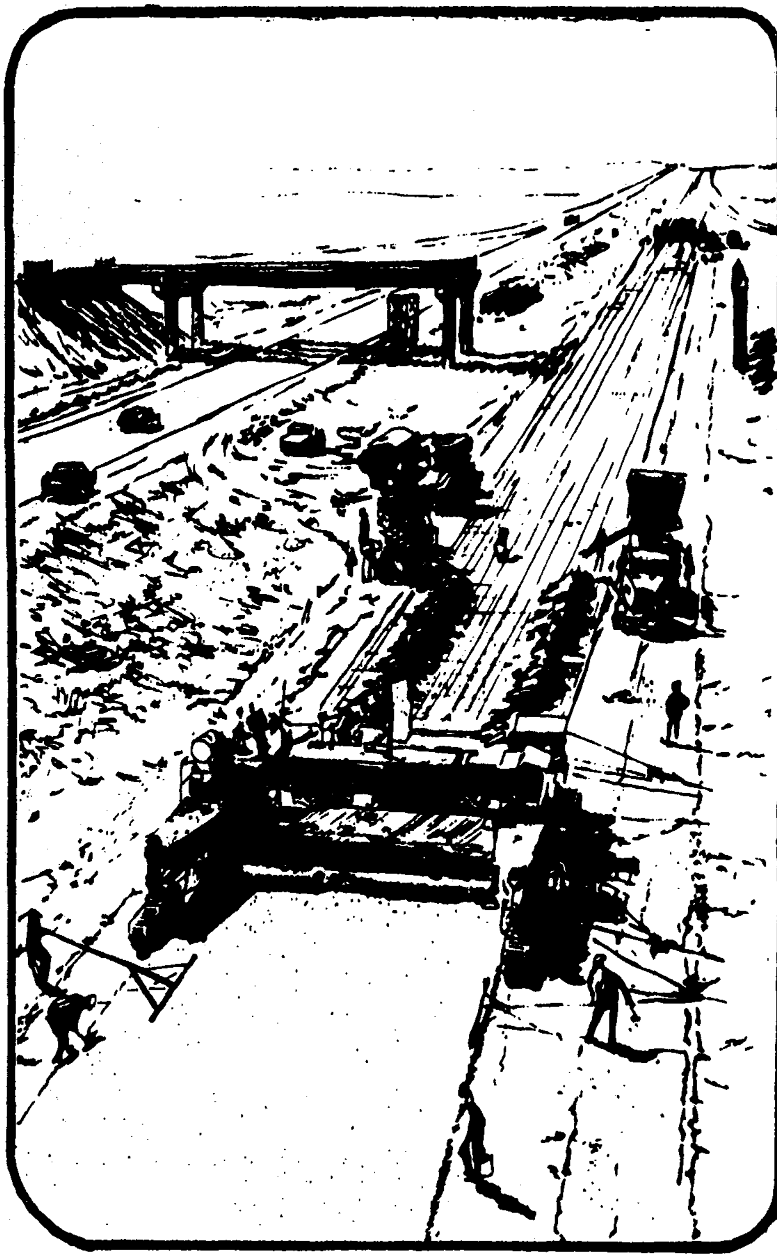
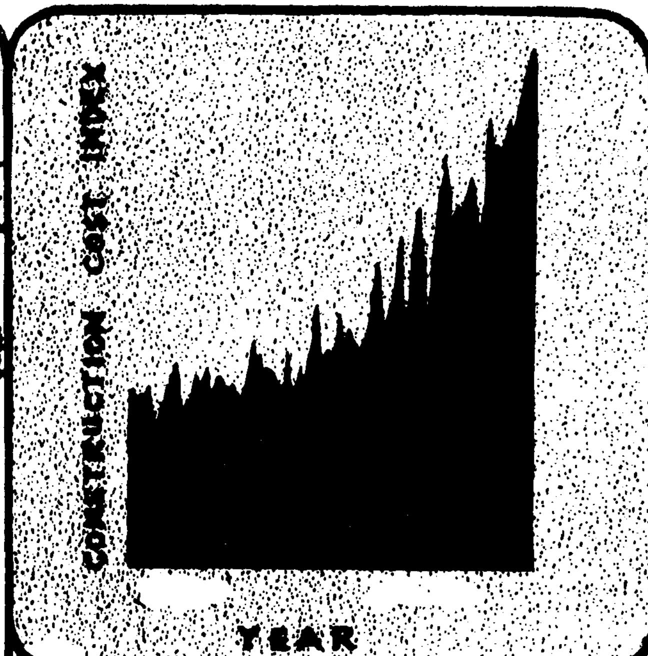
ENGINEERING ECONOMY AND ENERGY CONSIDERATIONS

