

MICHIGAN DEPARTMENT OF TRANSPORTATION
M•DOT
EVALUATION OF LIME, FLY ASH
BASE COURSE MIXTURES
Final Report



MATERIALS and TECHNOLOGY DIVISION

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EVALUATION OF LIME, FLY ASH
BASE COURSE MIXTURES
Final Report**

V. T. Barnhart

**An Experimental Project by the Michigan
Department of Transportation in Cooperation
with the U. S. Department of Transportation
Federal Highway Administration**

**Research Laboratory Section
Materials and Technology Division
Research Project 84 D-47
(Work Plan No. 93)
Research Report No. R-1310**

**Michigan Transportation Commission
Barton LaBelle, Chairman;
Charles Yob, Vice-Chairman;
William C. Marshall, Hannes Meyers, Jr.,
Irving Rubin, Richard White
Patrick Nowak, Director
Lansing, June 1991**

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ACTION PLAN

1. Materials and Technology Division

A. The Research Laboratory Section will terminate this research project (84 D-47) via a memo to the project file along with distribution of this report to the Design Division and the districts.

2. Engineering Operations Committee

A. No action necessary upon approval of this report.

SUMMARY

This project was initiated in 1984 to evaluate the use of bituminous and aggregate mixtures containing fly ash, when used in the construction of highway shoulder bases. The fly ash-extended (FAE) bituminous base course and the lime/fly ash/aggregate (LFA, a pozzolanic, weakly cementitious material) base course mixtures were placed on a shoulder reconstruction and resurfacing project on M 29 in St. Clair County in June and July of 1986.

Based on the results of this evaluation, there were no observed differences in the field performance of the bituminous and aggregate mixtures containing fly ash, and the conventional bituminous base course placed as a control section. Michigan's climate makes the construction scheduling of the LFA base difficult due to the necessity of the material to cure at summer temperatures prior to the onset of winter. From the results of laboratory investigation, the fly ash-extended bituminous base course was found to be more susceptible to moisture damage than the conventional bituminous base course.

INTRODUCTION

This research was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration and in conjunction with the Civil Engineering Department at the University of Michigan, and the Michigan Ash Sales Co.

The concept of using an aggregate mixture containing fly ash for highway shoulders was evaluated in 1959 (Research Project 59 E-18) by the Department and the results of the evaluation were not favorable (1, 2, 3, 4). The mixture was placed late in the year, and the final report (4) recommended that should the material be evaluated again, it should be placed only during the summer months so it could cure at least one month at elevated temperatures before being subjected to the effects of winter.

PROCEDURE

Test sections of two different types of fly ash material were placed as shoulder base on part of the shoulder reconstruction and resurfacing project (Control Section 77051, Job Number 24173A) on M 29 in St. Clair County (Fig. 1). The first material placed was a fly ash-extended (FAE) bituminous base course and the second material placed was a lime/fly ash/aggregate (LFA) base course. These base courses were placed in June and July of 1986, respectively. Two shoulder sections using a conventional bituminous base course (Bituminous Base Mix No. 500, 20C) were placed as control sections.

