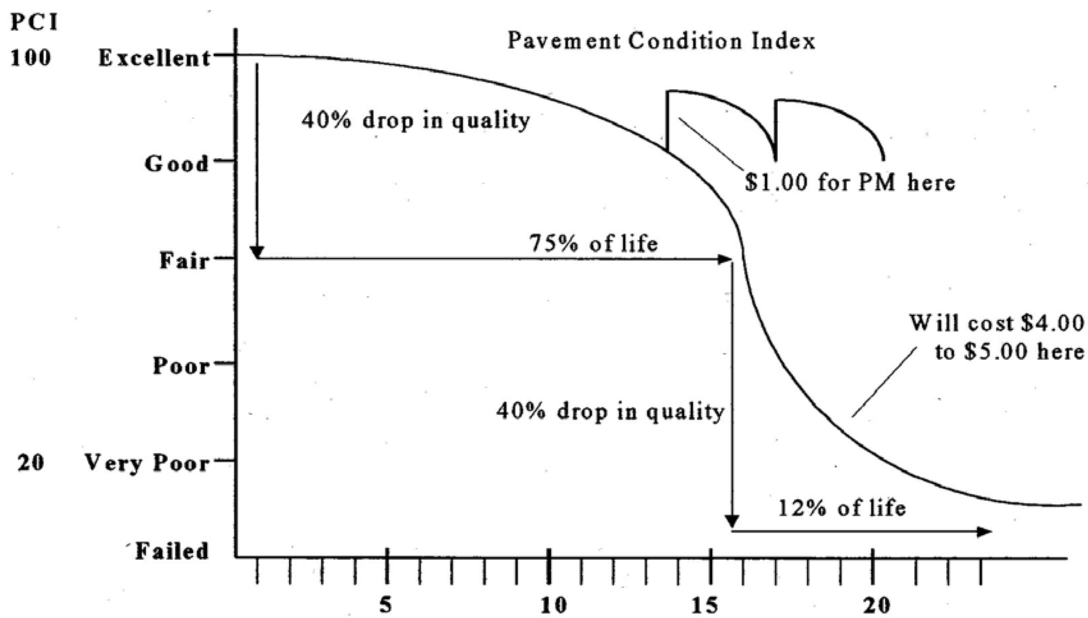

Figure 5.1 Typical Pavement Life Cycle (*Source*: Hicks, et al. [35])

In a similar way, it can be argued that a preventive maintenance mindset is a cost-effective tool for approaching the bleeding/flushing problem. Granted, the treatment of bleeding and flushed pavements is considered corrective as opposed to preventive maintenance. However, the fact remains that a preventive maintenance mindset is by far the most cost-effective maintenance solution discussed herein. “You show me a maintenance leader who approaches seal coat/surface treatment design and construction from the perspective of how to achieve high quality and avoid bleeding and flushing, and I’ll show you a maintenance crew that is relatively unbothered by the bleeding/flushing problem.”

Three topics emerge as being key to a preventive maintenance mindset focused on reducing bleeding and flushing in seal coats and surface treatments. These include avoidance of known pitfalls and problem areas (potentially avoidable causes), implementation of a centralized seal coat management program, and judicious selection of seal coat and surface treatment binders.

5.2 Potentially Avoidable Causes

The discussion of causes identified aggregate issues, binder issues, traffic issues, environmental issues, and construction issues as factors that result in bleeding and flushing. These can be viewed as falling along a spectrum relative to the extent to which they can be directly addressed in seal coat/surface treatment design and construction.

On one end of the spectrum are the *unavoidable causes* – factors which are simply part and parcel of the seal coat/surface treatment design and construction process and which cannot be changed. For example, traffic "is what it is." Similarly, climate and environmental conditions cannot be manipulated by maintenance forces. In such cases, the best that can be done is to be aware of the conditions that exist and the potential pitfalls associated with use of seal coats/surface treatments in these applications.

The other end of the spectrum consists of *purely avoidable causes*. These include things like poor construction practices and procedures, improper selection of aggregate and binder, and the like. These have no place in quality seal coat construction and *should be* avoided.

In between these two extremes are the *potentially avoidable causes* – certain situations that seem to regularly accompany bleeding and flushing problems. These include construction of seal coats/surface treatments during transition months at the beginning and end of the seal coat season, placing seal coats in excessively hot weather, and not providing sufficient curing time before allowing the traveling public on the new roadway surface.

The goal is to *cope* with unavoidable causes, *avoid* purely avoidable causes, and *manage* potentially avoidable causes. The remainder of this section discusses the potentially avoidable causes, factors which can be managed to yield a quality seal coat that will not bleed or flush.

5.2.1 Seal Coat/Surface Treatment Season

Many problems with seal coats and surface treatments have to do with the time of year the seals are applied. Transition months for seal coats can create many problems. The reason is that early and late season seals are more susceptible to being applied during cool weather and/or a late cold spell. Similar problems occur when a cooling rain comes through after the seal is placed.

Some districts have learned to customize their own seal coat/surface treatment season and have eliminated many of their problems. The seals need to have adequate time to cure and develop the full asphalt/aggregate bond before cool/cold weather. This will minimize rock loss and all of the subsequent problems associated with it, including flushing and bleeding.

Surface treatment projects (rehabilitation projects) are the prime offenders since many of these projects go year round. Construction projects seem to be where many bleeding/flushing problems start.

Some districts have learned to avoid applying any asphalt in the off-season. One of the benefits of this approach is that maintenance forces do not have to use cool weather asphalts. Ultimately, fewer problems occur when seal coats are placed in the asphalt or seal coat season.

5.2.2 Hot Weather Seal Coats

Cool weather is not the only challenge for seal coat/surface treatment construction. Many seal coat problems begin when contractors shoot seals during protracted periods of extremely hot weather (upper 90s and 100s) and prematurely open the road to traffic. In such cases, the asphalt/aggregate bond does not have a chance to fully develop.

This situation can result in rolling rock, severe bleeding, and "picking up" of the seal coat or surface treatment by the traveling public. Heavy construction traffic can also severely damage the seal coat mat before the public ever gets on it. This is one reason why contractors should be encouraged to keep water trucks full of lime water available on the jobsite. The point is that adequate curing time is needed for development of complete adhesion between the rock and the asphalt, and this is especially critical in hot weather under conditions of high traffic volume and heavy truck traffic.

5.2.3 Multiple Layers Of Seal Coats

System roadways typically have multiple seal coats, and a common scenario is when maintenance forces attempt to address bleeding/flushing on these roads with yet another seal coat. The new seal coat may stop the bleeding/flushing for a period of time; however, this is usually only a temporary fix.

The bleeding/flushing problem often continues and may increase in severity due to adding more asphalt. Rather than repeatedly applying more binder, consideration should be given to removing excess asphalt (flushing) during the seal coat preparation process in advance of seal coating operations.

5.2.4 Inadequate Curing Time

One cause of bleeding is when the traveling public is allowed on the fresh seal too quickly, before the asphalt/aggregate bond has been given adequate time to fully develop. This is most critical in adverse weather conditions and on roadways with high traffic volumes and heavy truck traffic.

A different kind of "curing time" poses another problem. This has to do with construction projects that use cool weather asphalts including emulsions and cutbacks. Many of the major offenders (bleeders) fit into this category, including emulsions such as CRS-1P and cutbacks such as RC-250, MC-2400, MC-3000, etc. The common thread is that volatiles, consisting of lighter fraction oils, kerosene, diesel, naphtha and even gasoline, are not allowed sufficient time to cure out before the seal is covered up with another course.

Emulsions and cutback materials are typically used as a prime coat on base or for the first course of a multiple course surface treatment. Prime coats require considerable periods of warm or hot weather for the light fraction cutbacks to cure out (volatilize).

Even though standard specifications require a certain number of minimum curing days for each type of material, the specifications do not define what a "curing day" is, and temperature and wind play a big factor. Some of the most severe and difficult bleeding problems occur as a result of volatiles being trapped inside (or beneath) a multiple course surface treatment or seal coat.

5.3 Centralized Seal Coat Program Management

Districts that utilize a centralized seal coat management program are having consistent success with their seal coats/surface treatments and fewer instances of problems such as bleeding and flushing. The centralized approach is an effective model for addressing seal coat design, construction and maintenance.

5.3.1 Description

Successful seal coat construction occurs where districts have a centralized seal coat program together with an experienced and committed seal coat team that is dedicated to quality.

Leadership is provided by the Seal Coat Program Manager. Typically this is a very experienced individual who is responsible for the entire district, and seal coats are this person's full-time priority. Other team members include seal coat professionals from district headquarters, area offices, and maintenance sections who are responsible for making the program work year in and year out. Districts that employ this centralized model are enjoying consistent success with seal coat construction and maintenance.

Quality seal coat construction happens as a result of a team effort between the design, maintenance, and seal coat construction groups. The process requires good communication and everyone working together. The seal coat team is responsible for every aspect of the seal coat program, from planning to construction inspection.

5.3.2 Seal Coat Planning

The seal coat planning process starts with a map of the roads to be sealed, and this map would be developed 2 to 3 years before actual seal coat construction. Many individuals provide input on project selection and priorities including the Seal Coat Program Manager, Area Engineers, Maintenance Section Supervisors, the Director of Maintenance, and the Director of Construction.

The Seal Coat Program Manager will typically visit the roads at different times of the year before seal coating. Traffic patterns tend to change throughout the year and these visits help the seal coat team get a better overall picture of the traffic on the roadways. The visits also help the team evaluate truck traffic types and levels since published ADTs do not normally reflect actual truck percentages.

Planning is critical. A multitude of factors are considered including existing pavement condition, skid resistance values, accidents, time since the last seal coat, and of course the budget. The number of years since the last seal coat is not always the key. The pavement condition (dry, rich, oxidized, etc.) and distresses such as rutting, bleeding, flushing, rock loss and cracking play a major role in the planning process.

5.3.3 Maintenance Preparation

Once the roads are chosen to be seal coated, several tasks proceed concurrently including maintenance preparation and seal coat design. Maintenance plays the major role in the seal coat preparation process. Maintenance crews are responsible for performing the necessary repairs to their roadways in advance of seal coat operations.

Seal coat preparation includes tasks such as crack sealing, repair of base failures, rutting repairs, edge repairs and level-up patching to name a few. Ideally, all patching and crack seals should be completed at least one year in advance of seal coat construction to allow any volatiles to cure and the patches to stiffen up. Good compaction and curing of the patches is critical so the overlying seal coat will not embed into a soft patch creating a potential flushing and/or bleeding problem.

Significant rutting must be repaired before a road is sealed. The establishment of a good cross slope is very important in minimizing the problems associated with rutting. If the rutting is not corrected, there is a tendency for asphalt to flow towards and accumulate in the bottom of the ruts when a new seal coat is placed. This will often lead to premature flushing and bleeding in the wheel paths.

5.3.4 Design

Another important part of the process is design (Figure 5.2). The Seal Coat Program Manager is typically responsible for seal coat design, which includes material selection (asphalt and rock), development of asphalt and rock base rates, use of variable rate nozzles, and preparation of plans.

Figure 5.2 Proper Design Based on Experience is Key to Quality Seal Coat Performance

Material selection is mostly based on experience and on what has worked well in the past. Design procedures such as the modified Kearby method can be used, and these methods are typically adjusted to account for local experience. Once the materials are selected and the base rates established, seal coat plans are developed, finalized and put out to bid.

5.3.5 Asphalt and Aggregate Application Rates

Proper asphalt and aggregate rates are critical to the success of every seal coat or surface treatment. The seal coat team, under the leadership of the Seal Coat Program Manager, typically calls all of the asphalt and aggregate rates during the construction process. Asphalt rates are established on the fly and are marked on the road in advance of the seal coat construction crew.

The rates are based on the actual pavement conditions at the time of construction and can be further tweaked to account for changes in the weather and contractor performance.

The goal is to apply the correct amount of asphalt to the pavement surface. A subtle threshold exists between too much asphalt (flushing and bleeding) and too little asphalt (rock loss). The default position is to stay at the upper limit of the asphalt rate, the idea being that flushing is preferred to loss of rock.

5.3.6 Seal Coat Inspection

A knowledgeable and experienced inspection staff is critical to the success of any seal coat program. Inspection crews ideally stay together as a team and follow the seal coat contractor to each location. Inspectors from each maintenance section supplement the seal coat inspection team whenever the contractor is working in their area. These maintenance section inspectors complement the chief inspectors with their local knowledge in addition to helping with rock or asphalt inspection.

The Seal Coat Program Manager is responsible for the development and training of a core of experienced inspectors. Experience is always the key to success and is the best long-term investment in the seal coat program. Full-time maintenance inspectors have a tendency to take ownership of the seal coat program as compared to the construction inspector who spends most of his time on construction projects. This approach results in more consistent quality seal coats with fewer problems.

New inspectors are put on the job under the supervision of the more seasoned inspectors and quickly learn that seal coating is more of an art than a science. Plan rates must be adjusted to accommodate varying field conditions, and inspectors need the ability to be flexible. There is a very fine line between success and failure; therefore, it is critical that an experienced inspector be on each job.

A trained inspector needs to be aware of the variations in aggregates and asphalts and must know when to change rates and why. It normally takes about 4 years, or seal coat seasons, of training in the field before an inspector is knowledgeable enough to take on more responsibility.

5.4 Binder Selection

Binder selection (both the type and application rate) is key to successful seal coat/surface treatment performance. The appropriate asphalt must be used in the appropriate season. The use of any asphalt binder outside the recommended temperature conditions (or asphalt season) for that asphalt can lead to problems with bleeding, flushing and/or rock loss.

5.4.1 Seasonal Considerations

The use of binders modified with latex, polymer and crumb rubber has significantly reduced bleeding problems across the state. The superior performance of these modified binders may be attributed to reduced temperature susceptibility, enhanced high-temperature properties and improved aggregate-binder bonding effectiveness.

Binder selection (both the type and application rate) is key to successful seal coat/surface treatment performance. Relative to bleeding/flushing, certain binders are more forgiving than others. The appropriate asphalt must be used in the proper season.

5.4.2 Warm Weather Binders – Contract Seals

Unmodified asphalt cement (AC) binders such as AC-5, AC-10 and AC-15 were used for seal coats and surface treatments before the advent of the tire rubber (TR) and other polymer-modified binders. Bleeding was very common when the AC binders were used. In contrast, the high-performance modified binders have dramatically reduced problems with bleeding.

Most districts are currently using tire rubber and polymer-modified binders as their warm weather binders of choice for seal coats and surface treatments, especially on higher-volume roads. Preference between the types of binders varies between individuals.

AC-15P is another binder that is commonly used for warm weather seal coats. The AC-15P is softer than the high-performance modified binders, and the softer asphalt will normally hold the rock better and have fewer problems with rock loss for low-traffic roads. In contrast, the stiffer (harder) asphalts tend to pull away from the rock when placed in a lower traffic environment. For this and other reasons, some districts correlate binder choice with traffic according to the following rule of thumb:

- ADT greater than 15000… use high-performance modified binder (example: AC-20-5TR and AC-20XP)
- ADT between 1000 to 15000… use modified hot asphalt binder (example: AC15P, AC10 with latex, AC5 with latex)
- ADT less than 1000… use emulsion (example: HFRS-2P or CRS-2P)

Certain districts use hot rubber asphalt (HRA) which they identify as being very forgiving with regard to asphalt rate and performance, and also very expensive. HRA is produced with AC-10 base asphalt and about 22 percent crumb rubber and a “sun screen” inhibitor to minimize photo-degradation. The hot rubber seal requires a higher asphalt application rate than comparable binders and is considered to be very resistant to long-term problems with flushing and bleeding.

5.4.3 Warm Weather Binders - In House Seals

Maintenance personnel normally use a CRS-2P (emulsion) for their warm weather “in-house” seals. This binder is normally used when air temperatures are 60°F and rising. Other in-house binders include HFRS-2P and CRS-2h. Maintenance forces will also use CRS-2 and RC-250 over base.