CORRECTION OF BLEEDING (FLUSHING) SURFACES

RESEARCH REPORT 214-28

JUNE 1981





COOPERATIVE RESEARCH PROJECT
2-9-74-214

"ENGINEERING, ECONOMY AND ENERGY CONSIDERATIONS IN DESIGN, CONSTRUCTION AND MATERIALS"

TEXAS STATE DEPARTMENT
OF HIGHWAYS
AND PUBLIC TRANSPORTATION
AND
TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

TASK FORCE ON ENGINEERING, ECONOMY AND ENERGY CONSIDERATIONS

Larry G. Walker, Task Force Chairman and Materials and Tests Engineer

Charles H. Hughes, Sr., Study Contact Representative and Assistant Materials and Tests Engineer

A.H. Pearson, Jr., Assistant State Engineer-Director

Wayne Henneberger, Bridge Engineer

Robert L. Lewis, Chief Engineer, Highway Design

Byron C. Blaschke, Chief Engineer, Maintenance Operations

J.R. Stone, District Engineer

William V. Ward, Urban Project Engineer-Manager

Phillip L. Wilson, State Planning Engineer

Franklin C. Young, District Engineer

Theodore E. Ziller, Construction Engineer

CORRECTION OF BLEEDING (FLUSHING) SURFACES

by

F. N. FINN AND J. A. EPPS

Research Report 214-28

June 1981

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas

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INTRODUCTION

In the State of Texas the wet weather accident rates are 2 to 3 times higher than the overall highway accident rate (1). It is not suggested that the large increase in wet weather accidents is entirely due to bleeding (flushing) asphalt type pavements or even to low skid numbers as there are many factors which can contribute to this increase; however, low skid numbers must surely be one of those contributors and bleeding pavements do create a condition which results in a low skid number.

The purpose of this report is to discuss the occurrence and consequences of bleeding pavements, methods for correction of bleeding pavements and a procedure for evaluation of corrective alternatives. For purposes of this report, bleeding (or flushing) is the presence of excess asphalt, or a film of asphalt on the pavement surface (2).

The best way to cope with bleeding asphalt pavements is to avoid such possibilities in the beginning; i.e., during design and construction. However, in spite of all that engineers and contractors can do, there will be some pavements which will bleed. In some situations it may be necessary to take a "quick fix" approach which will usually be a short term correction. More permanent corrections are preferred when circumstances permit adequate engineering planning and fiscal programming.

The selection of corrective action will always involve some considerations of money and its availability. In the later sections of this report, procedures for economic evaluation will be proposed. There may be other considerations, e.g. high accident frequency at a particular location, public complaints, and long range plans for rehabilitation to mention a few.

Whatever the basis for the decision to correct a bleeding pavement, some action will often be required even if it is only a local correction expected to perform for a short period. In the following sections background information related to bleeding and corrective procedures will be discussed and guidelines for corrective action will be provided.

OCCURRENCE AND CONSQUENCES OF BLEEDING

Excess surface asphalt can occur on either hot mix asphalt concrete, seal coats or surface treatments. In each case the consequences are the same; a potentially dangerous, slippery-when-wet condition exists.

Asphalt Concrete

The occurrence of bleeding in asphalt concrete is usually attributed to an excess of asphalt in the mix, overcompaction, loss of aggregate, migration of tack coat or under-seal asphalt, or an unusually high temperature susceptible asphalt. In some mixes bleeding can be aggravated by asphalt migration associated with hydrophilic (stripping) aggregates at high temperatures with heavy traffic. It is not within the scope of this report to discuss in detail the cause of bleeding in asphalt concrete since the objective of the report is to define corrective methods. However, it is always desirable to make an effort to diagnose the cause. First, such information may be useful in avoiding similar such conditions in the future, and second, it may be useful in selecting the corrective action to take. With respect to the corrective action, an investigation may indicate that other forms of distress, e. g. rutting, are also present which should be corrected as would dominate in terms of the rehabilitation process required. For example, if bleeding is associated with plastic deformation in the asphalt concrete layer, it is unlikely that a thin overlay will correct the problem. However, if the bleeding is associated with the upper layer only and the pavement does not exhibit plastic deformation a thin overlay may be possible, or removal and replacement of the upper layer may correct the condition. Cores would help determine the causes of the bleeding. If the asphalt concrete has been compacted to a zero void condition, partial removal of the surface layer would only be a temporary solution.