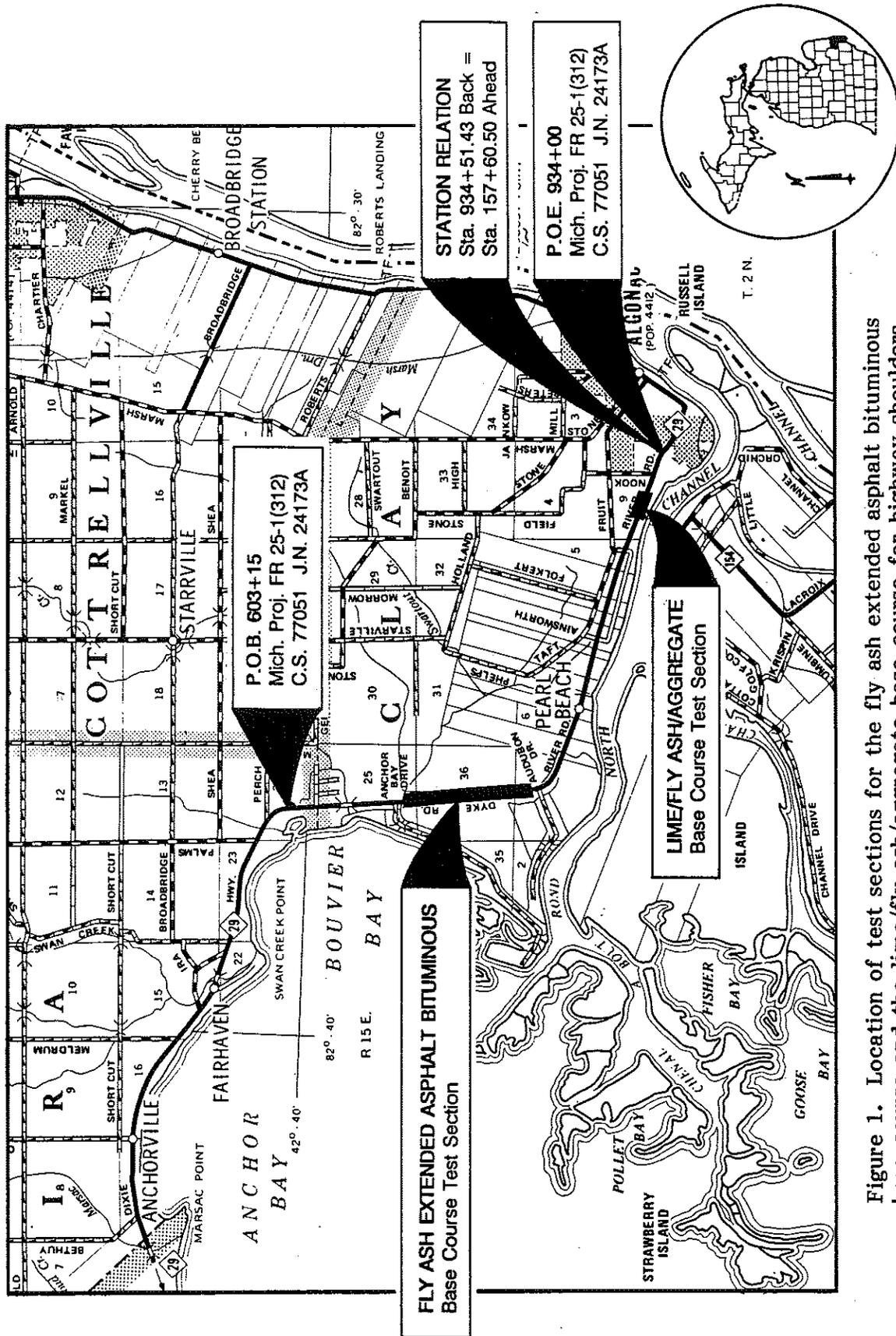


Figure 1. Location of test sections for the fly ash extended asphalt bituminous base course and the lime/fly ash/aggregate base course for highway shoulders.

The test section for the FAE bituminous base course was further subdivided into three subsections, each consisting of a different percent by weight of asphalt in the mix and percent of fly ash added, to reduce the amount of asphalt in the mix (Table 1). The test section layout, including the two control sections, is shown in Figure 2. The typical design cross-section for the test and control sections is shown in Figure 3.

TABLE 1
PERCENT BY WEIGHT OF ASPHALT IN, AND
FLY ASH ADDED TO, THE MIX IN EACH
SUBSECTION OF THE FAE TEST SECTION

Subsection Number	Asphalt in Mix by Weight, percent	Fly Ash Added by Weight, percent
1	3.6	2.1
2	3.4	2.6
3	3.1	3.1

Visual inspections were made in 1987 and 1990 to evaluate the performance of the FAE bituminous and LFA base courses. The inspections noted and recorded the following distress features:

- 1) Amount of cracking present in the shoulder
- 2) Amount of rutting present in the shoulder
- 3) Presence of any heaving or shear failures

The construction of the FAE bituminous base course and the LFA base course is covered in Research Report No. R-1281.

