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PERFORMANCE OF BLACK BASE PAVEMENTS IN TEXAS

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The Performance of black base and flexible base pavements in five of the Texas Highway Department's twenty-five is discussed in both general terms and by comparing performance based on road roughness measurements and by the utilization of a formal roadway maintenance evaluation system. Traffic load associated cracking is nearly non-existent on the fifty-four black base pavement sections surveyed in the climatic extremes of Texas. The amount of transverse and longitudinal cracking which often form a "large block" cracking pattern typical of the West Texas area can be reduced by the use of black bases rather than the conventional flexible base pavements. Swelling clay problems have not, however, been solved by the use of black base.

The recent escalation in the price of bituminous treated materials has increased the necessity to explore the use of other binder and aggregate systems than those conventionally utilized in black base. The types of materials utilized for black bases in Texas are discussed together with their thicknesses.

INTRODUCTION

The shortage of high quality aggregate together with increased traffic have created a need for treating local materials for use as base courses. Asphalt has become a common base stabilizer in the last eight years; however, the criteria developed for materials selection and design, and construction techniques have been based mainly on requirements developed for asphalt concrete surface courses. For these reasons and due to the recent increase in the cost of bituminous stabilized materials, it has become particularly important that the design, construction and performance of asphalt stabilized materials be investigated to determine the adequacy of this form of stabilization.

A somewhat indirect method to study the adequacy of bituminous stabilized materials is to study their field performance. The performance of materials stabilized with asphalt cement in Texas is reviewed in this paper. The types of materials stabilized are first discussed, followed by the types of distress noted on these materials and finally the performance of bituminous stabilized materials as compared to flexible bases is analyzed.

BITUMINOUS STABILIZATION IN TEXAS

Asphalt cements, cutback asphalts and emulsified asphalts are used for bituminous stabilization in Texas. A recent trend toward the use of asphalt cement in central plant operations is however very evident in Texas and appears to be following the national trend (1). The stabilized material produced by the use of asphalt cement in a graded aggregate is commonly called "black base" in Texas.

Black bases prior to about 1969 were commonly specified by the use of the larger maximum sized gradations used for hot mixed asphalt concrete courses with Hveem stability requirements to be not less than 30 and aggregates with a plasticity index not greater than 6 (Table 1). In 1970 a specification was prepared for plant mixed asphalt stabilized base. The specification is presently in common use and the gradations are shown in Table 1. As noted by these specifications, a rather wide range of gradations are acceptable. The Hveem stability requirement was not retained in the 1970 specifications and the plasticity index was established at 15 maximum with a

liquid limit of 40 maximum. Hveem stability tests are, however, commonly specified by the engineer and are often set at 30. The asphalt content is most often determined by compression testing at various rates of speed on gyratory compacted 6-inch diameter by 8-inch high samples (Test Method Tex-126-E) (2).

The types of aggregates used for black bases in Texas include crushed limestone, crushed caliche, crushed and uncrushed gravels in the western part of Texas while crushed and uncrushed gravels, iron ore gravel and some crushed limestone have been used in the eastern part of Texas. Asphalt absorption and a resulting brittle mix in some soft limestone and caliche materials have been noted. Gravels of various types have also exhibited some stripping problems particularly when used under continuously reinforced concrete pavements.

Typical thickness of the black bases of the pavements surveyed are shown in Table 2. Five to six inches of black base with one to one and one-half inches of asphalt concrete surfacing are usual thicknesses utilized on the State and United States designated highways. Some Interstate highways have up to 13 inches of black base. Fifty-four black base pavements have been surveyed in five Texas Highway Department Districts together with thirty-five flexible base pavements in two Texas Highway Department Districts. The typical flexible base pavements surveyed contained about 12 inches of a crushed limestone, caliche or gravel base and from one and one-half to 3 inches of asphalt concrete as a surfacing material.

Texas Highway Department Districts 5 and 25 with district offices in Lubbock and Childress were selected to represent colder, drier climates experienced in Texas while District 13, 15 and 17 with district offices in Yoakum, San Antonio and Bryan were selected to represent the wet, warmer Texas climate. General environmental conditions for these districts are shown in Table 3.

PERFORMANCE

Performance of black base pavements were discussed with concerned district personnel, and visual evaluations and road roughness measurements were made on each section. These results are presented below.