Seal Coats and Surface Treatments

The occurrence of bleeding with chip seals or surface treatments is most commonly associated with: (a) loss of aggregate due to a lack of embedment or (b) too much asphalt for the size and shape of the aggregate. Other contributing causes of bleeding can be many. Some of the more common causes would be; (a) improper match between pavement surface condition, aggregate size and asphalt application rate (design), (b) quality and grading of aggregate, (c) excessive delay between application of asphalt and aggregate, (d) climatic conditions during and immediately after construction, (e) improper match between asphalt type and grade and temperature, or (f) the inability to control traffic speeds immediately after placement. Other contributing causes are discussed in Reference (3). Thus there are many contributing causes for bleeding in seal coats which indicates that the probability that bleeding will occur prematurely is high.

It should be pointed out that seal and surface treatments are, when properly designed and constructed, one of the most cost effective construction and maintenance alternatives available to the highway engineer. Hence, there is no suggestion that the use of seal coats and surface treatments should be discouraged. The message is, "Be sure and do your homework. Be sure that proper attention has been given to asphalt selection, application rates and construction procedures (3)."

Consequences of Bleeding

The consquences of bleeding are a reduction in the wet pavement coefficient of friction and hazardous wet driving conditions. A question arises as to when the pavement is hazardous. Three basic conditions need to be evaluated: (a) the critical levels of skid number (proxy for wet pavements coefficient of friction), (b) the length or area of pavement which is affected by a low skid number and (c) the differential skid number between wheel paths.

There are no legal requirments as regards limiting values of skid number. The critical value is complicated by such factors as (a) transverse slope, (b) length of drainage path, (c) radius of curvature on curves, and (d) special situations such as intersections. Traffic volume, traffic speed as well as urban and rural locales all play a role in evaluating the skid number. Many bleeding pavements will have skid numbers of less than 20 with some as low as 8 or 10. These values are well below desirable minimums.

Polished aggregates can also cause low skid numbers and may be the dominant contributor in most cases. The ability to associate low skid numbers with bleeding or with polishing aggregates can often be accomplished by visual examination.

Bleeding is usually a gradual manifestation or occurrence for both asphalt concrete and seal coats or surface treatments. Bleeding will often initially appear at random spots throughout the length of a project. Two situations are thus created; (a) differential skid numbers between the wheel paths and (b) intermittent variations along the length of a project.

Burns (4) formerly with Arizona DOT, has defined differential friction as a " . . . condition that occurs when the individual wheel paths on which a vehicle rides have different or unequal coefficients of friction". With field trials Burns measured vehicle rotations up to 275° on wet pavements at speeds of 48 mph when the differential skid number was evaluated at 22; i.e. left wheel $SN_{40} = 47$ and right wheel path $SN_{40} = 25$. For the same differential skid number a rotation of 149 occured at a speed of 38 mph. Thus, some concern would be indicated if by visual indications or field measurements there is the possibility of a differential skid condition. Unfortunately, there are no specific criteria to use in interpreting differential measurements althought skid number differences of 10 points or more would be cause for concern.

In maintaining or correcting bleeding pavements it will be important to make full width corrections in a particular lane in order to avoid creating a differential skid condition.

When bleeding is intermittent along the length of a project, it may be expedient to correct only those sections which exhibit bleeding. However, if the pavement is subjected to relatively high traffic volumes, it may be useful to evaluate the entire project to determine if a more general action is appropriate (5). For example, if the sections which are not bleeding, soon will be, it would be worth considering extensive, overall corrective actions.

CORRECTIVE PROCEDURES FOR BLEEDING SURFACES

As indicated in the previous section of this report, the occurrences of bleeding or flushing may be non-uniform over the length of a project or section of roadway. The need to correct localized flushing is a matter of judgement and experience. Information contained in reference (2) will provide some criteria for taking corrective action. Table 1 provides general guidelines for establishing the need for corrective action based on the amount and severity of bleeding (2,5).

Assuming that some type of action is necessary to correct a bleeding condition, the next step is to determine what action should be taken. Table 2 is an attempt to enumerate possible actions; the remaining part of this section of the reprot will be directed to an evaluation of the various alternative actions.

Burning

Burning may be useful for spot treatments where a "quick fix" is necessary prior to more extensive repairs. Weed burners may be used; either had "wands" or trailer mounted unites have been used with some success.