Most emulsions perform fairly well as long as traffic volume is low (ADT less than 1000) and the road is not subject to abusive movements – turning, stop and go, etc. – that occur at intersections. Some flushing and bleeding is reported with higher traffic volumes and heavy truck traffic.

5.4.4 Cool Weather Binders – Contract Seals

Cool weather binders are used on construction projects for surface treatments or underseals, or for maintenance outside the traditional seal coat season. Contractors typically choose from CRS-2P, HFRS-2P, CRS-1P, and others. The choice is frequently a material availability issue where the contractors use whatever is being produced by the asphalt suppliers at the time.

Maintenance personnel report that emulsions placed in cool weather have experienced problems with bleeding later on — in warm to hot weather. Numerous complaints, for example, have been lodged about CRS-1P due to major problems with bleeding. *The suggestion is to avoid emulsions during the winter unless there is no other alternative. Waiting –delaying construction – is a viable alternative and may well be the best approach.* Emulsions are particularly troublesome in high traffic, at intersections, and under heavy truck traffic.

5.4.5 Cool Weather Binder – In House Seals

Asphalt suppliers typically stop making hot ACs between December and January, so maintenance forces end up having to use emulsions and/or cutbacks on construction projects during cool weather. Maintenance personnel prefer to avoid shooting asphalt during cool weather if at all possible.

Some maintenance forces utilize CRS-1P (emulsion) or RC-250 (cutback) for their cool weather binders. However, each of these binders can create problems with bleeding and flushing. The materials are very sensitive to the volume and type of traffic and have experienced bleeding problems in the past.

CHAPTER 6
SOLUTIONS FOR BLEEDING PAVEMENT

6.1 Overview

6.1.1 Corrective (Required) Maintenance

Bleeding asphalt pavement is an immediate maintenance problem that must be addressed using corrective or in some cases, emergency, maintenance. The conditions that call for treatment of a bleeding asphalt pavement include:

- The asphalt begins to soften and liquefy on the roadway surface.
- Vehicle tires start tracking liquid asphalt down the highway.
- Periods of hot weather and high humidity are anticipated (one or more days of 100°F or greater temperatures).
- TxDOT personnel receive complaints from the traveling public about asphalt on their vehicles.
- The wet asphalt begins to stick to vehicle tires, and in turn, starts to “pick up” or “roll up” the seal coat or surface treatment wearing course on the tires.

Maintenance personnel seek to treat a bleeding asphalt pavement before it starts to pick up to avoid the need for more extensive and costly pavement repairs.

6.1.2 Maintenance Treatment Strategy

Maintenance forces employ several methods to treat bleeding asphalt pavements. The basic approaches are (a) to bridge over the liquid asphalt by applying aggregate of various types and gradations, (b) to cool off the pavement surface by applying water with or without additives, or (c) to remove the bleeding asphalt and rebuild the pavement seal. The method chosen often depends upon the available materials, manpower and equipment at the time of treatment.

The selection of the treatment approach must also consider the severity of the bleeding problem as well as many other factors including environmental conditions (temperature and humidity), type of roadway, traffic levels and types, and specific locations on a roadway (curves, intersections, urban or rural environments).

Maintenance personnel indicate that many of the treatment methods are employed during the hottest times of the day when bleeding starts or is already active. The latter condition would be preferable when sand or aggregate materials are used as part of the treatment, the reason being that the asphalt must be liquid, hot, and sticky for the aggregate materials to adhere to the pavement surface.

6.1.3 Summary of Maintenance Solutions

Table 6.1 below identifies maintenance solutions for treatment of bleeding asphalt pavements. The remainder of this chapter is devoted to presenting each of these solutions from the maintenance supervisor perspective. Each solution includes the following components: description, application, effectiveness, materials, procedure, helpful tips, and concerns.

Table 6.1 Maintenance Solutions for Bleeding Asphalt Pavements

Maintenance Solutions for Bleeding Asphalt Pavement	Solution Type			Effectiveness			Cost		
	Bridge Over	Cool Down	Remove Replace	Short Term	Mid Term	Long Term	Low	Med	High
Apply layer of small size (Grade 5) aggregate	■			■	■			■	
Apply layer of larger size (Grade 4 or 3) aggregate	■				■	■		■	
Apply blotter material (coarse sand/ stone screenings)	■			■			■		
Sandwich seal	■					■			■
Apply lime water		■		■	■				
Apply water		■		■					
Remove bleeding pavement & replace			■			■			■
Other methods	■	■		■					

6.2 Apply Layer Of Small Size (Grade 5) Aggregate

6.2.1 Description

The application of Grade 5 aggregate is the most commonly-used maintenance solution for the treatment of bleeding asphalt pavements in Texas (Figure 6.1). Maintenance forces use this option if there is enough free asphalt on the pavement surface to “stick” the rock. Construction contractors also use this method.

6.2.2 Application

This method is typically used to treat light to moderate bleeding. The key with any aggregate remedy is to get the rock to stick to the pavement surface, and the primary objective is to get the tires out of the asphalt. Some maintenance forces use this treatment in conjunction with lime water.

Figure 6.1 Applying Small-Size Aggregate to Treat Bleeding Pavement

6.2.3 Effectiveness

Effectiveness varies with this method. This can be a short-term solution (1 to 3 days) or mid-term solution (several weeks), with success dependent upon a variety of factors including the severity of bleeding, temperature and humidity, traffic volume and type, pavement construction type and history (materials and methods), location (urban, rural, intersections, etc.), and others.

6.2.4 Materials

TxDOT standard specification Item 302 defines Grade 5 rock as having the gradation as shown in Table 6.2. The nominal size of Grade 5 rock is 0.19 inch (number 4 sieve). The particle size is smaller than 1/4 inch, but larger than 0.09 inch (number 8 sieve) as per Figure 6.2.

Table 6.2 Gradation for Item 302, Grade 5 Aggregate [32]

Percent Retained on US Standard Sieve	Grade 5S (single size)	Grade 5
1/2 inch	0	0
3/8 inch	0 – 5	0 – 5
1/4 inch	65 – 85	—
#4	95 – 100	50 – 80
#8	98 – 100	98 – 100

The application of Grade 5 aggregate is the most commonly-used maintenance solution for the treatment of bleeding asphalt pavements in Texas.

Figure 6.2 Small-Size (Item 302, Grade 5) Aggregate

While maintenance crews use the aggregate they have, preferences for a particular gradation or type of rock have been voiced on all sides of the issue. This has included modified (single size) versus standard gradation, lightweight versus hard rock aggregate, either precoated or uncoated. Local material availability and experience are the best guides in this instance.

6.2.5 Procedure

Maintenance forces plan their treatment approach on a case-by-case basis. A one-pass treatment might be adequate for light bleeding, whereas more severe bleeding might require a series of applications over several days.

An aggregate spreading operation typically uses one dump truck with a tailgate spreader (one driver and one spreader operator), one steel wheeled roller with operator, and a crash attenuation vehicle with driver (see Figure 6.3). Sometimes an additional dump truck is used. Traffic should be slowed or stopped (controlled) during the treatment process.

Figure 6.3 Application of Grade 5 Aggregate to Treat Bleeding

Treatments are typically scheduled during the hotter times of the day to maximize the chances for the rock to adhere to the asphalt.

The actual method of operation depends on traffic and circumstances. Crews frequently use a tailgate spreader on a dump truck to spread the rock, typically in the wheel paths only. However, crews may use a sand spreader when they want to get complete coverage across the entire road. The aggregate can be applied by hand (with shovels) for smaller areas. The dump truck is normally backed as the aggregate is spread for short stretches of road, and driven forward for longer sections.

The Grade 5 rock can be rolled with a small flat-wheel roller to seat the aggregate into the bleeding asphalt and to maximize the probability of rock adhesion. This is especially the case for larger treatment areas with a higher volume of traffic. In instances where a roller is not available, or where its use is not practicable, crews may use the dump trucks to roll the rock into the pavement surface. In some instances, usually on lower volume roads, crews may depend on the traveling public to roll the smaller aggregate into place.

6.2.6 <u>Helpful Tips</u>

Maintenance personnel recommend "catching it early" – as soon as the bleeding starts and the asphalt is hot enough – so the rock will stick. It is important to not let the bleeding get too far out of hand before applying the first treatment.

Maintenance personnel have used rotary brooms to sweep excess rock across a bleeding pavement (lane) in lieu of another application of rock. The swept rock sticks to the bleeding asphalt and traffic rolls it in. A shadow vehicle is used for this operation.

Some maintenance personnel would rather use two light to moderate treatments with Grade 5 rock as opposed to one very heavy application.

Some have included a bid item in seal coat construction contracts for Grade 5 rock (material only). This ensures that the material is available in the event it is needed to treat bleeding during construction.

6.2.7 Concerns

Given that a seal coat needs adequate voids between the rocks to accommodate asphalt volume changes, the use of finer aggregate materials such as Grade 5 rock, and more particularly screenings and/or sand, can make a bleeding situation worse. This occurs where the smaller rock continues to displace the asphalt to a higher level, above the seal coat rock. It is on this basis that some prefer to use Grade 5 modified (single size) rock because it has significantly fewer fines than the standard gradation.

One of the main concerns in the maintenance community relative to the use of aggregates is the potential for windshield damage if the rock does not stick. The concern escalates as the size of the aggregate particles increases – Grade 3 being the largest size, Grade 5 being the smallest.

6.3 Apply Layer Of Larger Size (Grade 4 Or 3) Aggregate

6.3.1 Description

The application of larger-sized aggregate – Grade 4 or Grade 3 rock – is another solution for bleeding asphalt pavements, the objective being to get the tires out of the asphalt. Ideally, maintenance personnel will use the largest size rock practicable to remediate bleeding, the key question being whether enough free asphalt exists for the larger aggregate particles to adhere to the bleeding pavement surface.

6.3.2 Application

Larger aggregates (Grade 3 and Grade 4) are used when bleeding is severe. This solution is typically employed by construction contractors for treatment of bleeding that occurs *during* or *shortly after* seal coat construction. Here, the contractor applies the same rock that was used for the original seal coat, these original aggregate materials being still available (stockpiled) on site.

Figure 6.4 Grade 3 Aggregate to Treat Bleeding

The use of larger-sized aggregate materials by maintenance crews is less common, simply due to the challenge of getting the rock to stick. However, when conditions are appropriate, maintenance crews do use Grade 4 aggregate for the more severe bleeding problems.

When properly done, this treatment method is considered a long term solution. Effectiveness depends on many factors including the quantity of free asphalt, binder type, temperature, traffic volume and type, underlying pavement condition, and others.

6.3.3 Materials

TxDOT standard specification Item 302 defines Grade 3 and Grade 4 rock as having gradations as shown in Table 6.3. As noted above, when construction contractors use larger-sized aggregate, it is typically the same as the original seal coat rock. Maintenance crews, however, tend to use only Grade 4 or Grade 4 modified rock for this solution. Maintenance forces typically do not use Grade 3.

Table 6.3 Gradation for Item 302, Grade 3 and Grade 4 Aggregate [32]

Percent Retained on US Standard Sieve	Grade 3S (single size)	Grade 3 non lightweight	Grade 3 lightweight	Grade 4S (single size)	Grade 4
3/4 inch	0	0	0	—	—
5/8 inch	0 – 5	0 – 2	0 – 2	0	0
1/2 inch	55 – 85	20 – 40	10 – 25	0 – 5	0 – 5
3/8 inch	95– 100	80– 100	60 – 80	60 – 85	20 – 40
1/4 inch	—	95– 100	95– 100	—	—
#4	—	—	—	95– 100	95–100
#8	99– 100	99– 100	98– 100	98– 100	98–100

As per Table 6.3, TxDOT standard specification Item 302 defines Grade 4 rock as having a nominal size of 1/4 inch. The particle size is generally smaller than 3/8 inch, but larger than 0.19 inch (number 4 sieve). TxDOT standard specification Item 302 defines Grade 3 rock as having a nominal size of 3/8 inch. The particle size is generally smaller than 1/2 inch, but larger than 1/4 inch.

6.3.4 Procedure

Placement and rolling of the Grade 4 or Grade 3 rock is accomplished in much the same manner as for the Grade 5 rock (see previous description).

Timing of this treatment is essential to success. The temperature must be hot enough for the rock to stick when it is applied – 1:00PM to 7:00PM would be appropriate in the summer (the hot time of the day).

The quantity of asphalt must be sufficient to stick the rock to the pavement surface. Although not commonly done, a light layer of hot asphalt can be shot over the affected (bleeding) area if sufficient asphalt is not available. This shot of relatively hot asphalt will heat up the underlying asphalt layer, enhancing the ability of the rock to stick to the pavement surface.

The aggregate is usually spread with a chip spreader, tailgate spreader, or a sand spreader (Figure 6.5). A light pneumatic tired roller is preferred to seat the larger-sized rock in the asphalt; however, tandem truck tires may be used if a pneumatic roller is not available. A steel wheeled roller should not be used if it will crush the rock.

6.3.5 Helpful Tips

TxDOT will occasionally purchase back excess seal coat rock (Grade 3 and Grade 4) from a contractor after construction and leave it stockpiled by the road in the event maintenance forces need to re-rock an area or treat a bleeding asphalt pavement.

Figure 6.5 Application of Grade 3 Seal Coat Aggregate

Some maintenance personnel prefer lightweight aggregate because there are fewer problems with windshield breakage. This rock is more uniform in size and thus is more effective relative to separating tires from the binder. Also, lightweight aggregate is more porous such that it may absorb excess asphalt.

6.3.6 Concerns

The key to success for this treatment option is getting the larger aggregate to stick to the bleeding asphalt pavement surface. Even when the bleeding problem is severe, the amount of hot liquid asphalt on the roadway may be insufficient. This is because the pavement temperature for bleeding asphalt is typically around 140°F to 165°F whereas the original application temperatures for hot asphalts range from 300°F to 350°F.

The main concern in the maintenance community relative to the use of larger-sized aggregates is the potential for windshield damage due to flying aggregate. Windshield damage and complaints/damage claims from the traveling public are more of an issue with the larger-sized aggregate.

6.4 Apply Blotter Material To Blot Up Excess Asphalt

6.4.1 Description

Aggregate with finer particle sizes (smaller than Grade 5) – for example, sand, ice

Figure 6.6 Application of Sand Blotter Material to Treat Bleeding Pavement at an Intersection

chatt, bottom ash, crushed stone screenings, and the like – can be used as blotter materials to soak up excess asphalt from the bleeding pavement surface (Figure 6.6). As with any aggregate solution, the objective is to get the tires out of the asphalt**.**

6.4.2 Application

Maintenance forces sometimes do not have access to their material of choice for treatment of a bleeding asphalt pavement and are constrained to use whatever is on hand at the time. Sand and similar finer-grained blotter materials frequently are viewed as being in this category – they are used to provide temporary complaint relief when nothing else is available.

Under the best of circumstances blotter materials are employed to treat light bleeding – that is, between a flushed and bleeding pavement condition. As bleeding becomes more severe, the finer-grained materials become increasingly problematic.

6.4.3 Effectiveness

This treatment method is typically considered to be a short term, temporary solution requiring multiple applications. Maintenance crews report that they get about 1 to 3 days of relief from bleeding when using this method. However, the diversity of materials represented by this category – ranging from manufactured ice chat to blow sand swept from the bar ditch – is such that effectiveness varies.

Some maintenance crews prefer finer-grained blotter materials over Grade 5 rock because of availability, lower cost, and less concern with windshield damage. Others consider the finer-grained materials to be a stop-gap treatment, used as "a last resort" and "better than nothing." Ultimately, effectiveness must be evaluated on a case by case basis.