General Observations

District 5 - Seventeen black base projects constructed in the last 2 to 6 years were examined in this district located in the Great Plains of West Texas. Two of these projects showed evidence of traffic load associated cracking in the form of discontinuous alligator cracks in the wheel path. One project has shown evidence of developing a transverse cracking pattern that is typical of West Texas flexible base pavements. Some meandering longitudinal cracks of limited length, believed to be associated with subgrade movement, are evident on a few projects. A longitudinal continuous crack in the center of the travel lane believed to be associated with segregation during the laydown operation was visible on two projects. All other projects appeared to be in excellent condition except for very minor rutting and limited surface associated flushing.

Fifteen flexible base pavements constructed from 5 to 8 years ago were visually examined. Eleven of the projects had a transverse cracking pattern evident. Three of the projects had 6 or more transverse cracks per station. Other types of distress included minor amounts of rutting and surface flushing with flushing being the most common.

District 5 personnel are well pleased with the performance of their black base pavements primarily due to the prevention of the formation of the transverse cracks which often progress to the large block or slab cracking. Additionally, little traffic load associated cracking is evident in their black base projects to date.

District 25 - District 25 is adjacent to District 5 but is located just off of the "cap rock" which forms the boundary between the Great Plains and the Coastal Plains. Fifteen black base projects constructed in the last two to eleven years were examined in this district. None of these pavements showed direct evidence of traffic load associated cracking; however, nine of the fifteen projects showed a transverse and/or large block cracking pattern. Figure 1 shows the black base pavement which contained the greatest amount of this type of cracking. This cracking pattern is very typical of that which occurs on flexible base pavement in the West Texas area. Flushing was evident on six of the projects.

Table 1. Typical black base gradations.

Sieve Size	Accumulative Percent by Weight Retained					
	Asphalt Concrete		Plant Mix Asphalt Stabilized Base			
	Type A	Type B	Grade 1	Grade 2	Grade 3	Grade 4
2 inch	0					
1 3/4 inch	0-5			0	0	
1 1/2 inch			0	0-10		As
1 inch		0	0-10			shown
7/8 inch	15-45	0-5				on
3/8 inch	30-65	20-55	30-55			plans
No. 4	40-80	30-78	45-70	45-75	60-85	
No. 10	65-80	60-75				
No. 40	62-95	52-94	70-85	60-85		
No. 80	76-98	72-97				
No. 200	92-100	92-100				

Table 2. Typical thicknesses of black bases.

District No.	Thickness, Inches			Average Daily Traffic	Number of Sections Surveyed	Comments
	Black Base	Asphalt Concrete	Other Base & Subbase			
5	3.4-5.5	1.5	12	3,000-10,000	17	Many black base sections are four-lane divided.
13	5.0	1.0	12	1,500- 6,400	6	
15	13.25	1.75	9-12	8,000-13,000	3	IH-10
	7-9.5	1.50	4-6	3,000- 5,500	4	IH-35
17	4-6	1.0	11-14	2,000- 3,500	9	
25				600- 4,000	15	

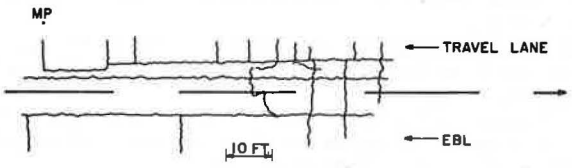
Table 3. General environmental conditions of surveyed districts.

District No.	Mean Annual Total Precipitation, Inches	Mean Annual Temperature, °F	Mean Length of Warm Season,* Days	Mean Average Air Freeze-Thaw Cycles	Physiographic Provinces of the United States
5	18	60	210	85	Great Plains
13	38	70	280	20	Coastal Plains
15	28	69	275	25	Coastal Plains
17	38	68	275	25	Coastal Plains
25	24	63	220	75	Central Lowlands

(after references 3,4)

* Number of days between the mean dates of last 32°F freeze in Spring and first 32°F freeze in Fall.

Figure 1. Typical West Texas cracking pattern.



Twenty flexible base pavements constructed from two to seventeen years ago were examined in this district. Eleven of these pavements showed evidence of a transverse cracking pattern. Four to twelve transverse cracks per station were, in general, evident on their projects. Flushing of the surface layer was evident on four projects.

District 25 personnel are well pleased with the performance of their black base pavement primarily due to reduced maintenance cost and better overall performance. It should be noted that five of the ten black base pavements contained an appreciable amount of transverse cracking while seven of the eleven flexible base pavements contained an appreciable amount of transverse cracking. None of the black base pavements in District 5 contained appreciable transverse cracking.