Care must be exercised not to completely char (reduce to carbon) the surface.

Burning is recommended for low traffic volume (Average Daily Traffic per lane) roads only and only when immediate action is required. While the pavement is still warm the surface should be rolled with a rubber tired roller to obtain a traffic seal. The pavement should not be rolled at a temperature which will result in excessive "pick-up" More extensive repairs will be needed within one year of taking this corrective action.

Sanding

This type of treatment has a low probability of success but as a temporary or emergency procedure it may be helpful. The treatment involves applying a coarse sand to the pavement during periods when the surface is at elevated temperatures; i.e. when air temperatures are 85 F or higher. If temperatures are less than 85 F consideration should be given to preheating the aggregate.

A Grade 4 aggregate (6) is preferred, although strict adherence to specification is not necessary. Fine sands are not recommended for this type of treatment.

Additional corrective action will be required if this type of treatment does not work. Careful monitoring of performance will be important in the event additional corrective action is necessary.

Heater-Planer Without Aggregate

Heater-planer without aggregate is a useful alternative for spot treatment where a "quick fix" is necessary prior to more extensive repairs. Conventional heater-planer equipment or combination burner (heater) and grader (blade, and motor patrol) may be used for treatment.

The procedure involves softening of the upper one-half inch of pavement by heat followed by planing to remove the excess asphalt: In effect this activity will expose fresh aggregate surface for improved skid resistance. In most cases bleeding will recur during warm weather in conjunction with traffic.

More extensive repairs will be needed after one year of taking this particular action. The estimated cost of this procedure ranges from $0.15 to $0.50 (7,8) per square yard of treatment.

Sprinkle with Aggregate

Sprinkle with aggregate is a unique application of the heater-planer. The heating units are used as an aid in this corrective maintenance activity. A layer of polish resistant aggregate is spread on the surface with a conventional seal coat spreader and the pavement and aggregate heated. Rolling follows immediately. An alternative is to heat the pavement with a commercial heating unit, spread the selected aggregate with a chip spreader and roll the surface with a steel wheel roller to embed the aggregate into the surface of the bleeding pavement. The procedures will provide a slightly rough surface texture with exposed aggregate. Further information on sprinkle treatments can be found in Report 214-4 entitled, "Sprinkle Treatment - How, Why, and Where" (9).

The estimated service life of this treatment could range from 5 to 8 years depending on traffic volume. The procedure is recommended for urban or rural roads with 5000 ADT (both lanes) or less. The cost of this type of treatment will range from $0.30 to $0.50 per sq. yd. in 1980 dollars.

Seal Coat

Pavements which exhibit flushing or bleeding are difficult to repair with seal coats. The bleeding may migrate through the seal coat unless the asphalt quantity applied to the roadway can be altered in those areas which exhibit bleeding; i.e. wheel path area. Seal coats utilizing a large maximum size aggregate are suggested if seals are to be utilized on bleeding surface. Thus, a Grade 3 or 4 aggregate (6) are recommended. If lightweight aggregates are available the Grade 4 gradation is suggested for use.

The estimated service life for this treatment is 3 to 6 years depending on traffic and the expertise and skill of personnel assigned to the task. The procedure is not recommended for roadways with more than 5000 ADT (both lanes). The cost of this type of treatment will range from $0.45 to $0.60 per sq. yd. in 1980 dollars.

Thin Hot Mix Asphalt Concrete Overlay

Assuming there are no other deficiences a thin (1 inch) asphalt concrete overlay will correct a bleeding pavement condition. It is possible in extreme cases that the bleeding will eventually migrate through the overlay; however, it should provide satisfactory service for 3 to 10 years after which other forms of distress may be of dominant concern.

Before placing a thin overlay on any pavement, and particularly a surface treatment, it is recommended that a structural analysis (nondestructive deflection testing) be made to determine if such a treatment is appropriate. Surface treatments can tolerate higher deflections than can asphalt concrete, and hence, in correcting one problem it is possible to create another unless proper precautions are taken.

The estimated life of a thin asphalt concrete overlay under average conditions is 7 years and the cost will range from $2.00 to $2.50 per sq. yd. in 1980 dollars.

Heater Scarification without New Materials

This procedure is an extension of the burning and planing treatment. The pavement is heated, scarified and subjected to various construction procedures. For example, after scarification the surface may be leveled and compacted with pneumatic tired rollers or it may be leveled, treated with a light application of binder (asphalt emulsion) or rejuvenator, and then compacted.