6.4.4 Materials

The sand and other fine-grained blotter materials have gradations smaller than Grade 5 aggregate, but typically do not have a defined material specification. The more commonly-used blotter materials include:

- Ice chatt… used for sanding roads and bridges during ice and snow events (also known as "ice rock").
- Uncoated crushed rock or stone screenings… a byproduct from the standard aggregate grade production process, yielding a material which is smaller than Grade 5 aggregate.
- Bottom ash… fine grained sand with some medium and coarse grained particles created as a by-product of power generation from coal-fired electric generation plants.
- Field sand, blow sand, creek sand… a fine to medium-grained, sandy, naturally-occurring material obtained from along the shoulder of a road or from a creek bank.
- Blended materials… bottom ash or sand blended with Grade 5 rock.

Performance of a particular material will be a function of its gradation and the nature of the aggregate. Some of the finer-grained materials, especially the ice chatt and the crushed stone screenings, are considered to be functionally equivalent to Grade 5 rock. That is, like Grade 5 rock, these materials serve to get the tires out of the asphalt rather than to blot up excess asphalt.

6.4.5 Procedure

Application and compaction of sand and other finer-grained blotter materials is accomplished in much the same manner as for the Grade 5 rock (see previous description).

Crews typically use a tailgate spreader on a dump truck and spread a thin layer of blotter sand in the wheel paths only. Alternatively, the blotter materials may be broadcast full-width over an entire lane with sand spreaders similar to those used to spread deicing rock during the winter. A pickup truck bed may be used to transport/spread screenings on smaller areas (with shovels) as per Figure 6.6.

Maintenance personnel indicated that they have also used a rotary broom to sweep relatively clean sand and dirt (without trash) from the roadside onto a bleeding pavement surface when nothing else was available.

The dump truck is normally backed as the blotter sand is spread, and crews typically depend on the traveling public to roll these materials into place. However, the rock can also be seated in the bleeding asphalt by a pneumatic tired roller, the claim being that rolling yields a slightly longer-lasting solution.

Timing of this treatment is essential. These materials should be spread in the heat of the day when bleeding is active and there is liquid asphalt on the pavement surface.

Figure 6.7 Hand Application of Aggregate to Treat Bleeding Pavement

6.4.6 Helpful Tips

This option is economically viable when maintenance resources run low of preferred aggregate materials toward the end of the year.

Some claim that the fine-grained blotter materials work well for minor bleeding. The sand and dust "kill" the oil and the wind/traffic blow excess material off the road.

Blotter sand/screenings must be completely dry. Otherwise, the material has a tendency to "patty up" or clump together with the liquid asphalt.

6.4.7 Concerns

When evaluating aggregate for treatment of bleeding asphalt pavements, one way to think about particle size is like the story of *Goldilocks and the Three Bears* – the rock can be *too large*, *too small*, or *just right*. Most maintenance personnel would say Grade 5 rock is the "just right" option, and if so, sand and the other finer-grained blotter materials are in the "too small" category.

As described in Section 3.2 of this report, a seal coat requires adequate voids between the rock particles to accommodate asphalt volume changes, and for this reason the application of finer aggregate materials such as blotter sand can make a bleeding situation worse. This occurs when the smaller particles displace the asphalt to a higher level, above the seal coat rock. Although the finer materials have a lot of surface area to absorb the asphalt, they also have a tendency to make "mud" and to "slick up" the road surface, creating skid problems.

Because traffic will push the fines down into the asphalt and raise the asphalt layer, some believe that blotter material should be limited to use as an "emergency treatment" only. One individual commented that blotter material can turn a 2 or 3 day bleeding problem into a summer-long bleeding problem.

6.5 Sandwich Seal

6.5.1 Description

The sandwich seal is a two-course surface treatment where aggregate is spread on an existing binder-rich surface before the application of a single-course surface treatment. It is very much like a two-course treatment except the first application of binder is omitted [36].

Coarse stone is placed directly on the road with no binder underneath it. A single application of binder is then sprayed on the uniformly-spread coarse stone, followed by a second application of aggregate using smaller stone. The new seal is then rolled.

This method is similar to and sometimes confused with an upside-down or inverted surface treatment. However, for the inverted seal the first layer of aggregate is the finer material and the second layer is coarse [36].

6.5.2 Application

While the sandwich seal directly addresses the mechanisms associated with moderate to severe bleeding (displacement of asphalt/loss of voids), this method has seen limited use within TxDOT. The most common application has been as a type of strip seal to correct moderate to severe bleeding and minor rutting in the wheel paths (Figure 6.7).

The sandwich seal is suited for treatment of chronic bleeding pavements where the maintenance section does not have the money to mill and inlay with hot mix.

The sandwich seal is not considered a maintenance seal in that it is typically not done by maintenance personnel. The sandwich seal is usually applied by a contractor or by the district Special Jobs Crew.

6.5.3 Effectiveness

This treatment method seals the roadway surface and improves skid resistance. It is considered to be a long term solution to bleeding.

6.5.4 Materials

Asphalt binder, coarse aggregate, and fine aggregate for the sandwich seal are typical materials for seal coats and are selected on a case-by-case basis. Materials should conform to TxDOT Standard Specifications.

6.5.5 Procedure

To construct a sandwich seal, first, a clean coarse aggregate (seal coat rock) is spread on top of the bleeding asphalt. A layer of asphalt binder is then sprayed on top of the untrafficked coarse aggregate, and then a second layer of finer seal coat rock is placed over

Figure 6.8 Sandwich Seal Used to Treat Bleeding Pavement in the Wheel Paths

the asphalt.

The asphalt rate for the sandwich seal is normally cut about a third from the original seal coat, recognizing that application rates differ widely for different binders.

The rock rate for each course of the sandwich seal should be around 98-100 sy/cy assuming a Grade 3 seal coat rock is used for the first course. A pneumatic tired roller is typically used to roll the rock.

For best performance, this treatment method must be used when the temperature is at its highest level and the asphalt is hot and sticky.

6.5.6 Helpful Tips

The sandwich seal is typically applied as a strip seal to correct moderate to severe bleeding and minor rutting in the wheel paths. This method yields exceptional friction or skid resistance properties with good macrotexture in the surface (Figure 6.8). Another benefit is that no coarse aggregate is loose and flying, considerably decreasing the chances of headlight and windshield breakage.

Figure 6.9 Improved Macrotexture in the Wheel Paths Using a Sandwich Seal

6.5.7 Concerns

The sandwich seal is a relatively complicated remediation method for bleeding pavements that involves three separate materials including two sizes of rock and an asphalt binder. This might be somewhat awkward for a maintenance section crew, the main challenge being equipment availability.

This method might fit into one of the more expensive remediation categories that would be better suited for contractor applications in larger areas.

The main challenge is having an adequate quantity of asphalt on the bleeding pavement surface to stick the first layer of coarse aggregate. To achieve consistency it may be necessary to spray at least a light shot of binder (tack coat) to hold the coarser rock. Thus the adhesion between the existing bleeding asphalt pavement and the first layer of coarse rock is the main concern. If the first layer starts to delaminate or lose its bond with the underlying pavement, flying and/or peeling chunks of sandwich seal may occur.

6.6 Apply Lime Water To Cool And Crust Over Bleeding

6.6.1 Description

The application of hydrated lime mixed with water is one of the most commonly-used maintenance solutions for the treatment of bleeding asphalt pavements in Texas (Figure 6.9). Customary practice is to mix lime water using a portable 1000 gallon water tank unit that slides into the back of a dump truck. The tank unit comes with an agitator pump to keep the lime in suspension, and the lime water is applied to the bleeding pavement surface using a spray bar.

Figure 6.10 Application of Hydrated Lime to Cool Bleeding Pavement

6.6.2 Application

This method is typically used to treat light to moderate bleeding on roadways that do not experience extremely high volumes of traffic. Both construction contractors and maintenance crews use this method, and they like it because it is quick and inexpensive and because it is a moving operation. A typical application is on freshly placed seal coats to control bleeding and to minimize the chances of the seal coat being picked up.

6.6.3 Effectiveness

The application of lime water is generally viewed as a short term solution to bleeding asphalt pavements – it "buys some time." Maintenance crews indicate that treatment effectiveness can range from as little as 2 to 4 hours to as much as 3 to 5 days. Multiple applications of lime water are normally required to achieve the desired result.

It is believed that the lime oxidizes (ages) the hot liquid asphalt, reduces the stickiness, crusts over the asphalt surface and turns the asphalt green in some cases – the color change indicates the lime is working. The lime powder chemically reacts with (adheres to) the hot asphalt particles and "kills" the asphalt, causing it to lose its "livened state". The lime water treatment also paints the road white, thereby reducing the pavement temperature due to the increased reflectivity.

Lime water essentially provides a temporary cooling effect on the pavement surface. The cooling effect can last for as long as 2 or 3 days but pavement temperature will begin to |climb again if air temperatures hover in the 100°F range for an extended time. The cooling effects eventually go away and additional treatments are required to maintain the lower pavement temperatures. Residual lime may also provide a temporary separation between the tires and the asphalt.

6.6.4 Materials and Equipment

No standard specification exists for the lime water method, so considerable variation exists in treatment practices. A successful lime water operation requires, at a minimum, Type A hydrated bag lime (50 pound bags, typical) and a potable water source (Figure 6.10).

Figure 6.11 50-lb Bag, Type A Hydrated Lime

The lime water treatment setup typically consists of one dump truck that contains a portable 1000 gallon water tank. These water tanks can be purchased from several sources and normally come with a 7-foot spray bar and water pump which is capable of providing continual circulation of the lime water mixture. Lime and water do not mix very well; therefore, it is very important to have a pump and hose mounted on the portable tank to effectively circulate and mix the lime water solution. The powdered lime needs to be circulated in the water tank for at least 5 to 10 minutes to be properly mixed. Constant circulation is critical.

The lime water is distributed by gravity flow through ½-inch diameter nozzles which are normally spaced along the spray bar on 2-inch centers. The maintenance crew normally plugs all of the nozzles in the spray bar except for those in the area of the wheel paths. It is usually not necessary to treat areas outside the wheel paths since bleeding frequently is limited to that area.

The operation requires a second truck which serves as the crash attenuator (traffic control vehicle). The crew is normally comprised of two persons, one driver for each truck. The crash attenuator truck follows the water truck at a distance that will ensure the pavement has fully dried before traffic is allowed back onto the treated roadway.

6.6.5 Procedure

Factors such as the air temperature, pavement temperature, humidity, severity of bleeding, tackiness of the asphalt, type of asphalt, type of roadway (urban, rural, number of lanes), traffic levels (ADT, truck traffic), roadway location (intersection, driveways, straight stretches of road) and time of day all come into play when defining the details of the lime water treatment application. Each bleeding asphalt pavement problem should be evaluated on a case by case basis.

It can be beneficial to wait until it gets “real hot” – 100°F and greater, with pavement temperatures on the order of 130°F-140°F – before treating a bleeding pavement with lime water. Maintenance forces have recorded pavement temperatures as high as 140°F-150°F in areas where bleeding is present, compared with 115°F outside the area of bleeding.

The rate of application is a function of the water truck speed, among other things. Maintenance forces typically operate the water truck between speeds of 25 to 45 mph, with speeds of 35 to 40 mph being customary. This operating speed is necessary to achieve a good splatter (dosage) of the lime water solution on the affected pavement surface. If the water truck moves slower than the recommended speed, lime water will start to accumulate in puddles, resulting in lime water spray on the cars. The lime water will usually “spread out” across the lane as the operation moves down the highway (Figure 6.11).

The lime water application on the pavement should be dry before allowing vehicles back on the treated roadway. Lime water treatment is sensitive to temperature, humidity, and wind (the heat index). In particular, if the humidity is high the lime water solution will not evaporate as fast but instead will tend to puddle on the road. It is undesirable for the lime water solution to remain on the pavement for 10 minutes or more. The objective in all situations is to keep the traveling public out of the lime water as it will splash on their vehicles and result in complaints.

Recipes for lime water concentrations vary with individuals and is more art than science. An incremental approach to lime water treatment is the recommended practice. This approach starts with a higher lime concentration for the first treatment and then reduces the lime water concentration with each successive treatment until the bleeding is under control.

Figure 6.12 The Lime Application Rate Should Achieve Good Splatter (Dosage) of Lime Water Solution on the Affected Pavement Surface

Maintenance crews typically start with an average concentration on the order of 5 sacks (250 pounds total) of hydrated lime in 1000 gallons of water. This initial concentration can be as low as 4 sacks and as high as 8 sacks dependent upon the site factors such as environmental conditions and the severity of bleeding. For example, 5 sacks might be appropriate for moderate bleeding at an air temperature around 100°F ; whereas, 8 sacks might be appropriate for very severe bleeding and air temperatures of 108°F or hotter.

In certain instances such as on a fairly remote low-volume FM road, crews will typically be more aggressive with their initial concentrations and will use a higher dosage than usual in an effort to minimize return trips.

The proper lime concentration for the initial treatment can be established/fine-tuned by assessing how much lime powder is left on the road after drying (how dusty it is). If lime powder is left on the pavement surface after drying, the initial concentration should be cut back.

The rule of thumb for the second treatment and subsequent treatments is to cut the initial concentration in half. For example, if the initial concentration was 5 sacks, the second treatment concentration would be 3 sacks. In some cases the bleeding might require more than two applications of lime water. In that case, maintenance forces would probably use 3 sacks again. The lime water treatment approach is subjective to some degree, and is based on past experience and performance for the most part.

Recommended practice for applying lime water may be summarized as follows:

- Apply lime water when pavement is hot for fast drying.
- If dust is excessive or cars are getting a white residue on them, cut back lime in mixture (reduce concentration).
- Never apply faster than 45 MPH.
- Pour lime in tank prior to adding water or while adding water.
- Use goggles, gloves and dust mask.
- Every other nozzle can be plugged and still get an effective coverage.
- Tanks will need a method to circulate the mixture. This will keep the lime suspended in the water.
- Empty tank at the end of each day. The tank may need to be rinsed out if there is a heavy build-up of lime in the bottom of the tank.

Some debate exists relative to timing of the lime water treatments. The standard, customary practice recommended herein is reactive – that is, to treat bleeding pavements in the afternoon when the pavement is hot. In contrast, another philosophy is to apply lime water in the morning before the bleeding starts (preemptive).

6.6.6 Helpful Tips

Lime water treatments should begin as soon as the initial signs of bleeding begin to appear. This will help prevent further deterioration and damage to the pavement. Once bleeding starts and the seal coat or surface treatment starts to peel up to the underlying layer or base, the extent of the problems and damage can rapidly escalate; for example, grow from a 1/2 mile section to a 10 mile section.

Some Districts include a general note in the seal coat or surface treatment construction plans requiring the contractor to provide a water truck/lime water setup to cool any hot spots or to treat a bleeding asphalt pavement during construction, if needed. This requirement enables the contractor to be ready with the proper equipment and materials in the event of bleeding during construction.

Some maintenance personnel view lime water treatment as a secondary approach. If Grade 5 aggregate will stick to the pavement, use it first. If not, lime water would be the next best thing.

6.6.7 Concerns

Some asphalts might not be amenable to treatment with lime water [37]. Intuition suggests that certain emulsions would fall in this category, especially on a fresh seal, since emulsion is a water-based product. In questionable circumstances, a small test section is recommended to confirm the treatment will do more good than harm.

One of the disadvantages of this treatment is that lime water puts a white film on everything and kills the reflectability of pavement markings and striping (Figure 6.12).

Figure 6.13 Lime Can Obscure the Reflectability of Pavement Markings and Striping

Lime is corrosive to paint. If the public is allowed to drive through wet lime slurry, this might result in claims by the public that lime has splattered their vehicles and damaged the paint. Because lime water is caustic, splashing potentially creates a safety concern for pedestrians/passers-by.

Lime water is considered to be a quick and cheap treatment method for bleeding asphalt pavements, but results may be very short term in some circumstances.

6.7 Apply Water To Cool Pavement Surface

6.7.1 Description

Water (not mixed with lime or other additives) is sometimes spray-applied to cool off bleeding asphalt pavements.