Inspection Results (1987 and 1990)

There were transverse cracks in the shoulder material in the control and test sections. There were five cracks in both of the control sections; six cracks in subsections one and three, and nine cracks in subsection two of the FAE bituminous base course; and nine cracks in the LFA base course. All of the cracks were open 1/8 to 1/4 inch. The cracking was sympathy cracking caused by cracks in the adjoining pavement, except for cracking at Station 707+69 which was caused by a culvert under the shoulder and pavement. However, not all of the cracks in the adjoining pavement had caused sympathy cracking in the shoulder.

There was no rutting, no heaving or shear failure noted in the shoulders in any of the sections.

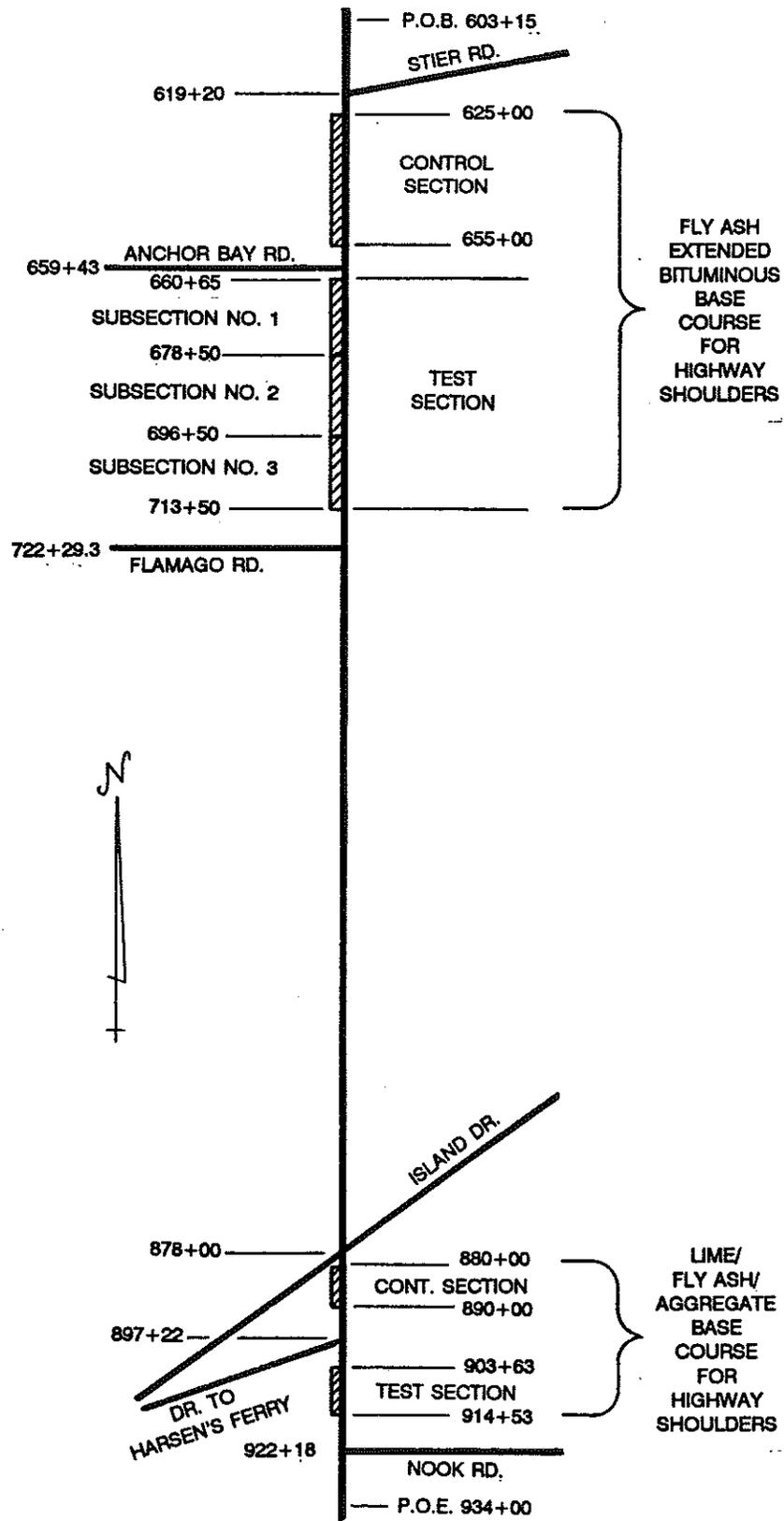
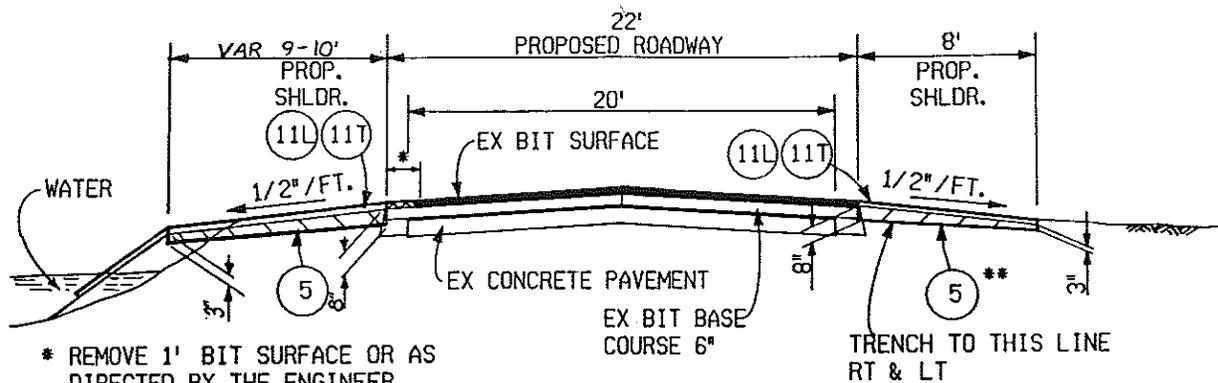