The estimated service life for this treatment is 2 to 3 years depending on traffic. The procedure is not recommended for roadways with more than 2000 ADT in both lanes. The cost of this type treatment will range from $0.25 to $0.80 per sq. yd. in 1980 dollars.

Heater Scarification with New Materials

This procedure will increase the service life of the treatment by the addition of new materials. New materials can include a sprinkle treatment, seal coat, slurry seal or new asphalt concrete. The procedure involves heating and scarifying, with the addition of a binder or modifier plus new material. Depending on the treatment, compaction may take place before or after the addition of new materials.

The following tabulation summarizes the appropriate uses of new materials in conjunction with heater scarification.

Type of Material or surfacing	Traffic Requirements, ADT	Service Life, yrs.	Cost Range, per sq.yd.
Sprinkle	< 5000	5-8	$0.30 - $0.80
Seal Coat	< 5000	3-6	$0.70 - $1.25
AC (50 lb/yd^2)	unlimited	8-12	$0.80 - $1.50

It should be noted that the use of heater scarification may also contribute to some improvement in ride quality if a screeding requirement is specified. Also, a reduction in the rate of crack reflection may occur if additional asphalt concrete is incorporated with heater-scarification (7).

Open Graded Friction Course

Open graded friction course overlays are very effective for correcting a bleeding condition. This type of treatment provides surface drainage and high friction for extended periods if polish resistant aggregates are used. Numerous studies have shown this type of hot mix asphalt concrete grading will have equivalent or better skid resistant properties than regular dense graded mixes. Gradation requirements for open graded mixes are provided in reference (10) published by The Asphalt Institute.

Procedures for the design (asphalt requirement) and construction of open graded mixes are available in the literature. In general, the mix is less "forgiving" than dense graded mixes and thus close attention to construction procedures is crucial. Maintenance of open graded mixes can be accomplished with regular dense graded patching materials although the appearance leaves something to be desired. Multiple seal coats to replace open graded mixes is also possible as a remedy for ravelled open graded mixes. The expected service life of an open graded asphalt concrete is 10 to 12 years and the cost ranges from $1.00 to $1.50 per sq. yd.

Cold Milling with or without New Material

Cold milling is a form of surface recycling which removes the upper one inch (approximately) of asphalt concrete and will at the same time improve the longitudinal profile.

If no new material is added, the finished surface will be somewhat rough textured and will provide a ride similar to a seal coat with 5/8 inch aggregate. The service life of such a treatment will depend on the condition of the remaining asphalt concrete. If the air voids are low (less than 2 percent) and the mix is essentially saturated with asphalt, the bleeding will recur within 1 or 2 years, depending on traffic. The cost of cold milling is $0.35 to $1.20 per sq. yd.

New materials; i.e. dense graded asphalt concrete, may be added to provide a new riding surface with an expected service life of 10 to 12 years. If the new material is limited to 200 lbs per sq. yd., the cost will range from $2.00 to $3.00 per sq. yd.

Summary

The corrective procedures described above have proven to be the most successful in solving pavement bleeding problems. Other methods have been recommended and have proven to be successful under certain conditions (11,12). The engineer is encouraged to monitor the performance of the various techniques utilized and report the findings for use by others.

EVALUATION OF ALTERNATIVE TREATMENTS

Three factors should be considered in selecting from among alternate treatments: (1) annual cost over analysis period, ( ) reliability of treatment and (3) energy requirements. Examples of alternate analysis are given in Tables 3 and 4 herein.

The procedures used for evaluation are explained in Report 214-20 (13). Briefly, the procedure to be followed will involve the following steps:

(1) Enumerate the alternative methods of correction considered appropriate for correction of the bleeding pavement; this may vary as a function of the type of surface to be treated, traffic and environment (see Table 3).

(2) Estimate cost, energy and probability of success associated with each method of correction. Table 3 contains values for each of these items for flushed seal coat. Exact values may be revised for specific projects and should be based on local experience.

(3) Estimate sequential activities for maintenance and rehabilitation associated with each method of correction and estimate cost and energy requirements. Table 4 through 7 illustrate this procedure for four methods of correction.

(4) Select from amoung the various methods that method which has the least life cycle cost. If two methods have comparable cost, select the method with the least energy requirement and/or greatest chance of success.

(5) The chance of success should be considered when comparing cost of various alternatives. For example, if the method is estimated to have a 40 percent chance of success, a cost penalty should be assigned to such a procedure. Thus, one approach will be to increase the estimated cost by 60 percent; i.e., 1.6 times initial cost, in order to compare with other methods with a higher chance of success.