6.7.2 Application

Both construction contractors and maintenance crews use this method. The typical application is as an emergency, stop-gap treatment to arrest bleeding on a freshly placed seal coat in order to minimize the chances of the seal coat being picked up.

6.7.3 Effectiveness

Water is considered a temporary measure to cool the pavement and to buy some time when other treatment methods or materials are unavailable. Water is considered to be a very short term solution for bleeding. Effectiveness ranges from 30 minutes to a few hours. Multiple applications are normally required.

6.7.4 Materials

The water does not need to be potable. For example, brine water – which is a byproduct of oilfield operations – has been used in west Texas.

6.7.5 Procedure

Customary practice is to apply water using a standard construction water truck equipped with a spray bar (Figure 6.13).

Figure 6.14 Application of Water Using a Standard Construction Water Truck

6.7.6 Helpful Tips

Some maintenance supervisors prefer to use a single straight nozzle and let the water splash directly from the truck on to the pavement surface. When used, water spreader bars — such as a cement spreader bar with large openings that will not clog — are preferred.

This treatment method should only be used for small isolated areas.

6.7.7 <u>Concerns</u>

Some maintenance personnel believe that straight application of water is a waste of money that might last 30 minutes at best. Its use should be limited to construction if there is no other option available.

Water can conceivably make things worse with certain asphalts such as a high float emulsions.

This treatment method can create more problems in certain instances. For example, the pavement surface may get hotter and bleed more after the water evaporates.

6.8 Remove Bleeding Pavement Surface And Replace With New Seal Coat

6.8.1 <u>Description</u>

When a fresh seal coat has gone bad, it can be removed and replaced with a new seal coat.

6.8.2 <u>Application</u>

This option is used only in the event of total failure of a new seal coat (Figure 6.14). The problem seal coat is usually removed (scraped off) by a blade.

This is not considered a maintenance seal in that it is not done by maintenance personnel. The new seal coat is usually applied by a contractor in the case of bleeding/failure during new construction. Otherwise, it would be done by the district Special Jobs Crew.

6.8.3 <u>Effectiveness</u>

This treatment method is considered to be a long term solution to bleeding pavement surfaces.

6.8.4 <u>Materials</u>

Asphalt binder and aggregate are typical materials for seal coats and are selected on a case-by-case basis. Materials should conform to TxDOT Standard Specifications.

6.8.5 <u>Procedure</u>

Recommended seal coat practices and procedures, as defined in the TxDOT Seal Coat Manual, should be used.

Figure 6.15 Removal and Replacement May Be Necessary When a Fresh Seal Coat Totally Fails

6.8.6 Helpful Tips

The cause of bleeding should be determined prior to applying a new seal coat.

6.8.7 Concerns

This treatment method is used on rare occasions in the event of total failure of a new seal coat.

6.9 Other Solutions

6.9.1 Overview

Maintenance forces have used various other methods to treat bleeding pavement surfaces. These other methods are used infrequently but are mentioned since they may have limited application for treatment in a particular circumstance. Following are brief descriptions of these less commonly-used treatment methods specific to bleeding.

6.9.2 Dry Powdered Lime

Powdered lime, purchased in bulk, can be dry-applied to a bleeding seal coat or surface treatment. Both construction lime (hydrated lime, quicklime) and agricultural lime (crushed limestone and chalk) have been used. The powdered lime is broadcast **over the** affected area using a shovel. Larger areas are treated using a tailgate spreader.

6.9.3 Portland Cement

Maintenance crews have used Portland cement to treat smaller areas of bleeding. The powdered cement is broadcast over the affected area using a shovel or a tailgate spreader.

6.9.4 Micro-blaze®.

A propriety product called Micro-blaze® has been used to treat bleeding asphalt pavement. Commonly used by fire-fighters to treat chemical spills, Micro-blaze® is an emergency liquid spill control product consisting of a non-toxic formulation of biological activators and selected non-pathogenic microbes, which digest fats, oils and grease, protein, starches and odors caused by organic waste. When applied to a hydrocarbon spill (e.g., liquid asphalt), it will disperse the hydrocarbon on contact, inert the hydrocarbon so that it is non-flammable, and will leave no slippery residue when washed down.

6.9.5 Brine Water

Contractors have used “brine water” to treat bleeding asphalt pavements during construction. This material is inexpensive, readily available and is a by-product of the oil field. They believe it works like lime water. Brine water is “salty, crusty, ugly & cheap.”

6.9.6 Apply Very Clean, Hot Aggregate

The idea behind this treatment is that the asphalt must be hot and soft enough (liquid enough) to achieve adequate rock embedment into the asphalt to get the rock to stick. Application of hot aggregate enhances this process [12]. Clean seal-coat aggregate is heated at a hot mix plant, delivered to the site, placed on the bleeding pavement surface, and rolled in using a steel wheel roller.

CHAPTER 7
SOLUTIONS FOR FLUSHED PAVEMENT

7.1 Overview

Flushed asphalt pavement, in contrast to bleeding pavement, is typically *not* a maintenance problem that must be addressed immediately. The maintenance thresholds that call for treatment of a flushed asphalt pavement include:

- The roadway surface is slick, with low skid resistance.
- The pavement surface is very slippery, particularly in wet weather conditions.
- The flushing is accompanied by rutting and water accumulation in the wheel paths.

Flushed asphalt pavement problems are often found in the wheel paths. This type of pavement distress does not normally warrant immediate or emergency maintenance measures; however, it must be monitored closely to minimize the probability for escalation into a wet weather safety concern or a bleeding pavement problem.

The pavement surface in these areas is usually slick and characterized by a loss of traction, low skid numbers, and a higher potential for hydroplaning during wet weather. Incidents including vehicles sliding off of the roadway and wet weather accidents can trigger the need for treatment.

7.1.1 Maintenance Treatment Strategy

Maintenance forces have employed a variety of methods to treat flushed asphalt pavements. The basic approaches are: (a) to retexture the existing flushed pavement surface, or (b) to add a new textured surface over the flushed pavement. The method chosen often depends upon economics as well as the availability of materials, manpower and equipment at the time of treatment.

The selection of the treatment approach must also consider the severity of the flushing problem as well as many other factors including environmental conditions (temperature and humidity), type of roadway, traffic levels and types, specific locations on a roadway (curves, intersections, urban or rural environments) and the like. Practical wisdom is the key to success of any treatment solution.

The objective of treatment is to increase the pavement macrotexture and improve skid resistance. In instances where rutting and flushing are seen in the wheel paths, maintenance crews will also try to improve surface water drainage flow off of the roadway, especially away from (or out of) the wheel paths.

In contrast to treatment of bleeding pavement surfaces, the timing for the retexturing options is during cooler weather when the asphalt binder is least active. The time for new texturing options varies depending on the method.

7.1.2 Summary Of Maintenance Solutions

Table 7.1 summarizes maintenance solutions for treatment of flushed pavement surfaces. The remainder of this chapter is devoted to presenting each of these solutions from the maintenance supervisor perspective. Each solution includes the following components: description, application, effectiveness, materials, procedure, helpful tips, and concerns.

Table 7.1 Maintenance Solutions for Flushed Asphalt Pavements

Maintenance Solutions for Flushed Asphalt Pavements	Solution Type		Effectiveness			Cost		
	Add New Textured Surface	Retexture Existing Pavement	Short Term	Mid Term	Long Term	Low	Med	High
Cold milling to remove flushed asphalt		■		■		■	■	
Apply new seal coat	■				■		■	
Microsurfacing	■				■		■	
Thin asphaltic concrete overlay	■			■	■		■	■
Ultra high pressure water cutting		■		■			■	■
Other solutions	■	■		■	■	■	■	■

7.2 Cold Milling To Remove Bleeding Asphalt With/Without Replacement

7.2.1 Description

Cold milling is the controlled removal of the surface of the existing pavement to the desired depth, with specially designed milling equipment (Figure 7.1). Milling is done either to prepare the surface to receive overlays (by removing rutting, flushing, and surface irregularities), to restore the pavement cross slopes and profile, or to re-establish the pavement's surface friction characteristics. Surface removal is typically done with a milling machine which uses a drum equipped with carbide-tipped teeth that impact and chip the pavement surface. The resulting textured pavement can be used immediately as a driving surface.

Figure 7.1 Cold Milling to Retexture Flushed Pavement in the Wheel Paths

7.2.2 Application

A typical application of milling is to reshape/retexture flushed pavement surfaces that exhibit rutting and low skid resistance. Maintenance personnel use milling to:

- Remove excess asphalt (in a solid state) from a flushed or slick pavement.
- Minimize or eliminate the potential for a flushed pavement to bleed in hot weather.

- Restore or establish pavement texture and skid resistance/traction.

The typical application is where rutting has occurred in the wheel paths, causing water to accumulate during rains, and skid resistance and hydroplaning are a concern. Milling is also used quite often at intersections where heavy starting and stopping movements have caused rippled, bumped and otherwise rough pavement surfaces.

This treatment method is commonly used as part of a mill and inlay operation where an old section of pavement is removed and replaced with a new asphaltic concrete overlay.

7.2.3 Effectiveness

Cold milling is considered to be a long term treatment for the restoration of pavement texture (skid resistance) associated with flushed pavements. This treatment is not considered effective for treatment of actively bleeding pavement surfaces.

7.2.4 Materials

The typical equipment requirements for cold milling include:

- modern, self-propelled cold milling machine
- haul trucks
- water truck
- sweeper or power broom
- traffic control

Milling equipment is available in a variety of sizes, ranging from mini-milling machines for localized milling, to high capacity machines capable of milling full lane widths in one pass.

7.2.5 Procedure

Milling is typically done in the wheel paths in cooler weather when the asphalt is in a solid state and can be cut more efficiently. Milling may be done either by maintenance forces or by contract under a Maintenance Service Agreement.

Maintenance forces typically perform “spot milling” operations with a milling attachment on a skid steer loader (Bobcat) with a drum width of approximately 18 to 24 inches. Milling can be to any depth; however, typical cuts for treatment of flushed pavements range from 1/2 to 3/4 inch maximum. Two or more passes may be required.

The miller essentially restores a planar surface in the wheel paths thus eliminating the troughs that tend to hold water during rains which can create a safety hazard associated with hydroplaning. The depth, surface inclination and width of the cut are apparently adjustable to some degree. In the process of milling these flushed areas, layers of excess asphalt may also be removed.

Contractors typically utilize larger, higher production machinery which can be equipped with drum widths ranging from 4 to 12.5 feet. Contract equipment can mill an entire lane in one pass and load the spoils (reclaimed asphalt pavement - RAP) by conveyor belt into a dump truck at the same time. The contractor typically provides the milling machine with an operator and one helper.

After the milling operation is completed, the pavement has a rougher texture and is grooved along the longitudinal axis of the roadway (Figure 7.2). This may garner some complaints from the traveling public – just as some seal coats with Grade 3 rock do – however, traveler safety is enhanced.

The pavement surface is often left in a milled condition for extended periods of time until subsequent treatments such as a new seal coat or hot mix overlay are applied. In some cases, maintenance crews will go back over the milled areas with premix patch materials using blade level-up methods in advance of subsequent seal coat or overlay operations.

Figure 7.2 Cold Milling Yields a Grooved Surface Texture Along the Longitudinal Axis of the Roadway

7.2.6 Helpful Tips

Milling to remove excess asphalt and restore texture to flushed pavements is normally done in the winter during cool or cold weather. Milling cannot be done when the asphalt is "live."

Some district maintenance personnel require skid resistance measurements in any areas of concern prior to planning corrective measures.

Milling leaves the surface of the asphalt open and more susceptible to water penetration. In some cases, maintenance personnel will shoot an underseal or a fog seal, or place a thin overlay over the affected area.

7.2.7 Concerns

One downside of milling is that it has a tendency to remove the positive benefit of a surface seal. Eventually it will be necessary to apply another seal coat or construct a hot mix overlay to effectively seal the pavement from the intrusion of water.

Milling can sometimes make a rutting situation worse.

Certain seal coat materials have a tendency to gum up the milling machine in hot weather, especially the crumb rubber seal.

7.3 New Seal Coat

7.3.1 Description

A new seal coat, typically in the form of a strip seal or spot seal, may be applied over a flushed pavement surface to arrest the flushing and restore skid resistance.

7.3.2 Application

The ideal application for this option is to treat the wheel paths of a flushed pavement where there is also minor rutting and loss of skid resistance.

On a much larger scale, this type of treatment is used to treat aged, flushed pavements where the flushing occurs due to aggregate wear and abrasion. This is normally accomplished as part of the district seal coat program. This would be a full-width repair.

7.3.3 Effectiveness

This treatment method seals the roadway surface and improves skid resistance. It is considered to be a long term solution to flushed pavement surfaces.

7.3.4 Materials

Asphalt binder and aggregate for new strip/spot seals are typical materials for seal coats and are selected on a case-by-case basis. Materials should conform to TxDOT Standard Specifications.

7.3.5 Procedure

Recommended seal coat practices and procedures, as defined in the TxDOT Seal Coat Manual, should be used. New seal coat materials should be similar to those used for the original seal coat.

When the flushing is severe, the asphalt binder application rate should be lighter. For typical applications, the amount of binder should be reduced by, say, 20 to 30 percent.

7.3.6 Helpful Tips

The cause of flushing should be determined prior to applying a new seal coat.

Patches or soft areas of the pavement substrate should be corrected before applying the new seal coat.

7.3.7 Concerns

Some maintenance personnel prefer not to apply a new seal coat (strip and spot seal) over a flushed pavement because it adds more asphalt and has the potential to make the condition worse (Figure 7.3).

This method should not be used to treat a bleeding pavement surface. The concern is too much asphalt. Bleeding will normally come through a new seal coat if it is not treated in advance of seal coat operations.

Some claim that the same concern exists relative to flushing. That is, preexisting flushing may presumably reappear through the new seal coat, especially in the wheel paths.

Figure 7.3 Strip Seals (a New Seal Coat in Wheel Paths) to Control Flushed Pavement Must Be Carefully Designed to Avoid Additional Flushing

7.4 Microsurfacing

7.4.1 Description

Microsurfacing is a tough, durable, thin cold overlay material which has been used for both corrective and preventive maintenance to restore the original properties to structurally sound pavements. By definition, microsurfacing is a mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives. These components are mixed together at the jobsite in a pugmill that is mounted on a self-propelled hauling unit.

7.4.2 Application

Microsurfacing is used on a limited basis to remediate problems associated with minor rutting, flushed pavement, ride quality and skid resistance, or a combination of these (Figure 7.4).

Selection of the microsurfacing method typically focuses on correcting problems associated with rutting in the wheel paths and providing improved macrotexture and skid resistance on a roadway. Flushing problems are often addressed as a by product of this treatment.

Microsurfacing is not typically used in and of itself to correct a flushed pavement problem. It is also not used to mitigate bleeding.

Microsurfacing is normally done on long stretches of road, often in urban environments, for roadways with high traffic volumes. The pavement section must be structurally sound.

Microsurfacing has also been utilized to restore skid resistance in intersections where the pavement is flushed, typically due to polishing (wearing down) of the aggregate.

Microsurfacing should not be used when a seal coat is needed – it is not a sealer. It is sometimes used as an emergency treatment for skid repair. This treatment is considered to be the next level up from a new seal coat.

7.4.3 Effectiveness

Microsurfacing is considered to be a long term treatment for flushed pavements and has to be done by specialty contractors under an engineer's contract. Maintenance personnel indicate that they have used this solution successfully and can get about 5 to 7 years of

Figure 7.4 Microsurfacing Can Be Used to Remediate Minor Rutting, Flushed Pavement, Poor Ride Quality and Low Skid Resistance

7.4.4 Materials

This method consists of furnishing and placing a microsurfacing system which is a mixture of cationic polymer-modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives. Microsurfacing materials, practices and procedures should conform to TxDOT Standard Specifications, Item 350.