District 13 - Six black base projects constructed in the last two to five years were examined in this district located on the lower Coastal Plains. One of these projects had a very limited amount of transverse cracking (about one crack per station). A second project showed some evidence of longitudinal cracking of the type associated with subgrade movement. All other projects were in excellent condition.

No flexible base pavements were examined as a part of this survey; however, randomly selected pavement sites have been selected and examined throughout the state as part of a maintenance evaluation project (5). The survey of flexible base pavements in the eastern part of Texas indicates that the type of pavement distress is normally alligator and rutting rather than the longitudinal or transverse cracking pattern evident in the western part of Texas.

District 13 personnel are pleased with the performance of their gravel black base pavements as no traffic load associated cracking is evident and materials normally unsuitable for base courses can be treated with asphalt and successfully used.

District 15 - Seven black base projects constructed in the last one to six years were examined in this district located on the Coastal Plains. All sections were located on Interstate highways and no evidence of traffic load associated cracking was evident. Swelling clays have presented problems, however, on three of the projects.

District 15 personnel are pleased with the performance of their black base pavements as heaving of the roadway sections, while being common to both flexible and black base pavements, can be more easily repaired by use of a heater-planer on the black base sections. Repair of the undulations associated with swelling clays (which may be in excess of one foot in this area) can be accomplished with the heater-planer on black base sections, as a substantial thickness of bituminous material can be "shaved off" without intersecting a granular material, upon which traffic cannot operate for an extended period. The use of black bases, as can be expected, does not prevent swell associated with high plasticity index clay subgrades.

District 17 - Nine black base projects constructed in the last one to seven years were examined in this district located on the lower Coastal Plains. None of the sections evaluated showed signs of wheel load associated cracking. Longitudinal cracking associated with subgrade soil movement was evident on three projects. It is not uncommon to see grass growing in these longitudinal cracks that are not in the direct traffic stream.

Some stabilized subgrades are commonly used in this district. Reflection cracking from these lime stabilized subgrades which contain 3 to 4 percent lime are not evident. However, five black base sections contained a lime stabilized (2 percent lime) crushed sandstone placed immediately below the black base exhibit a longitudinal and transverse cracking pattern.

Surface treatments placed directly on black base shoulders have experienced some "shelling" mainly due to insufficient asphalt. This is particularly true when hot sand asphalt bases are utilized.

Black bases have become very popular for use under continuous reinforced portland cement concrete pavements. Pumping of these segments of pavements has been observed, particularly where black base shoulders exist.

District 17 personnel have noted problems when black bases are placed on swelling clays. These problems are also associated with flexible base pavements placed on swelling clays. Some stripping has also been noted where black bases containing certain types of aggregates are placed in wet environments subjected to heavy traffic loads.

Roughness and Pavement Rating Scores

The general observations on pavement performance noted above were based on conversations with Texas Highway Department personnel and field observations. In an attempt to quantify these field observations the Mays Ride Meter and a Maintenance Evaluation System were utilized (5).

The Mays Ride Meter measures the vertical displacement between the axle and body of a car and this can be related to a Serviceability Index. The concept of Serviceability Index was developed at the AASHO road test and is used to represent the riding quality of the road on a scale from 5 to 0 with 5 considered to be very good and 0 very poor. Average Serviceability Index values for Texas highways as measured by the Mays Ride Meter are 3.3 for Interstate highways and 3.0 for the Farm-to-Market road system.

Serviceability Index for black base and flexible base pavements in District 5 and 25 as a function of traffic volume can be obtained from Figures 2 and 3. Serviceability Index versus age for pavements in District 5 are shown in Figure 4. In general, the black base pavements surveyed in these districts have better riding qualities than the average heavily traveled highways in Texas. It should also be noted that the black base projects have a somewhat better ride than the flexible base pavements.

Serviceability Index values for black base pavements in Districts 13 and 15 as a function of traffic are shown in Figure 5 and as a function of age on Figure 6. These also exhibit better than average riding quality. Serviceability Index values for District 17 ranged from 3.5 to 4.5 with an average value of 3.9.