Figure 2. Experimental fly ash material test and control sections.

TABLE 2
CHARACTERISTICS OF FLY ASH-EXTENDED AND CONVENTIONAL
BITUMINOUS BASE FOR BITUMINOUS SHOULDERS

Sample Identification	Date Tested	Average Density, lb/cu ft	Average Wet or Dry Indirect Tensile Strength	Retained Strength Ratio [INTSwet/INTSdry]
Control As Constructed	06/27/86	146		
Control Wet Accelerated Conditioned	02/06/87	157	146	0.89
Control Unconditioned			165	
Subsection 1 As Constructed	06/25/86 & 06/26/86	141		
Subsection 1 Wet Accelerated Conditioned	02/11/87 & 02/12/87	142	133	0.69
Subsection 1 Unconditioned			193	
Subsection 2 As Constructed	06/26/86	142		
Subsection 2 Wet Accelerated Conditioned	02/19/87	143	113	0.67
Subsection 2 Unconditioned			168	
Subsection 3 As Constructed	06/26/86	142		
Subsection 3 Wet Accelerated Conditioned	02/25/87	143	88	0.55
Subsection 3 Unconditioned			162	

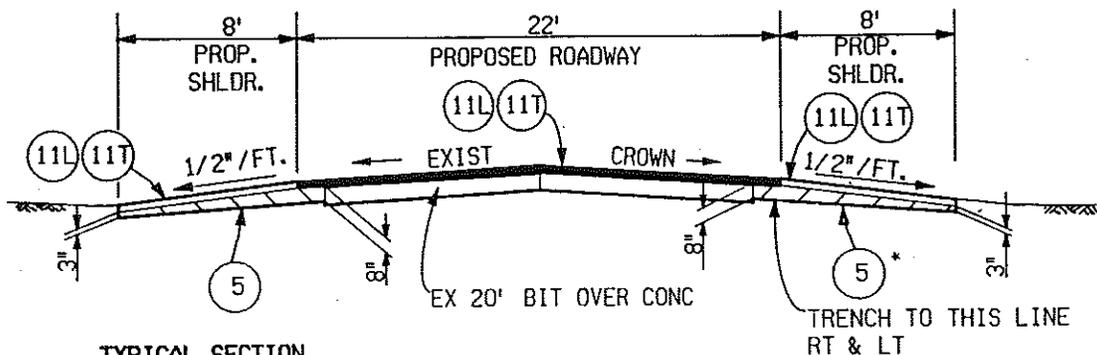


* REMOVE 1" BIT SURFACE OR AS DIRECTED BY THE ENGINEER (TYP BOTH SIDES)

** SEE PLAN SHEETS AND SPECIAL PROVISIONS FOR EXPERIMENTAL SHOULDER BASE STA 664+00 TO STA 716+00 BIT BASE COURSE SPECIAL

TYPICAL SECTION TO APPLY

STA. 646+00 TO STA. 719+00 (LOOKING SOUTH)
STA. 740+30 TO STA. 780+00 (END OF EX 22' PAV' T.) (LOOKING SE & E)



TYPICAL SECTION TO APPLY

STA. 780+00± TO STA. 798+00±
STA. 876+00± TO STA. 894+00±
STA. 904+00± TO STA. 934+00±

* SEE PLAN SHEETS AND SPECIAL PROVISIONS FOR EXPERIMENTAL SHOULDER BASE STA 904+00± TO STA 934+00± POZZOLANIC MIXTURE

BITUMINOUS APPLICATION TABLE - AWI = 310

ITEM	RATE OF APPLICATION	ESTIMATED THICKNESS	ASPHALT PENETRATION
11L BITUMINOUS MIX NO 1100L, 20AA	130*/SYD	1 1/4"	120-150
11T BITUMINOUS MIX NO 1100T, 20AA	120*/SYD	1"	120-150
5 BITUMINOUS BASE MIX NO 500, 20C	110*/INCH OF THICKNESS/SYD		120-150



TYPICAL CROSS-SECTIONS

DATE	SCALE	CONT. SECT.	JOB NO.	DESIGN UNIT	SHEET NO.
4/ 5/85	1" =	77051	24173A	J. KALMBACH	504 4

Figure 3. Typical cross-sections.

Two failures, areas where depressions occurred in the shoulder, were noted in the LFA base course test section. They appear to have been caused by subgrade soil problems, rather than a failure of the LFA material.

Laboratory Testing

At the time of construction, samples for laboratory testing were taken from the conventional bituminous base course, each of the subsections of the FAE bituminous base course, and LFA base course. Laboratory test samples were prepared from each type of material and the density (unit weight) was determined (Tables 2 and 3).

Unconditioned (dry) and accelerated wet-conditioned samples from the conventional bituminous base and from all three FAE bituminous base subsections, were tested for tensile strength. The results are summarized in Table 2.

The LFA base was tested for compressive strength and the results are summarized in Table 3.

**TABLE 3
CHARACTERISTICS OF AGGREGATE/LIME/FLY ASH (POZZOLONIC)
BASE COURSE FOR BITUMINOUS SHOULDERS**

Sample Identification	Date Tested	Average Moisture, Percent	Average Density, lb/cu ft	Average Compressive Strength, psi
As Constructed	07/15/86	6.9	122	NM
904+00 A	08/06/86	11.9	118	339
904+00 B				
911+00 B				
906+00 A	09/12/86	12.9	118	555
906+00 B				
908+00 A	10/08/86	12.7	118	478
908+00 B				
911+00 A	11/19/86	12.7	120	1901