7.4.5 Procedure

Microsurfacing is made and applied to existing pavements by a specialized machine, which carries all components, mixes them on site, and spreads the mixture onto the road surface.

Materials are continuously and accurately measured, and then thoroughly combined in the microsurfacing machine's mixer. As the machine moves forward, the mixture is continuously fed into a full-width surfacing box which spreads the microsurfacing across the width of the traffic lane in a single pass. Specially engineered rut boxes may also be used.

The new surface is initially a dark brown color and changes to the finished black surface as the surface cures and is opened to traffic.

7.4.6 Helpful Tips

Microsurfacing is done by specialty contractors and normally takes about a year to bring to fruition – from initial planning to construction.

Microsurfacing must be used on the "right road." The existing pavement must be structurally sound, preferably without cracking, and cannot flex. Falling weight deflectometer measurements are usually made on the existing pavement to provide the necessary data for the evaluation of the pavement section.

Microsurfacing is used to mitigate minor rutting and flushing, improve ride quality and restore skid resistance. Shallow ruts can be filled with a "scratch course" (one of two courses). The final treatment thickness is usually about 3/4 inch.

The microsurfacing should be constructed in the fall, as opposed to the heat of the summer.

The microsurfacing can be seal coated after it has served its useful life.

7.4.7 Concerns

Some maintenance personnel will not use microsurfacing over a flushed asphalt pavement due to concerns with the excess asphalt working its way through the surface treatment (Figure 7.5). That is, the microsurface does not adequately resist the migration of excess asphalt (flushing, not bleeding) through the treatment.

The microsurfacing material contains cement and can be prone to cracking with excessive pavement deflections.

Another downside of this treatment method is the tendency for cracking in the existing pavement to reflect through the overlying microsurfacing. It is not unusual to see some cracking in the treatment during its service life.

This proprietary treatment method is relatively expensive.

Figure 7.5 Excess Asphalt from Flushed Pavement Can Work Its Way Through Microsurfacing

7.5 Thin Asphaltic Concrete Overlay

7.5.1 <u>Description</u>

Maintenance forces use blade level-up techniques to create thin asphaltic concrete overlays in order to remediate chronic problems with flushed pavement, typically in association with repair of rutting, patches, and other pavement defects. Thin overlays are also sometimes constructed using asphalt laydown machines. This is usually done in conjunction with seal coat preparation work in advance of seal coat operations.

7.5.2 <u>Application</u>

Thin overlays are often used to treat flushed wheel paths with minor rutting, and as a wearing course over a milled pavement. Thin overlays normally are not used to treat a flushed pavement alone; that is, a pavement without any other problems.

Relative to a flushed pavement, the purpose of blade level-ups and other thin asphaltic concrete overlays is to restore friction and skid resistance (Figure 7.6). In rare circumstances thin overlays have been applied where minor bleeding is present, but thin overlays are typically not used over bleeding asphalt pavements due to concerns with propagation of the asphalt through the overlay.

Thin overlays frequently are applied in high-risk areas such as where accidents have occurred, along curves, and in the most critical (slick) pavement sections. Frequent complaints about hydroplaning or vehicles running off the road over larger areas or more continuous sections of roadway normally move the affected road up the overlay candidate list.

Mill and fill operations, where the overlay is constructed with a laydown machine, may be used at intersections where start-stop and other abusive traffic movements occur. This type of overlay is considered as the final, last-resort type of treatment where no other solution seems to work.

Figure 7.6 Blade Level-ups and Other Thin Asphaltic Concrete Overlays Restore Friction and Skid Resistance

7.5.3 Effectiveness

Thin asphaltic concrete overlays are one of the more expensive solutions for flushed pavements, but provide a long-term service life.

7.5.4 Materials

Maintenance forces use various materials to construct thin asphaltic concrete overlays.

When using blade level-up techniques, Limestone Rock Asphalt (LRA) premix (Type FS or DS) is the most commonly applied material. Maintenance crews prefer to use LRA premix because it is easy work. LRA premix with trap rock is particularly desirable in that it provides good traction due to the presence of the very hard, abrasion-resistant trap rock material.

Hot mix cold laid (HMCL) can be used without a tack coat if sufficient asphalt is present on the pavement.

Maintenance forces have used Type F, Type D, and Type C hot mix for thin overlay applications on flushed pavements. These materials can be delivered directly to a site from the hot mix plant, are easily compactable, and will not absorb as much seal coat oil as the LRA. Typically hot mix is applied using the laydown machine.

Asphaltic concrete materials should conform to TxDOT Standard Specifications.

7.5.5 Procedure

Maintenance forces apply thin overlays using both blade levelup techniques and using asphalt laydown machines (Figure 7.7).

A tack coat is frequently applied beneath thin overlays/ patches. In areas where the existing pavement is rich in asphalt, it is possible to lighten or in some cases eliminate the tack coat. Thin hot mix overlays should be rolled (compacted) with a steel wheel or pneumatic tired roller.

Recommended overlay practices and procedures, as defined in the TxDOT Hot Mix Manual, should be used.

Figure 7.7 Thin Overlays to Treat Flushed Pavement Can Be Applied Using Asphalt Laydown Machines

7.5.6 Helpful Tips

Older (dry) LRA premix material has been used successfully to soak up excess asphalt on bleeding pavements. Water may be added to the LRA if it is too dry.

For reasons of cost and mobilization effort, overlays are typically used to treat larger areas of pavement.

7.5.7 Concerns

This solution is normally used as a last resort on a bad stretch of road when other remedies have failed and conditions warrant this level of correction.

Some maintenance personnel believe that LRA is too porous, it absorbs too much seal coat oil, is difficult to compact and achieve good density, and needs to be compacted by the maintenance crews (rather than traffic), something that is rarely done.

Some maintenance personnel believe that blade patches create more problems than they solve at times. Ultimately the patches have to be sealed.

Some maintenance personnel do not use thin HMAC overlays to mitigate problems with bleeding and flushing, but instead use overlays to correct pavement structure problems.

7.6 Ultra High Pressure Watercutting

7.6.1 Description

The ultra high pressure (UHP) watercutter is an emerging technology, currently used in Australia/New Zealand and being considered by TxDOT for implementation in Texas, that holds promise for treatment of flushed pavements [38] [39] [40] [41]. The following discussion was synthesized from the referenced documents and other online sources.

The UHP watercutter machine combines both watercutting and road cleaning technologies in a single process to simultaneously remove excess binder and contaminants from pavement surfaces, and retexture aggregate surfaces improving road surface macrotexture and aggregate microtexture. The UHP watercutting machine was designed and fabricated in New Zealand by Fulton Hogan Limited.

The UHP watercutter combines a truck-mounted UHP pump, water supply, and vacuum recovery system with an independently operated umbilical deckblaster (Figure 7.8). A rotating spraybar uses specialized nozzles to direct very fine jets of ultra-high pressure water (36,000 psi) at ultrasonic velocity (Mach 1.5) on to the road surface.

7.6.2 Application

High pressure water can be used to restore surface texture and skid resistance on all types of pavement surfaces that have become slick or flushed, by removing excess binder, oil, grease or rubber tire particles. It can also be used to remove pavement markings, striping, spills, etc.

This treatment can be used in advance of seal coating operations to treat asphalt-rich patches, minor bleeding problems, and flushed areas and to create a uniform surface texture for a subsequent (new) seal coat. This treatment is less suitable for treating thin surfaces which may be easily damaged or dislodged.

7.6.3 Effectiveness

Life expectancy of the treatment will be influenced by, among other things, the underlying cause of asphalt flushing and the likelihood of further aggregate embedment or flushing of binder.

Promotional literature for this treatment option claims that when the UHP watercutter is used to retexture a flushed pavement, several years should elapse before further retexturing or resurfacing is required (data from New Zealand). Effectiveness has not been established for U.S. (Texas) roadway conditions.

Retexturing removes the excess build-up of asphalt binder that would otherwise make further sprayed seal treatments difficult to apply without the risk of a repeat of flushing/bleeding in the new seal.

Cost of the treatment will depend on the size of the project, with larger machines treating more surface area in a single shift.

Figure 7.8 The UHP Watercutter Combines a Truck-Mounted UHP Pump, Water Supply, and Vacuum Recovery System with an Independently Operated Umbilical Deckblaster. *Source*: Fulton Hogan, Ltd. [www.fh.co.nz]

7.6.4 Materials

The UHP watercutter equipment consists of very high pressure pumps, usually truck mounted and self contained, and applicators, which may vary from the hydro-mower (umbilical) type for treating smaller areas, to large tractor or truck mounted units. Both machine types include tanks for the supply of fresh water and storage of collected water and debris. Machines currently are in use in Australia and New Zealand.

Precise control of pressure, water volume and speed allows effective removal of excess asphalt binder and surface contamination with minimal damage to the surface or dislodgement of coarse aggregate particles (Figure 7.9). Powerful suction heads are used to collect water and debris from the surface for later disposal.

Figure 7.9 Ultra High Pressure Watercutting Allows Effective Removal of Excess Asphalt Binder *Source*: Fulton Hogan, Ltd. [www.fh.co.nz]

7.6.5 Procedure

Detailed procedures for UHP watercutting in Texas have not been developed. The following general requirements and procedures are typical for the UHP watercutting process:

- A source of clean water is required. Water pressure needs to be controlled to prevent damage to the surfacing. The hardness of the binder in a seal or asphalt will influence the pressure required and time taken to achieve a satisfactory result.

- The process leaves a slimy residue which must be washed off. State and local environmental requirements regarding disposal of the water and any debris must be followed.

- The area will need traffic control to prevent damage to vehicles or skidding problems.

7.6.6 Helpful Tips

The process is most effective on sprayed seals and asphalt showing loss of texture due to flushed binder. Excess surface binder is removed from a flushed sprayed seal to expose the well-textured aggregate surface.

UHP watercutter treatments should be done during the cooler time of the year when pavement temperatures are lower and the asphalt material is stiffer (more brittle) and can be cut more efficiently and effectively achieving better production rates.

The process can be operated in cold, damp or wintry conditions where other resurfacing options are not feasible. Treatments can also be made during wet weather and at night if necessary.

Treatment of flushed asphalt pavements should not be done during the hotter times of the year when the pavement temperatures are higher and the asphalt is more ductile (softer). Watercutting during these conditions will significantly reduce production rates and treatment effectiveness, and has a tendency to “gum up” the machinery requiring continual cleaning and maintenance of the equipment.

Retexturing should not be used on thin seals where rapid failure may occur as a result of insufficient remaining binder to adequately hold the seal in place.

Care must also be applied when treating very weak and previously patched pavements. Contingency plans may be needed for restoration of patches damaged by the retexturing operations.

7.6.7 Concerns

Waste materials must be disposed of in an approved environmental manner. Depending on the process, a typical day’s operation may collect up to 2-4 cubic yards of solids and use up to 10,000 gallons of water.

Disposal is covered by state environmental regulations. Waste disposal classifications must be determined before commencing work. Classification of liquid wastes and solid wastes that may liberate free liquids when stockpiled, transported and disposed of, are particularly important. All stockpiled waste materials must have environmental controls in place to avoid pollution of the surrounding environment.

7.7 Other Solutions

7.7.1 Overview

Maintenance forces have used various other methods to treat flushed pavement surfaces. These other methods are used infrequently, but are mentioned since they may have limited application for treatment in a particular circumstance. Following are brief descriptions of these less commonly-used treatment methods.

7.7.2 Grooved Mold Boards

Maintenance personnel have cut grooves in a motor grader mold board in order to score the flushed pavement surface (Figure 7.10). This treatment improves texture (skid resistance/traction) on the pavement surface.

A similar approach consists of welding carbide bullet tips on the mold board. Either approach creates a tool which can be used to score/texture the pavement surface.

Figure 7.10 Grooves in a Motor Grader Mold Board Can Score the Flushed Pavement to Improve Surface Texture

7.7.3 Heat Pavement Surface and Roll In Hot Aggregate

In this method, the flushed pavement surface is pre-heated and new aggregate is applied, the idea being to get the asphalt hot and soft enough to stick the aggregate to the pavement surface. Maintenance forces can use a weed-burner, either hand-wand or tractor-mounted, or a more sophisticated heater-planer, to preheat the pavement surface. Preheating is followed by the application of a hot aggregate (typically, Grade 4) which may be obtained from a hot mix plant or may be preheated in the drier of a portable patching machine. The hot aggregate is rolled in using a steel wheel roller.

7.7.4 Slurry Seal

Slurry seals, which are similar to microsurfacing, are mixtures of cationic emulsified asphalt, mineral aggregates, mineral filler, water and additives, properly proportioned, mixed and spread with a machine over a properly prepared surface. A slurry mixture forms an impervious thin overlay over an existing pavement. The aggregate is relatively fine (less than1/4 inch). The fine aggregate at the pavement surface corrects loss of skid resistance typically associated with flushed pavement by providing increased friction. The slurry seal is a thin surface treatment intended to provide pavement sealing and some pavement texturing, but is not appropriate to resolve pavement structural deficiencies. Like microsurfacing, slurry seals are applied only by specialty contractors.

CHAPTER 8
SOLUTIONS FOR INTERSECTIONS

8.1 Overview

8.1.1 Typical Distress Conditions at Intersections

Seal coats and surface treatments have limitations in their ability to resist the effects of heavy traffic and abusive traffic maneuvers at high-stress traffic areas such as intersections, median openings, and the like. Turning and braking of heavy vehicles can cause aggregate to roll, leading to loss of aggregate and bleeding of the seal. Concentrations of heavy traffic at intersections may cause aggregate embedment, leading to flushing of the binder. The maintenance thresholds that call for treatment of bleeding and flushed asphalt pavements at intersections include:

- The asphalt begins to soften and liquefy on the roadway surface.
- Turning movements cause the seal coat/surface treatment aggregate to dislodge (shelling).
- Turning movements cause the seal coat/surface treatment aggregate to mound up/shove.
- The roadway surface is slick and slippery, with low skid resistance, particularly in wet weather conditions.

Fundamentally, the problem with intersections and other high-stress traffic areas is a mismatch between structural/performance requirements and the pavement surface type.

8.1.2 Maintenance Treatment Strategy

Maintenance forces have employed a variety of methods to treat bleeding and flushed asphalt pavements at high-stress traffic areas such as intersections. The basic approaches are (a) to retexture the existing pavement surface, or (b) to replace the seal coat /surface treatment with a new, more durable, pavement material. The method chosen depends upon economics as well as the availability of materials, manpower, and equipment at the time of treatment.

The selection of the treatment approach must also consider the severity of the problems as well as many other factors including environmental conditions, type of roadway, traffic levels and types, specific locations on a roadway (curves, intersections, urban environments) and more. Practical wisdom is the key to success of any treatment solution.

The objective of treatment at intersections is to provide a pavement surface which is less susceptible to damage due to high traffic and abusive traffic maneuvers. This includes not only correction of bleeding/flushing but also rutting, shoving, and other roadway defects.

Corrective action should also try to improve surface water drainage flow off of the roadway, especially away from (or out of) the wheel paths.

8.1.3 Summary of Maintenance Solutions

Table 8.1 summarizes potential solutions for treatment of bleeding and flushed pavements at intersections. The remainder of this chapter is devoted to presenting each of these solutions from the maintenance supervisor perspective. Each solution includes the following components: description, application, effectiveness, materials, procedure, helpful tips, and concerns.

Table 8.1 Maintenance Solutions for Treatment of Bleeding and Flushed Pavements at Intersections

Maintenance Solutions for Bleeding/Flushed Asphalt Pavement at Intersections	**Solution Type**		**Effectiveness**			**Cost**		
	New Textured Surface	**Durable Overlay**	**Short Term**	**Mid Term**	**Long Term**	**Low**	**Med.**	**High**
Microsurfacing	■				■		■	
Hot mix asphalt pavement		■			■			■
Portland cement concrete pavement		■			■			■
Racked-in seal	■			■		■		

Arguably the first three solutions — microsurfacing, hot mix asphalt, and portland cement concrete — are not routine maintenance activities. These have been included to illustrate the range of options and for the sake of completeness.