The information contained in Tables 3 to 9 is for a specific project in East Texas with an average daily traffic of 600 vehicles per lane. The possible alternatives have been considered on a first cost and "first" energy requirment basis as well as estimated chances of success in Table 3. The anticipated life cycle cost of alternatives 1 to 4 has been evaluated in Tables 4 to 7 with the results tabulated in Table 8. Tables 3 and 8 should be used by the district staff to select the appropriate rehabilitation alternative.

A second example of the use of the technique to evaluate rehabilitation alternatives is shown in Tables 9 and 10. The analysis was performed for an interstate highway in West Texas that had excessive or free asphalt on approximately 40 to 50 percent of its surface area. Six alternatives were evaluated as summarized in Table 9. Anticipated initial and life cycle cost for each alternative are shown in Table 10. These data were transferred to tables such as those shown in Tables 4 to 7 and life cycle costs calculated. A summary of these calculations is shown in Table 9. Energy requirements were not calculated.

The data presented on Tables 9 and 10 were used by the district to select rehabilitation alternative 1 (open graded friction course) (14).

SUMMARY

Excessive asphalt on a pavement surface can cause a dangerous condition during wet weather. This report describes a number of alternative treatments which can be used to correct such conditions.

Procedures for evaluating different methods of correction are also provided which include cost, energy requirements and chance of success associated with the treatment.

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9. Epps, J. A., and Hughes, C. H. Sr., "Sprinkle Treatment - How, Why and Where", Research Report 214-4 Texas Transportation Institute, December, 1975.

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TABLE 1. Guidelines for Establishing Need for Corrective Action Related to Bleeding Pavements

Area of Bleeding %	Severity of Bleeding (2)		
	Slight	Moderate	Severe
1-15	No	No	Yes
16-30	No	Yes	Yes
>30	No	Yes	Yes

(1) Definitions of Severity

Slight - initiation or start of bleeding, coarse aggregate above surface of asphalt

Moderate - coarse aggregate and asphalt nearly at same plane; but coarse aggregate readily visible, looks slick in appearance.

Severe - black appearing surface, few aggregate particles visible, slick in appearance.

Note: In all probability the skid number associated with severe bleeding would be unacceptable (less than 20) and for moderate bleeding would be marginal or unacceptable depending on the polishing characteristics of the aggregate.

Table 2. Recommended Corrective Action for Bleeding Pavements.

Relative Service Life	Type of Construction: Surface Treatment	Seal Coat	Hot Mix Asphalt Concrete
Short ↑			Burning Heater-planer without aggregate
	Sprinkle with aggregate (hot or cold)	Sprinkle with aggregate (hot or cold)	Sprinkle with aggregate (hot)
	Seal Coat	Seal Coat	Seal Coat
	Thin HMAC overlay*	Thin HMAC overlay*	Thin HMAC overlay*
			Heater scarification with or without new surfacing
			Surface milling (hot or cold) with or without new surfacing
↓ Long	Thin HMAC overlay*	Thin HMAC overlay* Open graded HMAC overlay	Open graded HMAC overlay

*Only after completing an engineering evaluation.

TABLE 3. FACTORS TO BE CONSIDERED IN EVALUATION OF METHODS OF CORRECTION OF FLUSHED SEAL COATS IN EAST TEXAS.

Method of Correction	*Change of Success	Initial Cost $/SQ YD	Initial Energy BTU/SQ YD
Asphalt Concrete Overlay - 1.25" HMAC	90	2.25	35,000
Sanding or Fine Aggregate	20	0.10	2,000
Aggregate or Chip Seal	40	0.40	2,000
Open Graded Friction Course	90	1.20	20,000
Sprinkle Treatment + Heating	50	0.50	14,000
Heater Scarification + Aggregate	60	0.65	16,000
Cold Milling	80	0.80	2,000
Milling + Overlay - 1.25 inches	95	3.05	37,000

*For 6 Year Life

TABLE 4. Estimates of Cost and Energy Requirements for HMAC Overlay of Flushed Seal Coat