Sample No. 904+00 B broke while handling for compressive strength testing.
*NM - Not Measured

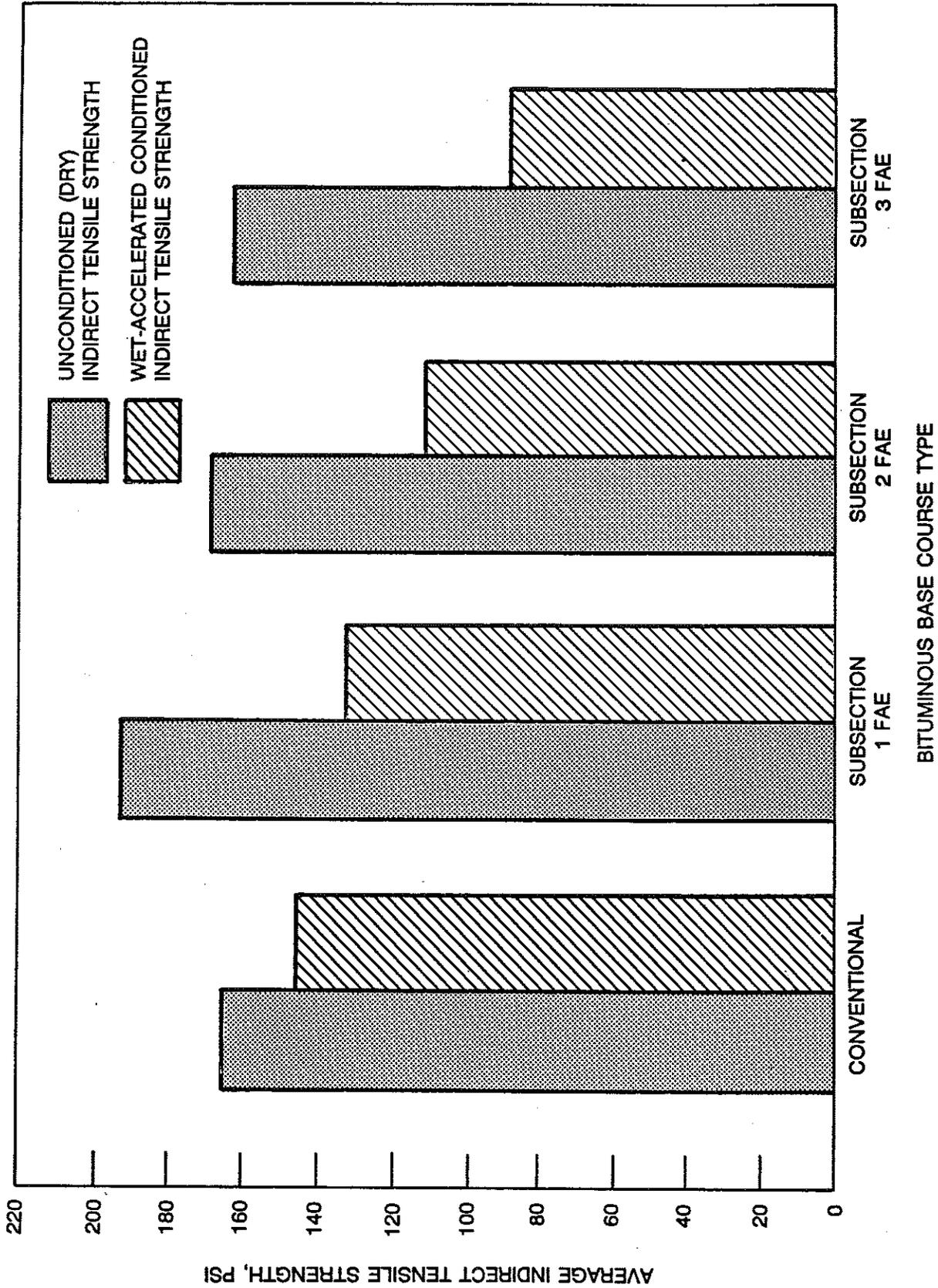


Figure 4. Unconditioned (dry) and wet accelerated conditioned indirect tensile strength.