In contrast, the fourth solution — the racked-in seal — is very compatible with typical maintenance activity and may prove to be a promising alternative for treatment of bleeding/flushing at intersections.

8.2 Microsurfacing

8.2.1 Description

Microsurfacing (see also Section 7.4) is a tough, durable, thin cold overlay material which has been used for both corrective and preventive maintenance to restore the original properties to structurally sound pavements. By definition, microsurfacing is a mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives. These components are mixed together at the jobsite in a pugmill that is mounted on a self-propelled hauling unit.

8.2.2 Application

Microsurfacing is used to remediate problems associated with minor rutting, flushed pavement, ride quality and skid resistance (usually a combination of these). Microsurfacing is not used to correct bleeding.

Selection of the microsurfacing method typically focuses on correcting problems associated with rutting in the wheel paths and providing improved macrotexture and skid resistance on a roadway. Relative to intersections, microsurfacing provides a tough, durable pavement surface which is less susceptible to damage from high traffic and abusive traffic maneuvers.

Microsurfacing is often done in urban environments for roadways with high traffic volumes. The pavement section must be structurally sound.

8.2.3 Effectiveness

Microsurfacing is considered to be a long term treatment for flushed pavements and has to be done by specialty contractors. Maintenance personnel indicate that they have used this solution successfully and can get about 5 to 7 years of service life.

8.2.4 Materials

This method is done under construction contract and consists of furnishing and placing a microsurfacing system consisting of a mixture of cationic polymer-modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives. Microsurfacing should conform to TxDOT Standard Specifications, Item 350.

8.2.5 Procedure

Microsurfacing is made and applied to existing pavements by a specialized machine, which carries all components, mixes them on site, and spreads the mixture onto the road surface.

Materials are continuously and accurately measured, and then thoroughly combined in the microsurfacing machine's mixer. As the machine moves forward, the mixture is continuously fed into a full-width surfacing box which spreads the microsurfacing across the width of the traffic lane in a single pass. Specially engineered rut boxes may also be used.

8.2.6 Helpful Tips

Microsurfacing is done by specialty contractors and normally takes about a year to bring to fruition – from initial planning to construction.

Microsurfacing must be used on the "right road." The existing pavement must be structurally sound, preferably without cracking, and cannot flex. Falling weight deflectometer measurements are usually made on the existing pavement to provide the necessary data for the evaluation of the pavement section.

8.2.7 Concerns

Some maintenance personnel will not use microsurfacing over a flushed seal coat or surface treatment due to concerns with the excess asphalt working its way through the surface treatment. That is, the microsurface does not adequately resist the migration of excess asphalt (flushing) through the treatment.

The microsurfacing material contains cement and can be prone to cracking with excessive pavement deflections.

Another downside of this treatment method is the tendency for cracking in the existing pavement to reflect through the overlying microsurfacing. It is not unusual to see some cracking in the treatment during its service life.

This proprietary treatment method is relatively expensive

8.3 Hot Mix Asphalt Pavement

8.3.1 Description

Hot mix asphalt pavement may be used to remediate chronic problems with rock loss and attendant bleeding/flushing at intersections, normally in association with repair of rutting, patches, and other pavement defects (see also Section 7.5). The construction process will typically be a mill and fill operation. The existing pavement surface (seal coat/surface treatment) is removed to a predetermined depth and hot mix asphalt is placed with a laydown machine.

8.3.2 Application

The decision to use hot mix asphalt at an intersection largely depends on economic considerations including life cycle costs. Among other things, this will be a function of the existing pavement condition, traffic volume, traffic type, and long term maintenance objectives.

Frequent maintenance repair effort and/or consumer complaints and concerns about safety move the affected intersection up the candidate list (Figure 8.1).

8.3.3 Effectiveness

Hot mix asphalt is one of the more expensive solutions for bleeding/flushed pavement at intersections, but at the same time provides a long service life.

8.3.4 Materials

Asphalt binder and aggregate for new hot mix pavements are typical roadway construction materials and are selected on a case-by-case basis. Materials should conform to TxDOT Standard Specifications.

8.3.5 Procedure

Design of hot mix asphalt pavements for intersections must recognize that slow-moving or standing loads subject the pavement to higher stress conditions, which may be enough to induce rutting and shoving. In addition, an increase in trucks and heavier wheel loads can also play a significant role in the premature failure of some pavements. Thus the pavement must be designed and constructed to withstand the more severe conditions.

To perform well, an intersection pavement must have adequate thickness to provide the structural capacity to meet traffic needs. Pavement thickness design must account for normal factors such as subgrade strength, drainage and traffic. Any failed or weak layers in the existing pavement structure must be removed since paving over existing failed material will likely result in recurring failure.

Figure 8.1 Use of Hot Mix Asphalt at an Intersection Largely Depends on Economic Considerations Including Life Cycle Costs

Careful selection of the asphalt binder is key to providing desirable performance. A more rutting-resistant binder is needed at intersections. Aggregates used in intersection mixtures must also be carefully selected. The aggregate structure has to be capable of carrying the load and developing a high degree of stone- to-stone interlock that will resist shearing.

The goal of the mix design process is to select and proportion appropriate materials that resist rutting.

8.3.6 Helpful Tips

The performance history of intersections and other similar high stress areas should be evaluated. This will play a key role in deciding whether changes should be made to the normal design and construction procedures.

8.3.7 Concerns

This method is among the more expensive treatment solutions.

8.4 Portland Cement Concrete

8.4.1 Description

Portland cement concrete pavement may be used to remediate chronic problems with bleeding/flushing at intersections, normally in association with repair of rutting, patches, and other pavement defects. The construction process will typically be a mill and fill operation. The existing pavement surface (seal coat/surface treatment) is removed to a predetermined depth and a full-depth Portland cement concrete pavement is placed.

8.4.2 Application

The decision to use portland cement concrete at a selected intersection largely depends on economic considerations including life cycle costs. Among other things, this will be a function of the existing pavement condition, traffic volume, traffic type, and long term maintenance objectives.

Candidate intersections include those that are severely rutted and distressed from loads, slow moving vehicles, and warm temperatures. Frequent maintenance repair effort and/or consumer complaints and concerns about safety move the affected intersection up the candidate list.

8.4.3 Effectiveness

Portland cement concrete is particularly effective at handling the very rigorous stopping, starting, standing, and turning actions of vehicles at intersections.

Portland cement concrete provides a long term service life and requires very minimal, if any future rehabilitation. The construction user costs and disruption to traffic that are necessary with future asphaltic concrete inlays during its design life are reduced when portland cement concrete is used.

Proponents further claim that portland cement concrete offers a safer, more durable, smoother, and longer-lasting pavement.

This is one of the more expensive solutions for bleeding/flushed pavements. However, life cycle cost analysis of portland cement concrete reconstruction versus asphalt concrete pavement reconstruction and future inlays shows that portland cement concrete intersection reconstruction may compete with asphalt paving.

8.4.4 Materials

Portland cement concrete pavement materials should conform to TxDOT Standard Specifications.

8.4.5 Procedure

Design of Portland cement concrete pavements for intersections must recognize that slow moving or standing loads subject the pavement to higher stress conditions. In addition, the increase in the number of trucks and heavier wheel loads can also play a significant role in the premature failure of some pavements. Thus the pavement must be designed and constructed to withstand the more severe conditions.

To perform well, an intersection pavement must have adequate thickness to provide the structural capacity to meet traffic needs. Pavement thickness design must account for normal factors such as subgrade strength, drainage and traffic. Any failed or weak layers in the existing pavement structure must be removed since paving over existing failed material will likely result in recurring failure.

8.4.6 Helpful Tips

The performance history of intersections and other similar high stress areas should be evaluated. This will play a key role in deciding whether changes should be made to the normal design and construction procedures.

8.4.7 Concerns

The major disadvantage with portland cement concrete intersections is the higher initial construction cost. This method is among the more expensive treatment solutions

8.5 Racked-in Seal

8.5.1 Description

The racked-in seal is a variation to the single course seal coat (Figure 8.2). The racked-in seal consists of one heavy layer of binder followed by two layers of cover aggregate. The second layer of aggregate, or scatter coat, is smaller than (one-third to one-half size) the first layer. The smaller aggregate fills the voids and displaces the binder further upward on the larger stone, thereby mechanically locking the larger aggregate in position and producing a stable matrix.

Figure 8.2 The Racked-In Seal Can be Used at Intersections to Improve Seal Coat Performance Under Heavy Traffic or Abusive Traffic

8.5.2 Application

The racked-in seal has been proposed for use in Texas at high stress areas, for example, heavily-trafficked intersections that otherwise would be sealed with a traditional seal coat. It is frequently used in association with asphalt emulsion binders.

The purpose behind the racked-in seal is to provide a stronger seal coat treatment. The scatter coat aggregate is intended to prevent the seal coat rock from sliding, rolling over or scrubbing off of the underlying pavement. The analogy is to billiards, where a rack holds cue balls in a tight pattern.

8.5.3 Effectiveness

The racked-in seal has been used in Canada, Europe, Asia, Australia, and New Zealand on roadways where traffic is heavy and/or fast [36] [42] [43] [44] [45] [46].

The racked-in seal has been introduced in Texas only recently and has seen limited application on system roadways. Recommended details for construction and performance data on Texas roadways are not available at this time.

8.5.4 Materials

Asphalt binder, coarse aggregate, and fine aggregate for the racked-in seal are typical materials for seal coats and are selected on a case-by-case basis. Materials should conform to TxDOT Standard Specifications.

8.5.5 Procedure

The racked-in technique involves a light application of a small size aggregate (scatter coat) over a traditional coarser aggregate seal coat. The scatter coat aggregate rock is applied before traffic and serves to reduce rolling over of coarse aggregate particles during the critical initial aggregate reorientation stages of seal coat compaction.

Generally the second application of aggregate (scatter coat) is half the size of the first. A typical combination is 0.2-inch rack rock (Grade 5) over 3/8-inch seal coat rock (Grade 3). This enables the smaller aggregate to lodge in the void spaces in the larger aggregate, holding the larger aggregate in place and providing a strong mechanical key against traffic shearing forces (Figure 8.3).

Layout for a typical intersection would involve placing the racked-in seal at least 100 feet beyond the intersection in all directions. Seal coat construction could use either hot asphalts or emulsions.

Two chip spreaders are required to construct the racked-in seal. The initial portion of the racked-in seal is constructed like a normal seal coat. However, the seal coat aggregate application rate is normally reduced so that the second layer of aggregate (scatter coat) is firmly held as a permanent part of the seal.

Rolling procedures are established in accordance with the characteristics of the seal coating system. Intermediate rolling is advisable for the initial embedment of the seal coat rock forming the lower layer of a racked-in system.

Figure 8.3 The Racked-In Seal Involves a Light Application of Small Size Aggregate (Scatter Coat) Over a Traditional Coarser Aggregate Seal Coat

A variation on the racked-in seal is the "dry lock" process. The terms "racked-in" and "dry lock" are used somewhat interchangeably. However, in the "dry lock" technique the initial aggregate application rate (seal coat rock) is unchanged and it is expected that most of the second layer of aggregate (the scatter coat, or rack rock) will be lost during the early service life of the seal.

8.5.6 Helpful Tips

A Special Specification has been developed for the racked-in seal: SPECIAL SPECIFICATION 3057, "Racked in Aggregate for Surface Treatments."

8.5.7 Concerns

Aggregate whip-off for the scatter coat (rack rock) should be anticipated for the racked-in system.

The racked-in seal has been introduced in Texas only recently and has seen limited application on system roadways. Recommended details for construction and performance data on Texas roadways are not available at this time

CHAPTER 9
BINDER QUALITY CONSIDERATIONS

9.1 Binder Issues Associated with Bleeding and Flushing

Binder considerations influence the occurrence of bleeding and flushing. For example, our screening survey identified three factors – too much binder, poor quality binder, and improper binder type – as potential causes of bleeding. Further, our district interviews indicated that the quality of binder, use of inappropriate (too high or too low) binder application rates, and poor binder application practices can lead to bleeding and flushed pavements.

One binder property of particular interest is when highly temperature-susceptible asphalt binder is used in the layer below the seal coat [47]. This binder can soften at very high pavement service temperatures resulting in the aggregates of the seal coat pressing into the underlying pavement layer. This pushes the asphalt binder upwards causing flushing and bleeding. For this reason, we attempted to evaluate laboratory test properties of certain binders, and temperature susceptibility in particular, to determine whether this is a significant cause associated with bleeding and flushing.

9.2 TxDOT's Binder Quality Assurance Database

The TxDOT Laboratory Information Management System (LIMS) stores the results from all testing done by the Department on all material including asphalt binders. Both the samples collected at the asphalt plant and in the field are tested for quality assurance purposes at the Department laboratory.

We obtained access to TxDOT's asphalt binder test data in order to explore possible correlations between the binders used in bleeding seal coats and their laboratory test properties. Our goal was to look into factors that influence bleeding, in particular, binder temperature susceptibility.

Our basic approach was to identify representative projects (case studies) from our site interviews, obtain information about these projects including the pavement condition, the seal coat design, the construction history, the nature and extent of post-construction bleeding/flushing, corrective measures, and the like. With this information, we would examine laboratory test properties from the TxDOT LIMS during the seal coat construction period, and compare performance with the properties to determine whether binder quality was at issue.

9.3 Selection of Representative Projects

We requested project-specific data for representative bleeding/flushing projects as part of our District interview process. Specific data from the field evaluations yielded information on 30 roadway projects. For various reasons, however, only ten of these projects proved to be potential candidate projects for analysis.

We contacted persons who were knowledgeable about the ten projects in an attempt to obtain information sufficient to facilitate analysis based on binder quality assurance data from the TxDOT LIMS. Despite persistent efforts to obtain information about the binder supplier and the approximate construction date, we were ultimately only able to obtain complete information for three projects. These are:

- FM 624, McMullen County (San Antonio District)
- SH 70, Donley County (Childress District)
- US 59, Cass County (Atlanta District)

We performed detailed evaluations of these projects, and the findings are summarized in the following section of this report.

9.4 Data Analysis

Temperature susceptibility refers to the rate of change in asphalt consistency with a change in temperature [47]. The data analysis focused on several potential indicators of binder quality relative to temperature susceptibility, as available. These included:

- Penetration test values.
- Ductility test values.
- Laboratory test results for absolute viscosity at 140°F and at 275°F were evaluated against lower specification limits and upper specification limits for both plant and field samples as a direct indicator of binder quality. The viscosity of asphalt cement at 140°F is important because during hot Texas summers, the surface temperature of pavement can reach (or exceed) 140°F.
- Inasmuch as only a limited number of tests were performed, we conducted statistical analyses of the viscosity data to estimate the expected percentage of results that would not meet specification, which is an indicator of the variability of the binder properties.
- We used penetration test results to calculate viscosity values at 77°F in order to plot the viscosity versus temperature gradient at working temperatures for the binder (77°F and 140°F). Here the goal was to evaluate whether the gradients were steeper than the critical curve. Such a finding would indicate higher temperature susceptibility.
- We evaluated the viscosity values at 140°F and at 275°F for outliers, the goal being to determine whether results were consistent.

Results of these analyses from the three case study projects are summarized below.