FLUSHED SEAL COAT

Year	Present Worth Factor 8% INT.	Alternate No. 1	90% Chance of Success		
		Rehab & Maint Action	Cost	P.W.	BTU's
0	1.0000	1.25" HMAC Overlay	2.25	2.250	35,000
1	.9259				
2	.8573				
3	.7938				
4	.7350	RM - Pot Hole Patch	0.03	0.022	500
5	.6806	RM - Blade On	0.04	0.027	1,500
6	.6302	RM - Blade On	0.08	0.050	3,000
7	.5835	Seal Coat GR 4	0.40	0.233	2,000
8	.5403				
9	.5002	RM - Pot Hole Patch	0.03	0.015	500
10	.4637	RM - Blade On	0.04	0.019	1,500
11	.4289	RM - Blade On	0.08	0.034	3,000
12	.3971	RM - Blade On	0.12	0.048	4,500
13	.3677	2" HMAC Overlay	3.25	1.195	56,000
14	.3405				
15	.3152				
16	.2919				
17	.2703	RM - Pot Hole Patch	0.03	0.008	500
18	.2502	RM - Blade On	0.04	0.010	1,500
19	.2317	RM - Blade On	0.08	0.019	3,000
20	.2145	Seal Coat GR 4	0.40	0.086	2,000
			6.87	4.016	114,500

TABLE 5. Estimates of Cost and Energy Requirements for Sanding of Flushed Seal Coat

FLUSHED SEAL COAT

Year	Present Worth Factor 8% INT.	Alternate No. 2 — Rehab & Maint Action	20% Chance of Success — Cost	P.W.	BTU's
0	1.0000	Blot With Aggr	0.10	0.100	2,000
1	.9259	Blot With Aggr	0.05	0.046	1,000
2	.8573	Blot With Aggr	0.05	0.043	1,000
3	.7938	RM - Blade On	0.08	0.064	3,000
4	.7350	RM - Blade On	0.12	0.088	4,500
5	.6806	2" HMAC Overlay	3.25	2.212	56,000
6	.6302				
7	.5835				
8	.5403				
9	.5002	RM - Pot Hole Patch	0.03	0.015	500
10	.4637	RM - Blade On	0.04	0,019	1,500
11	.4289	RM = Blade On	0.08	0.034	3,000
12	.3971	Seal Coat GR 4	0.40	0.159	2,000
13	.3677				
14	.3405				
15	.3152	RM - Pot Hole Patch	0.03	0.009	500
16	.2919	RM - Blade On	0.04	0.012	1,500
17	.2703	RM - Blade On	0.08	0.022	3,000
18	.2502	RM - Blade On	0.12	0.030	4,500
19	.2317	1.5" HMAC Overlay	2.70	0.626	42,000
20	.2145				
			7.17	3.479	126,000

TABLE 6. Estimates of Cost and Energy Requirements for Seal Coat of Flushed Seal Coat

FLUSHED SEAL COAT

Year	Present Worth Factor 8%	Alternate No. 3 — Rehab & Maint Action	40% Chance of Success — Cost	P.W.	Btu's
0	1.0000	Seal Coat GR 3	0.40	0.400	2,000
1	.9259				
2	.8573				
3	.7938				
4	.7350	RM - Pot Hole Patch	0.03	0.022	500
5	.6806	RM - Blade On	0.08	0.054	3,000
6	.6302	RM - Blade On	0.08	0.050	3,000
7	.5835	1.5" HMAC Overlay	2.70	1.575	42,000
8	.5403				
9	.5002				
10	.4637				
11	.4289	RM - Pot Hole Patch	0.03	0.013	500
12	.3971	RM - Blade On	0.08	0,032	3,000
13	.3677	RM - Blade On	0.08	0.029	3,000
14	.3405	Seal Coat GR 4	0.40	0.136	2,000
15	.3152				
16	.2919				
17	.2703	RM - Pot Hole Patch	0.03	0.008	500
18	.2502	RM - Blade On	0.08	0.020	3,000
19	.2317	RM - Blade On	0.08	0.019	3,000
20	.2145	1.5" HMAC Overlay	2.70	0.579	42,000
			6.77	2.937	107,500

TABLE 7. Estimates of Cost and Energy Requirements for Open Graded HMAC of Flushed Seal Coat