Results

Figure 4 shows that for the unconditioned (dry) samples, the indirect tensile strength is about the same for the conventional bituminous base and the FAE bituminous base materials. It shows that for the accelerated wet-conditioned samples, the indirect tensile strength loss is less for the conventional bituminous base course than for the FAE bituminous base course.

Figure 5 shows that the retained strength ratio of the accelerated wet-conditioned indirect tensile strength to the unconditioned (dry) tensile strength was 0.89 for the conventional bituminous base course and 0.69, 0.67 and 0.55 for subsections 1, 2, and 3 of the FAE bituminous base course, respectively. Thus, using the criteria established for NCHRP Project 4-8 (3) in NCHRP Reports 192 and 246, the FAE bituminous base course is more susceptible to moisture damage (i.e., stripping) than the conventional base course.

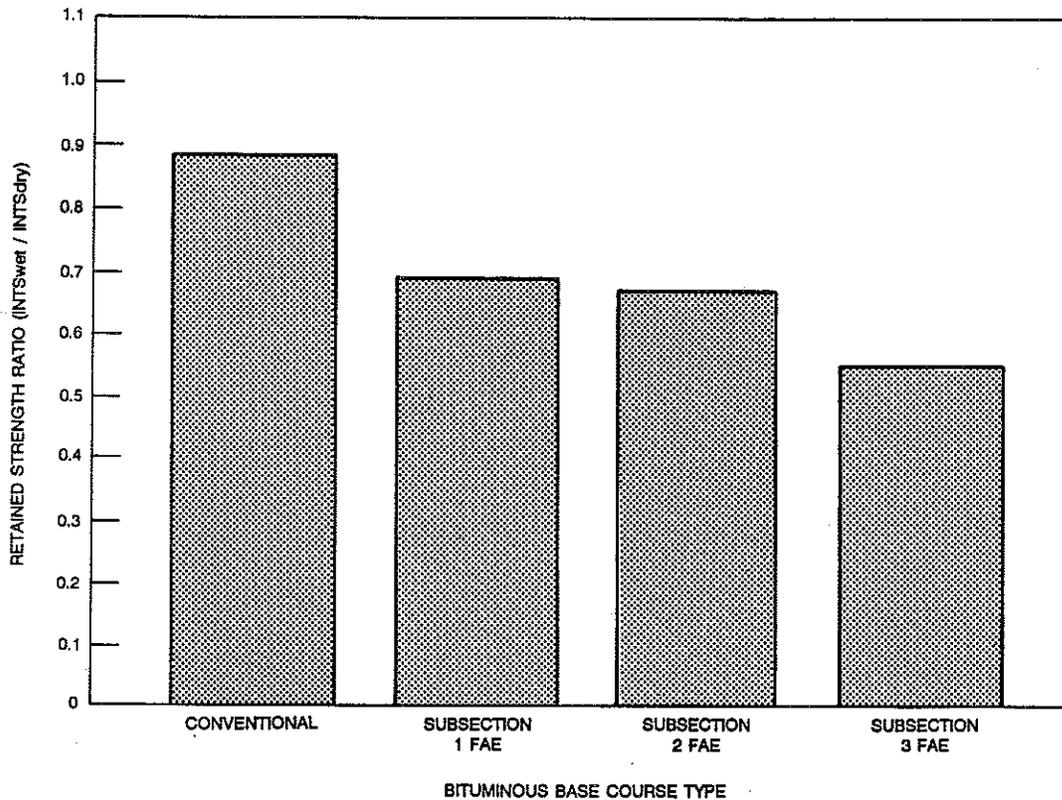


Figure 5. Comparison of retained strength ratios.

Figure 6 shows that in general, as the LFA base course increases in age, the compressive strength of the material also increases.