9.4.1 <u>FM 624, McMullen County (San Antonio District)</u>

The quality of HFRS-2P binder produced by the supplier during the period from November 2005 to May 2006 was evaluated. Tests included Absolute Viscosity at 140°F, Saybolt Viscosity at 122°F and Penetration at 77°F. Absolute viscosity values at 140°F and at 275°F for the binder samples were plotted against specification limits and those test results met the specification requirements except for two tests. We conducted statistical analyses of the viscosity data to estimate the expected percentage of results that would not meet specification. The percentage outside specifications was 19.3 percent whereas the typical acceptable limit is 5 percent. This suggests a lack of consistency of the binder production process; however, the number of data points (only 9) is low so this finding is not conclusive. Using an empirical equation developed by Halstead, et al. [48] which incorporates calculated viscosity at 77°F and viscosity at 140°F, we examined the behavior of the binder under anticipated field service temperatures. Our analysis showed that the gradients of all binder samples were flatter than the critical curve as defined by project specifications, an indicator that the binder temperature susceptibility is within requirements outlined by the specifications. In summary, these viscosity analyses suggest that binder quality in general and temperature susceptibility in particular were not responsible for the bleeding problem on this project.

9.4.2 SH 70, Donley County (Childress District)

The quality of AC-5 with 2% latex binder produced by the supplier during the period March 2005 through September 2005 was evaluated. Absolute viscosity values at 140°F and at 275°F were plotted against specification limits and those test results met the specification requirements. Using the equation developed by Halstead, et al. [48], we examined the behavior of the binder under anticipated field service temperatures. Our analysis showed that the gradients of all binder samples were flatter than the critical curve as defined by project specifications, an indicator that the binder is less susceptible to temperature change. These viscosity analyses suggest that binder temperature susceptibility was not responsible for the bleeding problem on this project. However, penetration tests at 77°F and ductility tests at 39.2°F do not meet the basic specification criteria set by TxDOT. Further, statistical analyses of the viscosity tests at 140°F suggest that the expected percentage of results that would not meet specification is 10 percent, and this is outside the acceptable limit of five percent. Penetration test and ductility test results show similar inconsistency. In summary, the binder used for the project had some quality issues.

9.4.3 US 59, Cass County (Atlanta District)

The quality of AC-15 5TR binder produced by the supplier for the period March 2003 through September 2003 was evaluated. Absolute viscosity values at 140°F and at 275°F were plotted against specification limits and those test results met the specification requirements. Statistical analyses of the viscosity tests at 140°F suggest that the expected percentage of results that would not meet specification is 19.6 percent, and this is outside the acceptable limit. This suggests a lack of consistency of the binder production process; however, the number of data points is low so this finding is not conclusive. Using the equation developed by Halstead, et al. [48], we examined the behavior of the binder under anticipated field service temperatures. Our analysis showed that the gradients of all binder samples were flatter than the critical curve as defined by project specifications, an indicator that binder temperature susceptibility is within requirements outlined by the specifications.

We also determined there were no outliers. In summary, these viscosity analyses suggest that binder quality in general and temperature susceptibility properties in particular were not responsible for the bleeding problem on this project.

9.5 Findings

Our research suggests that the development and appropriate use of polymer modified and other binders has improved seal coat and surface treatment performance due to the increased cohesion, toughness, and reduced temperature susceptibility of these binders. Poor binder quality is sometimes an issue, and where it is, this must be addressed. But most of the time, binder quality is not a major problem, especially in recent years. Anecdotal evidence from our interviews, respondent indicators from the screening survey, and this limited analysis of binder quality based on LIMS data suggest that binder quality in general and temperature susceptibility in particular is not a major factor responsible for bleeding and flushing problems.

One observation can be made, however. Our screening survey (Table 3.4) indicates that the primary cause of bleeding asphalt pavement is pre-existing bleeding of the pavement surface – apparently it is difficult to correct a bleeding problem once it starts. Relative to this discussion of binder quality, this suggests that some of the older bleeding pavements used binders that *were* temperature susceptible, for example, the softer unmodified asphalt cements such as AC-5 and AC-10. These binders can continue to cause problems with bleeding, and while the newer binders are not as temperature susceptible, this is not to say that the problems associated with the older binders are completely in the past.

Binder considerations have and will continue to play a major role in quality seal coat construction. The good news for TxDOT is that today's binders offer superior performance and show evidence of being more forgiving relative to bleeding and flushing.

CHAPTER 10

SUMMARY AND RECOMMENDATIONS

10.1 Summary of Findings

This report summarizes the findings of research sponsored by the Texas Department of Transportation directed at identifying maintenance solutions to the problem of bleeding and flushed asphalt pavements with seal coats or surface treatments. The research focused on documenting typical manifestations of bleeding and flushing, discovering the cause(s) and underlying factors that contribute to bleeding/flushing, and identifying cost-effective treatment approaches.

This work associated with this one-year research project was accomplished in five tasks. We began with a literature review, international in scope (Task 1). Here the focus was on gaining breadth of information. Task 2 consisted of conducting structured interviews with various non-TxDOT knowledge sources, nationwide, in order to further develop and refine our understanding of the bleeding asphalt problem. In Task 3, we shifted our data-gathering focus from breadth to depth and conducted face-to-face interviews with knowledgeable persons within TxDOT at both the Division and District levels in order to capture the wealth of institutional knowledge and expertise resident within the agency. More than 120 TxDOT personnel participated in this effort, allowing us to capture more than 2,500 years of construction/maintenance experience and institutional knowledge. Analysis of the data (Task 4) – consisting of practical, hands-on, performance-focused, expertise gained from international, national, and statewide sources – has been articulated as recommended practices for addressing the problem of bleeding and flushed asphalt pavements. The reporting (Task 5) documents our findings for both the maintenance and scholarly communities.

General agreement exists in the research and roadway maintenance communities that the basic mechanism associated with both bleeding and flushing has to do with excess asphalt binder filling the voids between the aggregate particles (cover stone). This situation – inadequate voids between the aggregate particles – can manifest itself as either bleeding or flushing. The terms *are* different even though the origin of the problem is the same in both cases. One of the more helpful descriptions we heard in the Districts is that “flushed” is past tense; whereas, “bleeding” is an active verb.

The main factors that contribute to bleeding and flushed pavements include aggregate issues, binder issues, traffic issues, environmental issues, and construction issues. The maintenance supervisor looking for solutions to bleeding/flushing will do well to recognize and understand these causes, since in many cases the best solution is to not get into the problem in the first place. Aggregate issues include rock loss, application of too much rock, use of dirty rock, use of soft rock, and judicious use of modified aggregate grades. Binder issues relative to bleeding and flushing include binder selection, historically problematic binders, binder application rate, binder curing, and binder quality. Traffic considerations relative to bleeding and flushing include traffic volume, traffic type (heavy trucks), traffic movements (stop & go, turning, etc.), and intersections. The key environmental factors associated with flushing/bleeding pavements are high temperature, humidity, changing temperatures, and low temperatures. Construction issues relative to preventing/avoiding bleeding and flushed pavements include proper assessment of existing pavement conditions, use of good seal coat preparation techniques, treatment of rutting in wheel paths, attention to the special curing needs of new seal coats, use of fog seals to mitigate rock loss problems, and avoidance of poor construction practices.

There is no better advice for dealing with bleeding and flushed pavements than to avoid the problem from the outset during seal coat/surface treatment design and construction. As in medicine, so in maintenance: "An ounce of prevention is worth a pound of cure." In a similar way, it can be argued that a preventive maintenance mindset is a cost-effective tool for approaching the bleeding/flushing problem. Three topics emerge as being key to a preventive maintenance mindset focused on reducing bleeding and flushing. These include avoidance of known pitfalls and problem areas, implementation of a centralized seal coat management program, and judicious selection of seal coat and surface treatment binders. From a maintenance perspective, the goal is to *cope* with unavoidable causes, *avoid* purely avoidable causes, and *manage* potentially avoidable causes. Also, Districts that utilize a centralized seal coat management program are having consistent success with their seal coats/surface treatments and fewer instances of problems such as bleeding and flushing. Further, binder selection – both the type and application rate – is key to successful seal coat/surface treatment performance. The appropriate asphalt must be used in the appropriate season.

Bleeding asphalt pavement is an immediate maintenance problem that must be addressed using corrective or in some cases, emergency, maintenance. Maintenance forces employ several methods to treat bleeding asphalt pavements. The basic approaches are (a) to bridge over the liquid asphalt by applying aggregate of various types and gradations, (b) to cool off the pavement surface by applying water with or without additives, or (c) to remove the bleeding asphalt and rebuild the pavement seal. The method chosen often depends upon the available materials, manpower and equipment at the time of treatment. The selection of the treatment approach must also consider the severity of the bleeding problem as well as many other factors including environmental conditions (temperature and humidity), type of roadway, traffic levels and types, and specific locations on a roadway (curves, intersections, urban or rural environments).

Flushed asphalt pavement, in contrast to bleeding pavement, is typically *not* a maintenance problem that must be addressed immediately. The maintenance thresholds that call for treatment of a flushed asphalt pavement include a slippery pavement surface, low skid resistance, and rutting and water accumulation in the wheel paths. This type of pavement distress does not normally warrant immediate or emergency maintenance measures; however, it must be monitored closely to minimize the probability for escalation into a wet weather safety concern or a bleeding pavement problem. Maintenance forces have employed a variety of methods to treat flushed asphalt pavements. The basic approaches are: (a) to retexture the existing flushed pavement surface, or (b) to add a new textured surface over the flushed pavement. The method chosen often depends upon economics as well as the availability of materials, manpower and equipment at the time of treatment.

Intersections can be especially problematic. Seal coats and surface treatments have limitations in their ability to resist the effects of heavy traffic and abusive traffic maneuvers at high-stress traffic areas such as intersections, median openings, and the like. Turning and braking of heavy vehicles can cause aggregate to roll, leading to loss of aggregate and bleeding of the seal. Concentrations of heavy traffic at intersections may cause aggregate embedment, leading to flushing of the binder. Maintenance forces have employed a variety of methods to treat bleeding and flushed asphalt pavements at these high-stress traffic areas. The basic approaches are (a) to retexture the existing pavement surface, or (b) to replace the seal coat /surface treatment with a new, more durable, pavement material. The method chosen depends upon economics as well as the availability of materials, manpower, and equipment at the time of treatment.

Binder considerations influence the occurrence of bleeding and flushing. For example, poor quality of binder, use of inappropriate (too high or too low) binder application rates, and poor binder application practices can lead to bleeding and flushed pavements. Our research suggests that the development and appropriate use of polymer modified and other binders has improved seal coat and surface treatment performance due to the increased cohesion, toughness, and reduced temperature susceptibility of these binders. Poor binder quality is sometimes an issue, and where it is, this must be addressed. But our research suggests that binder quality in general and temperature susceptibility in particular are not a major factor responsible for current bleeding and flushing problems.

10.2 Recommendations for Further Research/Implementation

The research findings suggest three promising areas for further research/implementation relative to solutions for bleeding/flushing. These include: (a) use of lime water, (b) ultra high pressure water cutting, and (c) the racked-in seal.

10.2.1 Lime Water

Our research indicates that application of lime water is very commonly used in the Districts – the second most common solution for bleeding after placing Grade 5 aggregate. However, one of the principal findings about this method is that the mechanisms associated with lime are not understood well at all, and no definitive procedures exist for its application.

It is generally believed that the lime treatment can help a bleeding asphalt pavement in the following ways:

- Coats asphalt particles/ crusts over liquid asphalt
- Stiffens the asphalt cement through chemical interaction
- Cooling of the hot pavement when the lime solution is applied on the roadway
- Less heat is absorbed to the asphalt pavement surface when the while lime pigment is deposited on the pavement

Further, the effectiveness of a lime treatment appears to depend on several factors such as:

- Asphalt binder on the pavement surface on which lime is applied
- Timing of the lime treatment (pre-emptive or reactive treatment)
- Lime application rate
- Level of traffic on the highway section
- Traffic type; *e.g.*, trucks/heavy loads
- Traffic movements; *e.g.*, slow moving, stop/go, turning, intersections, etc.
- Ambient temperature and humidity conditions

Previous research has shown the effectiveness of lime as an asphalt stiffening agent. However, a comprehensive study that takes into consideration all of the factors indicated above has not been undertaken. The first aspect – identifying the mechanisms associated with lime such as why it works, how it works, the domain for greatest effectiveness, etc. – represent focused research questions for which we feel additional research study would be appropriate. The second aspect – effective standard procedures for application of lime water – represents an implementation-type question.

We recommend a laboratory-based research program to test various aspects of lime water application specific to bleeding. Key independent variables include lime application rate, binder type, traffic, and temperature/humidity. The influence of these factors could be evaluated using laboratory tests such as dynamic shear rheometer (DSR), viscosity, and penetration tests. The goal would be to learn which lime application rates are most effective for given binder/traffic/temperature-humidity combinations. By exploring the influence of temperature and humidity on effectiveness of the solution, this should offer insight on the timing of the lime application; that is, whether it is better to preemptively apply lime early in the morning to stave off bleeding, or is it better to apply lime later in the day when the seal coat surface is already hot/bleeding?

From an implementation perspective, a field-based program could be used to verify the laboratory research findings on the road under a representative set of test conditions; that is, for binder, traffic, temperature/humidity, etc. The implementation goal would be to field test/ optimize standard procedures for application of lime water.

10.2.2 Ultra High Pressure Watercutting

While none of the Districts currently use ultra high pressure water cutting for correction of flushed pavements, this solution generated quite a bit of interest for its potential application.

Ultra high pressure (UHP) watercutting technology is currently being used by Fulton Hogan Limited (FHL) in New Zealand and Australia to restore texture to chip-sealed road surfaces that are slick with excess asphalt binder (flushed). Research has indicated that significant improvements can be made to pavement macrotexture, microtexture, texture depth and skid resistance. It also appears that this type of treatment can be used to prevent potential bleeding problems in flushed areas and can be used in advance of seal coating operations to minimize the chance of previous flushing and bleeding problems to continue through a subsequent (new) seal coat.

Fulton Hogan Limited is fundamentally a road construction and maintenance contractor in New Zealand and Australia. They have developed a UHP watercutter for their use and operate five of these units at the present time. Based on our discussions with FHL, they are not in a position to have one of their existing machines shipped to the United States and are not in the business of building machines to sell. FHL suggested that we identify a US equipment manufacturer to fabricate a UHP watercutter, built to FHL specifications under a license agreement with them.

Implementation research to evaluate the use of the UHP watercutter for treatment of flushing/bleeding pavements for TxDOT maintenance applications would involve two basic tasks:

1. Acquire (facilitate fabrication of) a Fulton Hogan UHP watercutter for US (Texas) roadways
2. Monitor and evaluate use of the UHP watercutter for treatment of flushing/bleeding asphalt pavements under a variety of roadway conditions

As to the first task, our research suggests that significant design changes and modifications would be necessary to manufacture a prototype watercutter suitable for use on Texas roadways. This is because roadway design, roadway construction, traffic volumes, traffic types, traffic control, safety and preventive maintenance techniques differ substantially between Texas and Australia/New Zealand.

As to the second task, the treatments should be done during the cooler time of the year when the pavement temperatures are lower and the asphalt material is stiffer (more brittle) and can be cut more efficiently and effectively achieving better production rates. Treatments can also be made during wet weather and at night if necessary. Treatment of flushed asphalt pavements should not be done during the hotter times of the year when the pavement temperatures are higher and the asphalt is more ductile (softer). Watercutting during these conditions will significantly reduce production rates and treatment effectiveness, and has a tendency to “gum up” the machinery requiring continual cleaning and maintenance of the equipment.

A valid implementation research program would require treating numerous test sections at various locations throughout the state. Test sections could be identified through a review of wet weather accident data which would result in the identification of the more critical sections in need of treatment (slick pavement and skid resistance problems). Sections should also be identified for treatment where bleeding has been a problem in the past to determine if this treatment method has the potential to stem future bleeding problems. Other possibilities include binder-rich pavement areas; *e.g.*, patches, which can be treated in advance of new seal coats.

Extensive monitoring would be required in advance of and immediately after the treatments to evaluate the post-treatment changes in the pavement texture and skid resistance. Long-term monitoring will also be required for a period of at least one year to evaluate the durability and effectiveness of the treatments over time as they relate to pavement texture and skid resistance.