Pavement Rating Score

The pavement rating score is obtained by use of a rating form and its associated scoring system as described in reference 5. Pavement distress including rutting, raveling, flushing, corrugations, alligator cracking, longitudinal cracking, transverse cracking and patching are noted on this form, as to their extent and severity. Average pavement rating score for Texas highways as determined in a 1973 random sample scoring is 73. Scores for District 5 as a function of age and traffic are shown on Figures 7 and 8, respectively. From these limited data it appears as if the black base pavements are performing better than the flexible base pavements. Pavement rating scores for Districts 13 and 15 black base pavements as a function of traffic are shown in Figure 9. Better than average scores were obtained for these districts as well as for District 17.

While being an indication of the performance of a pavement as determined from the surface of the roadway, the pavement rating score may not be a particularly good indicator of the performance. These data do, however, suggest that better than average performance of black base pavements has existed to date.

Detailed information of the performance and the types of materials used in the pavements evaluated in this study can be obtained from reference 6.

OTHER CONSIDERATIONS

As previously noted the performance of black base pavements has been favorable. Thus the Texas Highway Department engineers in many areas of the state are interested in using this type of pavement section provided they can be economically justified. The price increases noted in the last 18 months has changed such that the (based on initial construction costs) flexible bases are more economical. For example, a review of cost information in 1972 indicates that the price of asphalt concrete was in the range of 6 to 8 dollars per ton, black base 5 to 7 dollars per ton and good quality flexible bases 3.50 to 5.50 per ton. These figures indicate that black bases were acceptable economic substitutes for flexible bases provided one inch of black base could replace from one and one-half inch to two inches of flexible base as is commonly practiced (7).

Recent price information indicates that asphalt concrete is typically 18 to 20 dollars per ton, black base 16 to 18 dollars per ton and flexible base materials 4 to 7 dollars per ton. Thus, the economic advantage of black bases on a first cost basis has been lost. Examples of the price escalations experienced in Texas from May 1973 to May 1974 are shown in Figure 10. These tremendous price increases, although they have slowed in the last few months and may have peaked in December 1974, have rein-

Figure 2. Relationship between serviceability index and traffic volume, District 5.

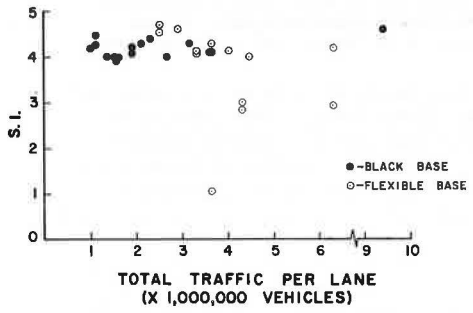


Figure 3. Relationship between serviceability index and traffic volume, District 25.

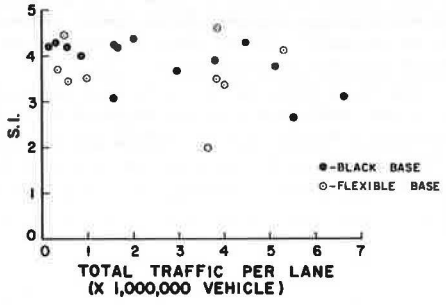


Figure 4. Relationship between serviceability index and pavement age, District 5.

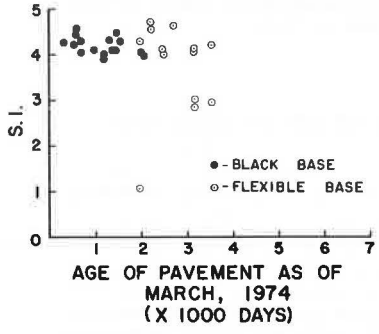


Figure 5. Relationship between serviceability index and traffic volume, Districts 13 and 15.

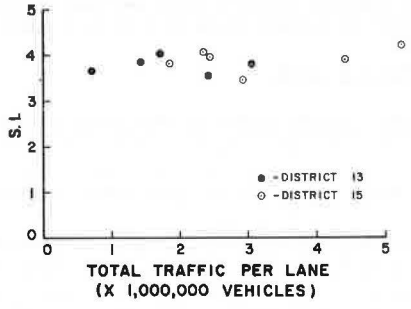


Figure 6. Relationship between serviceability index and traffic volume, Districts 13 and 15.

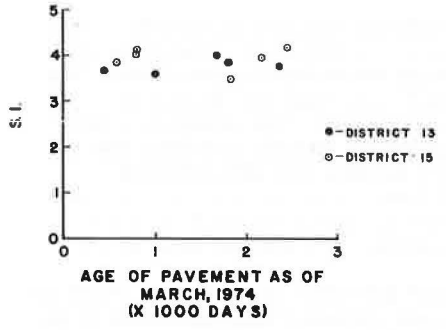


Figure 7. Relationship between pavement rating score and pavement age, District 5.