FLUSHED SEAL COAT

Year	Present Worth Factor 8% INT.	Alternate No. 4	90% Chance of Success		
		Rehab & Maint Action	Cost	P.W.	BTU's
0	1.0000	Open GR Frict CRSE	1.20	1.200	20,000
1	.9259				
2	.8573				
3	.7938				
4	.7350	RM - Pot Hole Patch	0.01	0.007	200
5	.6806	RM - Pot Hole Patch	0.01	0.007	200
6	.6302	RM - Pot Hole Patch	0.02	0.013	400
7	.5835	RM - Pot Hole Patch	0.02	0.012	400
8	.5403	RM - Pot Hole Patch	0.03	0.016	500
9	.5002	Seal Coat GR 3	0.60	0.300	2,000
10	.4637				
11	.4289				
12	.3971	RM - Blade On	0.04	0.016	1,500
13	.3677	RM - Blade On	0.08	0.029	3,000
14	.3405	2" HMAC Overlay	3.25	1.107	56,000
15	.3152				
16	.2919				
17	.2703				
18	.2502	RM - Pot Hole Patch	0.03	0.008	500
19	.2317	RM - Blade On	0.08	0.019	3,000
20	.2145	Seal Coat GR 4	0.04	0.086	2,000
			5.77	2.820	69,700

Table 8. Summary of Rehabilitation Alternatives for a Flushed Seal Coat in East Texas.

Rehabilitation Alternative	First Cost*	"First" Energy Required Btu's sq.yd.	Present Worth Over 20 Years		Uniform Annual Cost over 20 Years		Energy Required Over a 20 Year Period, Btu's Per sq. yd.	Changes of Success
			0**	8	0	8		
Asphalt Concrete Overlay-1.25 in.	2.25	35,000	6.87	4.016	0.344	0.201	114,500	90
Sanding	0.10	2,000	7.17	3,479	0.359	0.174	126,000	20
Chip Seal Coat	0.40	2,000	6.77	2.937	0.339	0.147	107,500	40
Open Graded Friction Course	1.20	20,000	5.77	2.820	0.289	0.141	69,700	90

*Cost in dollars per square yard
**Interest rate, rate of return

Table 9. Anticipated Rehabilitation and Maintenance Cost per square yard for West Texas Project.

	ALTERNATIVE					
Year initial cost	1 0.80 OGFC	2 1.80 2"AC	3 0.35 SC	4 1.60 SMH"AC	5 1.50 HSH"AC	6 0.45 HS
1.						
2.				0.05		
3.		0.05 RM	1.80 2"AC			0.05 RM
4.	0.05 RM			0.12	0.05 CM	1.80 2"AC
5.		0.12 RM			0.10 RM	
6.	0.12 RM			0.12	1.80 2"AC	
7.		0.12	0.05 RM	0.12		0.05 RMR
8.	0.12 RM			1.80 2"AC		
9.		0.12 RM	0.12 RM		0.05 RM	0.12 RMR
10.	1.80 2"AC	1.35 1.5"AC				
11.			0.12 RM	0.05	0.15 RM	0.12 RMR
12.						
13.	0.05 RM	0.05 RM	0.12 RM	0.12	0.12 RM	0.12 RMR
14.			0.12 RM			0.12 RMR
15.	0.12 RM	0.12 RM	1.35 1.5"AC	0.12	0.12 RM	0.12 RMR
16.					0.12 RM	1.80 2"AC
17.	0.12 RM	0.12 RM		0.12	0.12 RM	
18.	0.12 RM	0.12 RM	0.05	0.12	1.35 1.5"AC	
19.	0.12 RM	0.12 RM		0.12		0.05 RMR
20.	0.12 RM	0.12 RM	0.12	1.35 1.5"AC	0.05 Rm	

OGFC - Open Graded Friction Course

AC - Asphalt Concrete

SC - Chip Seal Coat

RM - Routine Maintenance

HS - Heater - Scarification

SM - Surface Milling

HP - Heater - Planer and Aggregate

Table 10. Summary of Rehabilitation Alternatives for a Bleeding Asphalt Concrete in West Texas.

Rehabilitation Alternative	First Cost*	Present Worth Over 20 Yrs		Uniform Annual Cost Over 20 yrs		Chance of Success
		0**	8*	0	8	
1. Open graded Friction course with overlays and maintenance	0.80	3.54	1.98	0.36	0.20	90
2. Two inch asphalt with overlays and routine maintenance	1.80	4.21	2.85	0.43	0.29	80
3. Seal coat with overlays and routine maintenance	0.33	4.20	2.47	0.43	0.25	50
4. Surface milling and 1 inch asphalt concrete overlay with overlays and routine maintenance	1.60	5.81	3.33	0.59	0.34	80

Table 10. (continued)

5. Heater-scarification and 1 inch asphalt concrete and routine maintenance	1.50	5.50	3.31	0.56	0.34	70
6. Sprinkle aggregate, heat aggregate and roadway and roll with overlays and routine maintenance	0.45	4.80	2.61	0.49	0.27	60

*Costs in dollars per square yard
**Interest rate of return