In sum, implementation research should be directed at (a) becoming familiar with the watercutter method, (b) exploring its costs and production capability, (c) comparing the effectiveness of this application to other methods including cold milling, application of a strip seal, or microsurface, (d) training requirements, and the like.

10.2.3 Racked-in Seal

A promising area for further study in the aggregate family of bleeding solutions would be the "racked-in seal." This appears to be an economical alternative to the traditional seal coat at intersections. Most all the maintenance personnel that we talked to would prefer to have hot mix asphaltic concrete or Portland cement concrete pavements at intersections, especially in higher trafficked areas, urban areas that experience more stop and go or slow-moving traffic, or areas where one sees heavy truck traffic (especially heavy or over-weight loads). But hot mix asphaltic concrete or Portland cement concrete pavements typically are not a viable option due to the high cost.

As described herein, the racked-in seal procedure consists of a traditional seal coat at an intersection with a Grade 3 or 4 rock followed by a cover course (scatter coat) of Grade 5 crushed stone over the seal coat, without additional asphalt. The Grade 5 rock is rolled-in over the seal coat and released to traffic when appropriate. The theory of the racked-in seal is that the smaller Grade 5 rock "locks in" the underlying larger sized seal coat rock and prevents or minimizes the likelihood for the rock to roll before the asphalt-aggregate bond is complete or the road is released to traffic. The intent is that the rocks will have fewer tendencies to move around at the intersection minimizing the typical washboard effect where the aggregate piles up in mounds in some areas and is completely scrubbed off the pavement surface in others.

The effectiveness of a racked-in seal appears to depend on several factors including those indicated below:

- Level of traffic on the highway section
- Traffic type; *e.g.*, trucks/heavy loads
- Traffic movements; *e.g.*, slow moving, stop/go, turning, etc.
- Binder type and rate
- Seal coat rock grade
- Seal coat rock rate
- Scatter coat rock grade
- Scatter coat rock rate

A comprehensive study that takes into consideration all of the factors indicated above has not been undertaken. From an implementation perspective, the research questions have to do with optimizing the rack seal procedure. That is, it would be appropriate to explore the effect of varying the seal coat binder rate and the aggregate grade and rate for both the seal coat and the rack-in seal layers under a variety of binder, traffic and roadway conditions.

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Appendix A

Screening Survey Questionnaire

TechMRT MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION

SURVEY INSTRUCTIONS

TxDOT 0-5320, BLEEDING ASPHALT PAVEMENT SCREENING SURVEY

This survey questionnaire is to obtain your opinion on practices and procedures for solutions to bleeding on TxDOT roadways with seal coats or surface treatments.

Confidentiality Statement

Your responses will be CONFIDENTIAL in that responses are returned directly to Texas Tech University and individual names are never linked to responses.

Instructions for Participating in this Survey

The questions we are asking you to answer request opinions about your own experiences at TxDOT relative to dealing with the problem of bleeding on pavements with seal coats and/or surface treatments. For the purposes of this survey, *bleeding* is defined as "excess asphalt binder occurring on the pavement surface." Bleeding may create a shiny, glass-like surface that may be tacky to the touch, and is usually found in the wheel paths. Less-severe bleeding is sometimes termed "flushing."

While we appreciate accuracy, it will not be necessary anywhere on this questionnaire to refer to your records. There are no right or wrong answers; just use your memory as best you can. If you do not understand the meaning of a particular word or phrase, feel free to call the researcher (see "When you Finish" below). Also, note the following:

1. The survey is intended to be "**paperless**." The first step is to save this document to your computer (click "save").
2. To take the survey, just click the appropriate box and type "X". Please read each question *carefully*. Mark only *one* answer per question.
3. After you answer all the questions, "save" the document again to record your responses.

When you Finish...

Return the completed survey to us by email (william.d.lawson@ttu.edu). Or, you may fax the completed survey to 806.742.0444. If you have questions, please contact the Research Supervisor, Bill Lawson, by phone at (806)742-3521, or by email.

THANK YOU FOR YOUR HELP WITH THIS RESEARCH!

A. GENERAL

Please describe the general conditions relative to bleeding problems for seal coats/surface treatments in your district.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	-
1. What portion of the roads in your District are surfaced with a seal coat or a surface treatment?	NONE ☐	☐	☐	☐	☐	☐	ALL ☐	DON'T KNOW ☐
2. How common is it for the roads with seal coats/surface treatments in your District to have problems with bleeding?	NEVER HAPPENS ☐	☐	☐	☐	☐	☐	VERY COMMON ☐	DON'T KNOW ☐
3. How extensive (geographic area) across your district is the bleeding problem on roads with seal coats/surface treatments?	FEW AREAS ☐	☐	☐	☐	☐	☐	WIDE-SPREAD ☐	DON'T KNOW ☐
4. When and where bleeding occurs, how severe is the bleeding problem?	NOT A PROBLEM ☐	☐	☐	☐	☐	☐	MAJOR PROBLEM ☐	DON'T KNOW ☐

B. CAUSES OF BLEEDING

Following are some common causes of bleeding. Please identify the extent to which each of the following factors *causes* bleeding on pavements with seal coats/surface treatments in your district.	(1) NOT A PROBLEM	(2)	(3)	(4)	(5)	(6)	(7) MAJOR PROBLEM	DON'T KNOW
5. Loss of aggregate	☐	☐	☐	☐	☐	☐	☐	☐
6. Too much asphalt	☐	☐	☐	☐	☐	☐	☐	☐

Please identify the extent to which of each of the following factors *causes* bleeding on pavements with seal coats/surface treatments in your district.	(1) NOT A PROBLEM	(2)	(3)	(4)	(5)	(6)	(7) MAJOR PROBLEM	DON'T KNOW
7. Excessive delay between application of asphalt and aggregate placement	☐	☐	☐	☐	☐	☐	☐	☐
8. Inadequate curing of seal coat before road is opened to traffic	☐	☐	☐	☐	☐	☐	☐	☐
9. Improper or inadequate rolling of aggregate	☐	☐	☐	☐	☐	☐	☐	☐
10. Water vapor pressure from the base or subgrade (stripping)	☐	☐	☐	☐	☐	☐	☐	☐
11. Improper binder type	☐	☐	☐	☐	☐	☐	☐	☐
12. Poor binder quality	☐	☐	☐	☐	☐	☐	☐	☐
13. Inadequate curing time of patching materials prior to seal coating	☐	☐	☐	☐	☐	☐	☐	☐
14. Pre-existing bleeding of existing pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
15. Climatic conditions (cold/wet) during and immediately after construction	☐	☐	☐	☐	☐	☐	☐	☐
16. Seal coat was constructed outside the seal coat season	☐	☐	☐	☐	☐	☐	☐	☐

C. SOLUTIONS TO BLEEDING (FREQUENCY)

Following are some solutions to the bleeding problem. Please identify the *frequency* with which you use the following solutions in your district.	(1) NEVER	(2)	(3)	(4)	(5)	(6)	(7) VERY OFTEN	DON'T KNOW
17. Apply layer of small size (grade 5) aggregate	☐	☐	☐	☐	☐	☐	☐	☐
18. Apply layer of larger size (grade 3) aggregate	☐	☐	☐	☐	☐	☐	☐	☐
19. Apply blotter material (coarse sand/stone screenings) to blot up excess asphalt	☐	☐	☐	☐	☐	☐	☐	☐
20. Sandwich Seal (apply layer of coarse aggregate directly on the bleeding pavement surface, shoot a layer of asphalt, and then apply a wearing course of smaller rock)	☐	☐	☐	☐	☐	☐	☐	☐
21. Apply very clean, hot aggregate directly to the bleeding pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
22. High pressure water treatment to remove excess asphalt and restore texture (water blaster, water cutter)	☐	☐	☐	☐	☐	☐	☐	☐
23. Apply new seal coat over bleeding pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
24. Remove bleeding pavement surface and replace with new seal coat	☐	☐	☐	☐	☐	☐	☐	☐
25. Apply microsurface (application of a thin layer – or layers – of dense-graded aggregate, polymer-modified asphalt emulsion, water and mineral fillers)	☐	☐	☐	☐	☐	☐	☐	☐
26. Apply slurry seal (application of slow setting emulsified asphalt, well-graded fine aggregate, mineral filler or other additives, and water)	☐	☐	☐	☐	☐	☐	☐	☐
27. Cold milling to remove bleeding asphalt layer, with or without replacement materials	☐	☐	☐	☐	☐	☐	☐	☐
28. Apply lime water to cool and crust over the bleeding pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
29. Apply water to cool the pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
30. Apply a thin asphaltic concrete overlay	☐	☐	☐	☐	☐	☐	☐	☐

D. SOLUTIONS TO BLEEDING (EFFECTIVENESS)

Following are some solutions to the bleeding problem. Please indicate the *effectiveness* of the following solutions (how well it works) for your district.	(1) NOT EFFECTIVE	(2)	(3)	(4)	(5)	(6)	(7) HIGHLY EFFECTIVE	DON'T KNOW
31. Apply layer of small size (grade 5) aggregate	☐	☐	☐	☐	☐	☐	☐	☐
32. Apply layer of larger size (grade 3) aggregate	☐	☐	☐	☐	☐	☐	☐	☐
33. Apply blotter material (coarse sand/stone screenings) to blot up excess asphalt	☐	☐	☐	☐	☐	☐	☐	☐
34. Sandwich Seal (apply layer of coarse aggregate directly on the bleeding pavement surface, shoot a layer of asphalt, and then apply a wearing course of smaller rock)	☐	☐	☐	☐	☐	☐	☐	☐
35. Apply very clean, hot aggregate directly to the bleeding pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
36. High pressure water treatment to remove excess asphalt and restore texture (water blaster, water cutter)	☐	☐	☐	☐	☐	☐	☐	☐
37. Apply new seal coat over bleeding pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
38. Remove bleeding pavement surface and replace with new seal coat	☐	☐	☐	☐	☐	☐	☐	☐
39. Apply microsurface (application of a thin layer – or layers – of dense-graded aggregate, polymer-modified asphalt emulsion, water and mineral fillers)	☐	☐	☐	☐	☐	☐	☐	☐
40. Apply slurry seal (application of slow setting emulsified asphalt, well-graded fine aggregate, mineral filler or other additives, and water)	☐	☐	☐	☐	☐	☐	☐	☐
41. Cold milling to remove bleeding asphalt layer, with or without replacement materials	☐	☐	☐	☐	☐	☐	☐	☐
42. Apply lime water to cool and crust over the pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
43. Apply water to cool the bleeding pavement surface	☐	☐	☐	☐	☐	☐	☐	☐
44. Apply a thin hot mix asphaltic concrete overlay	☐	☐	☐	☐	☐	☐	☐	☐

E. ABOUT YOU

45. Please indicate which of the following best describes your present job function:

- ☐ Maintenance Supervisor/ Assistant Supervisor
- ☐ District Seal Coat Manager
- ☐ Maintenance Administrator
- ☐ Maintenance Engineer
- ☐ Director of Maintenance/ Director of Operations
- ☐ Other (please list): ____________

46. <u>Total</u> years of work experience in building/maintaining roads:

☐ <1 ☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 21-25 ☐ 26-30 ☐ 31-35 ☐ 35+

47. <u>Your District</u>: (type in BOX) [ ]

F. FURTHER INPUT

48. Type any comments/suggestions about this research:

<u>THANK YOU</u> FOR YOUR PARTICIPATION IN THIS SURVEY.

0-5230-1
Appendix B
District Interview Questionnaire

TxDOT Research Project Number 0-5230
Short Term Solutions to Bleeding Asphalt Pavements (BAP)
District Interview Questions

For the purposes of this interview and the subject research project, responses to these questions should be limited to existing asphaltic pavements which consist of surface treatments (ST) on base course or asphaltic concrete pavements (ACP) which have experienced one or more seal coat applications or ST courses over the original pavement.

The focus of this study is on bleeding asphalt pavements. The term *bleeding* is often used interchangeably (by many) with the term *flushing*. In many instances, the "condition" known as flushing is thought of as a precursor to bleeding.

For the purposes of this interview, the questions have been sorted into three basic categories as follows:

- Characterization of the flushing and bleeding problem
- Causes of flushing and bleeding
- Solutions to the flushing and bleeding problem

In instances where one or more of your district's "project team" (interview or site visit attendees) have completed and returned the "Bleeding Asphalt Pavement Screening Survey," we will be sharing the results of your district's screening survey (as applicable) during the interview process.

Characterization of Flushing and Bleeding

1.) How would you describe a bleeding problem; that is, how do you define "bleeding" in your district?

2.) How do you define "flushing" in your district? What is the relationship between a flushed pavement and a bleeding pavement?

3.) What percentage of flushed pavements become bleeding problems?

4.) How do you treat flushing and/or bleeding in terms of a maintenance function code? Are these pavement distresses addressed in TxMAP?

5.) What percentage of the roads in your district is surfaced with a seal coat or a surface treatment?

6.) How common is it for the roads with seal coats or surface treatments in your district to have problems with bleeding?
(1=never happens; 7=very common; 0=don't know)

7.) How extensive (geographic area) across your district is the bleeding problem on roads with seal coats or surface treatments?
(1=few areas; 7=widespread; 0=don't know)

Causes of Flushing and Bleeding

8.) In your opinion, what factors or conditions lead to flushing in your district?

9.) In your opinion, what factors or conditions contribute to bleeding problems in your district?

10.) Have you experienced bleeding with both contract and in-house seal coat programs? Do you experience more problems with contract or in-house seal coats?

11.) Which warm weather binder grades give you the most bleeding problems? Which ones give you the least problems?

12.) Which cool weather binder grades give you the most bleeding problems? Which ones give you the least problems?

Solutions to the Flushing and Bleeding Problem

13.) In your opinion, what condition(s) call for the treatment of a flushing asphalt pavement problem?

14.) In your opinion, what condition(s) call for the treatment of a bleeding asphalt pavement problem? In other words, what would be the "threshold" where immediate treatment would be required versus placing the repair on a maintenance "list of things to do?"

15.) The following are some potential solutions to a flushing or bleeding problem. Please identify the following as it relates to each of these methods:

- Is the solution applicable to a flushing or bleeding problem (or both)?
- How often do you use the following solutions in your district?
- How effective is the particular solution?
- Do you view this as a short term or a long-term solution?
- Provide details of how you actually implement a particular solution.
- Provide relative costs for each solution.

(a) Apply layer of small size (Grade 5) aggregate

(b) Apply layer of larger size (Grade 4) aggregate

(c) Apply blotter material (coarse sand/stone screenings) to blot up excess asphalt

(d) Sandwich Seal (apply layer of coarse aggregate directly on the bleeding pavement surface, shoot a layer of asphalt, and then apply a wearing course of smaller rock)

(e) Apply very clean, hot aggregate directly to the bleeding pavement surface

(f) High pressure water treatment to remove excess asphalt and restore texture (water blaster, water cutter)

(g) Apply new seal coat over bleeding pavement surface

(h) Remove bleeding pavement surface and replace with new seal coat

(i) Apply microsurface (application of a thin layer or layers of dense-graded aggregate, polymer-modified asphalt emulsion, water and mineral fillers)

(j) Apply slurry seal (application of slow setting emulsified asphalt, well-graded fine aggregate, mineral filler or other additives, and water)

(k) Cold milling to remove bleeding asphalt layer, with or without replacement materials

(l) Apply lime water to cool and crust over the bleeding pavement surface

(m) Apply water to cool the pavement surface

(n) Apply a thin asphaltic concrete overlay

16.) Does your district use any other remedies to treat bleeding or flushing pavements other than the ones mentioned above?

17.) Are you aware of any other methods for treating flushing or bleeding asphalt pavements that you would like to try in your district?

18.) OPEN ENDED QUESTION: Any other thing relative to bleeding asphalt pavement solutions that you would like to share with us that you think would help our research?