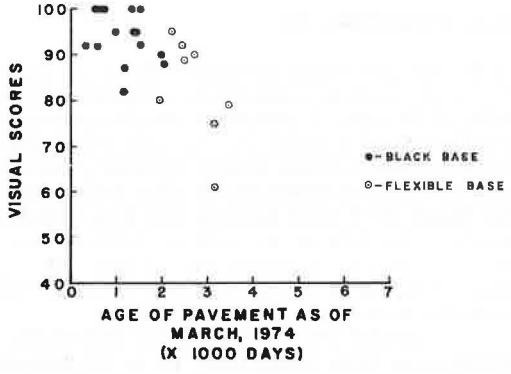


Figure 8. Relationship between pavement rating score and traffic volume, District 5.

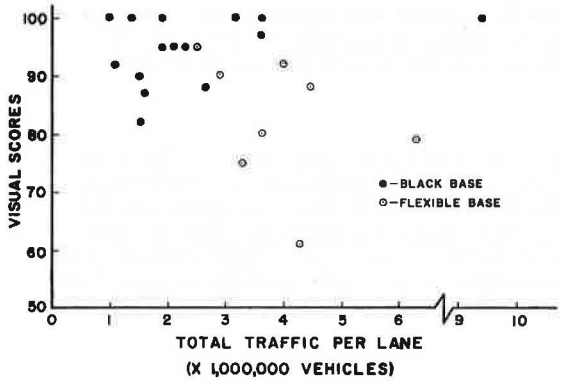


Figure 9. Relationship between pavement rating score and traffic volume, Districts 13 and 15.

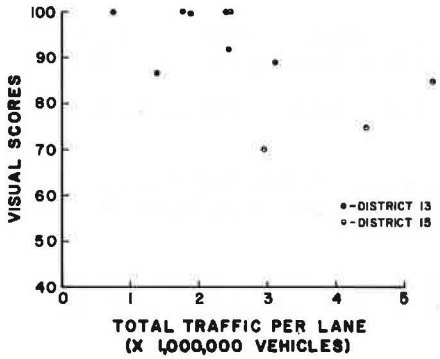
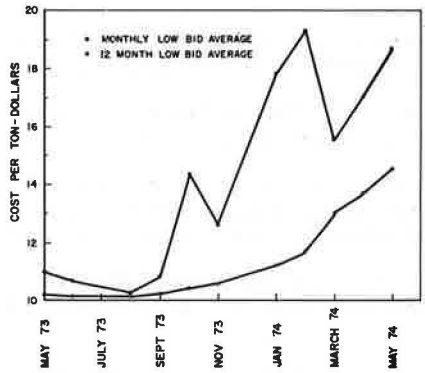


Figure 10. Asphalt stabilized and flexible base price information.



forced efforts to produce more economical asphalt treated bases.

From a review of the component cost of hot mix, it appears as if significant savings can be effected by reducing materials cost by some 50 percent, if the total cost of hot mix production can be attributed to asphalt and aggregates. Substitute binders such as sulphur-asphalt and the use of marginal aggregates are areas requiring further study if the price of black base is to be significantly reduced.

SUMMARY

The performance of black base pavements based on ten years experience in Texas is favorable. Only minor amounts of traffic load associated distress has been noted. The "block" cracking pattern typical of West Texas flexible base pavements can be reduced by the use of black base pavements. The effect of swelling clays on pavement roughness cannot be solved by the use of black bases. Reflection cracking from lime treated subbases can be expected to propagate through the asphalt treated base and asphalt surface course. As several district representatives have said, "We like black bases".

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PERFORMANCE OF COARSE AGGREGATE, HOT SAND AND ASPHALTIC CONCRETE BASES IN OKLAHOMA

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During the late 1940's and early 1950's Oklahoma experienced considerable success with road mix sand asphalt bases. This success encouraged the trial and subsequent use of hot mix sand asphalt bases with the advent of the interstate system. This paper depicts the experience in Oklahoma of not only the sand asphalt bases but also the coarse aggregate and asphaltic concrete bases which have been in service since the late 1950's.

This is not intended as a formal paper but rather as a dissertation on the experience in Oklahoma of the various type bituminous bases.