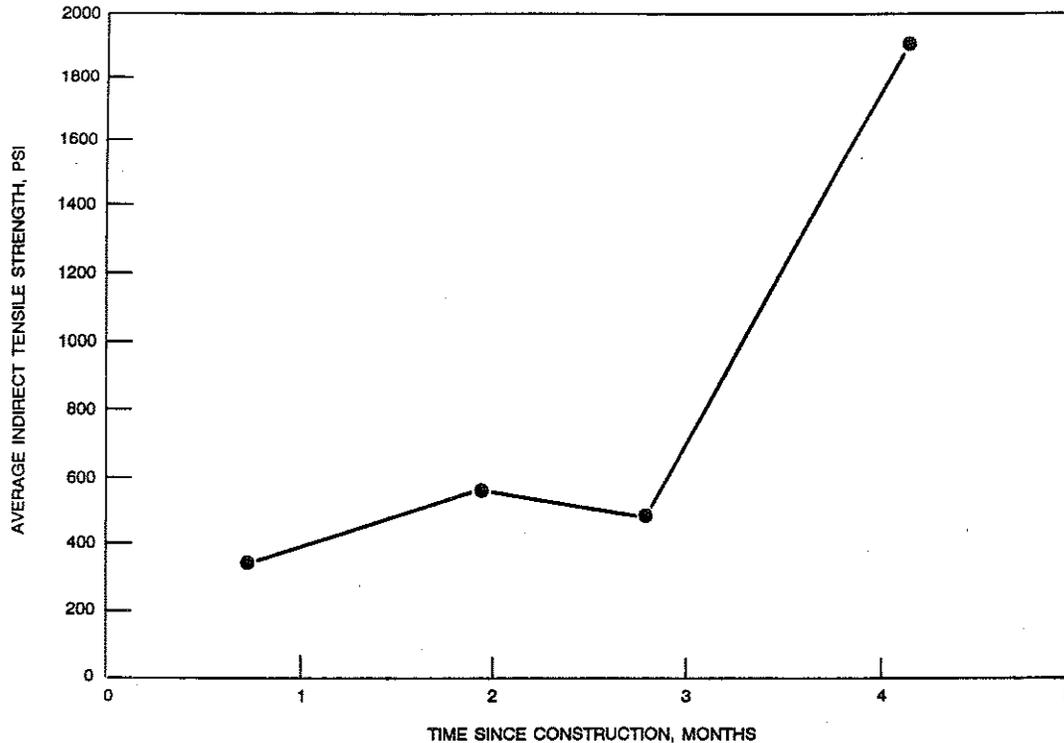


Figure 6. Compressive strength of the lime/fly ash/aggregate (pozzolonic) base course for highway shoulders since the time of construction.

CONCLUSIONS AND RECOMMENDATIONS

While there was little difference in the observed performance of the LFA base course and the conventional bituminous base course, the cost to place the LFA base course (from Research Report No. R-1281) was \$1.00/ton more than the cost of the conventional bituminous base course. Thus, since there is no appreciable difference in performance no conclusion as to the cost effectiveness of the LFA base course is possible at this time. However, Michigan's climate makes the construction scheduling of the LFA base difficult due to the necessity of this material to cure at summer-like temperatures prior to the onset of the first winter (4).

The field investigation indicated that there was little difference in the performance of the FAE bituminous base course sections and the conventional bituminous base course. The cost of placing the FAE bituminous base (from Research Report No. R-1281) was \$4.00/ton more than the cost to place the conventional bituminous base course. Thus, the FAE bituminous base course would have to perform significantly better than the conventional base course to be cost effective. Also, from laboratory investigations, the retained strength ratio indicates that the FAE bituminous base course is more susceptible to moisture damage (i.e., stripping) than the conventional base course. Therefore, it seems very

unlikely that the needed additional life for attaining cost effectiveness would be achieved.

While additional time will be required to make the final determination, present results are not encouraging for either experimental treatment, and they are not recommended for further use.

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