Report No. CDOT-DTD-R-92-3

GILSONITE, AN ASPHALT MODIFIER

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4201 East Arkansas Avenue
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Final Report
March 1992

Prepared in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views of the Colorado Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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16. Abstract

Over the last several years Colorado asphalt pavements have experienced early deterioration and premature pavement failures. This study evaluated the product, Gilsonite. Gilsonite is a naturally occurring solid hydrocarbon and is currently being marketed as a asphalt modifier. Gilsonite is a modifier which is intended to increase the stability of the pavement and help resist rutting often found on today's pavements.

Conclusion

Following the 3-year evaluation, the data indicates the addition of Gilsonite, although it does appear to reduce or retard rutting, tends to harden the pavement creating a pavement structure which is more susceptible to premature cracking. The cracks appeared at a much faster rate and the cracks tended to deteriorate quicker and to a greater extent in the Gilsonite section.

17. Key Words	18. Distribution Statement
Gilsonite, asphalt modifier, rutting, asphalt additive,	No Restrictions: This report is available to the public through, the National Information Service, Springfield, Virginia 22161

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I. INTRODUCTION

Over the last several years Colorado asphalt pavements have experienced early deterioration and premature pavement failures. Many factors have been identified which contributed to these early failures and steps to improve or prevent future failures have been initiated. Rutting in asphalt pavement is one distress that is a major concern. Rutting, both the quantity and severity have increased over the years. Methods to increase the stability of the design mix without sacrificing any of the positive characteristics have been tried.

This research study evaluated the product Gilsonite. Gilsonite is a naturally occurring solid hydrocarbon and is currently being marketed as an asphalt modifier. Gilsonite is mined in the Uintah Basin of eastern Utah approximately 45 miles southeast of Vernal. This is the only known location where commercial deposits of Gilsonite can be found.

Gilsonite is a modifier, which is intended to increase the stability of the pavement and help resist rutting often found on today's pavements.

II. OBJECTIVE

The objective of this study was to evaluate the effect the Gilsonite additive had on the rut resistant performance of the pavement when compared to the standard mix using AC-10. Appendix A contains the specification for the standard mix as well as the mix containing the Gilsonite. Also included in this Appendix is some information about Gilsonite furnished by the supplier.

III. CONSTRUCTION

Project CX 08-0050-10 located on State Highway 50 in Mesa County begins at M.P. 32.57 (the south end of the Colorado River Bridge) and extends south to M.P. 34.19 (B 1/2 Road). The location of this project is shown in figure 1.

The majority of the project consisted of 1-1/4" of HBP Grading E and a 3/4" Type B Plant Mixed Seal coat (PMSC) as the surface coat. A 600-foot control section, using this pavement design was selected to compare to the Gilsonite test section. The 600-foot control section is located in the southbound driving lane just south of Palmer Street.

The 600-foot test section containing the Gilsonite modifier was placed at the Unweep intersection. This section consisted of a 2" lift of HBP Grading E containing the Gilsonite additive in lieu of the 1-1/4" HBP and the 3/4" PMSC section.

This location for the test section was selected by the district because of the increased rutting in this area. Rutting was more pronounced due to increased shoving caused by the traffic at the intersection. In 1987, the average daily traffic through the intersection was 23,000 vehicles

with 6% trucks. Site maps showing the location and layout of the test and controls sections are shown in figure 2 and figure 3.

Although the pre-construction rutting measured in the intersection of the test section was more severe, the overall average of rutting in the control section was slightly higher than the average rutting in the test section. This made the evaluation of the test and control sections comparable.

The pre-construction evaluation revealed that the existing pavement was alligator cracked in both wheel paths. This was intermittent throughout the project. The cracking pattern of the test and control section was fairly uniform and considered comparable.

Prior to paving the cracks were cleaned and filled with a scrap rubber crack filler. In the test and control section this was the only preparation of the existing pavement surface before paving began.

Paving began on April 15, 1988. The plant was located 15 minutes away from the project site and was capable of producing 200+ tons per hour. The mix left the plant at 290^{o}F and was placed at 270^{o}F. No modification was made to the mixing or placing temperature for the Gilsonite additive. Throughout the construction of the Gilsonite section two representatives from American Gilsonite Company were on site to monitor construction.

In the test section the plans called for 5.4% AC, which was to include 0.4% Gilsonite. The supplier was responsible for controlling the addition of the Gilsonite modifier material. Because of the small quantity involved a representative of The American Gilsonite Company added the Gilsonite to the mix by hand. Test results indicated the total AC content to be 5.9%, therefore reducing the overall effective percentage of Gilsonite in the mix.

With the higher % AC and a lower effective % of Gilsonite it would have been expected to find rutting in the Gilsonite section and see very little cracking. As noted in the conclusions of this report, this was not the case.

There were no problems with laydown operations during construction on the Gilsonite section. Construction personnel indicated they did not notice any difference in workability of the mix with Gilsonite as compared to the mix without the additive.

Construction photographs are located in Appendix B.

FIGURE 1

PROJECT LOCATION MAP

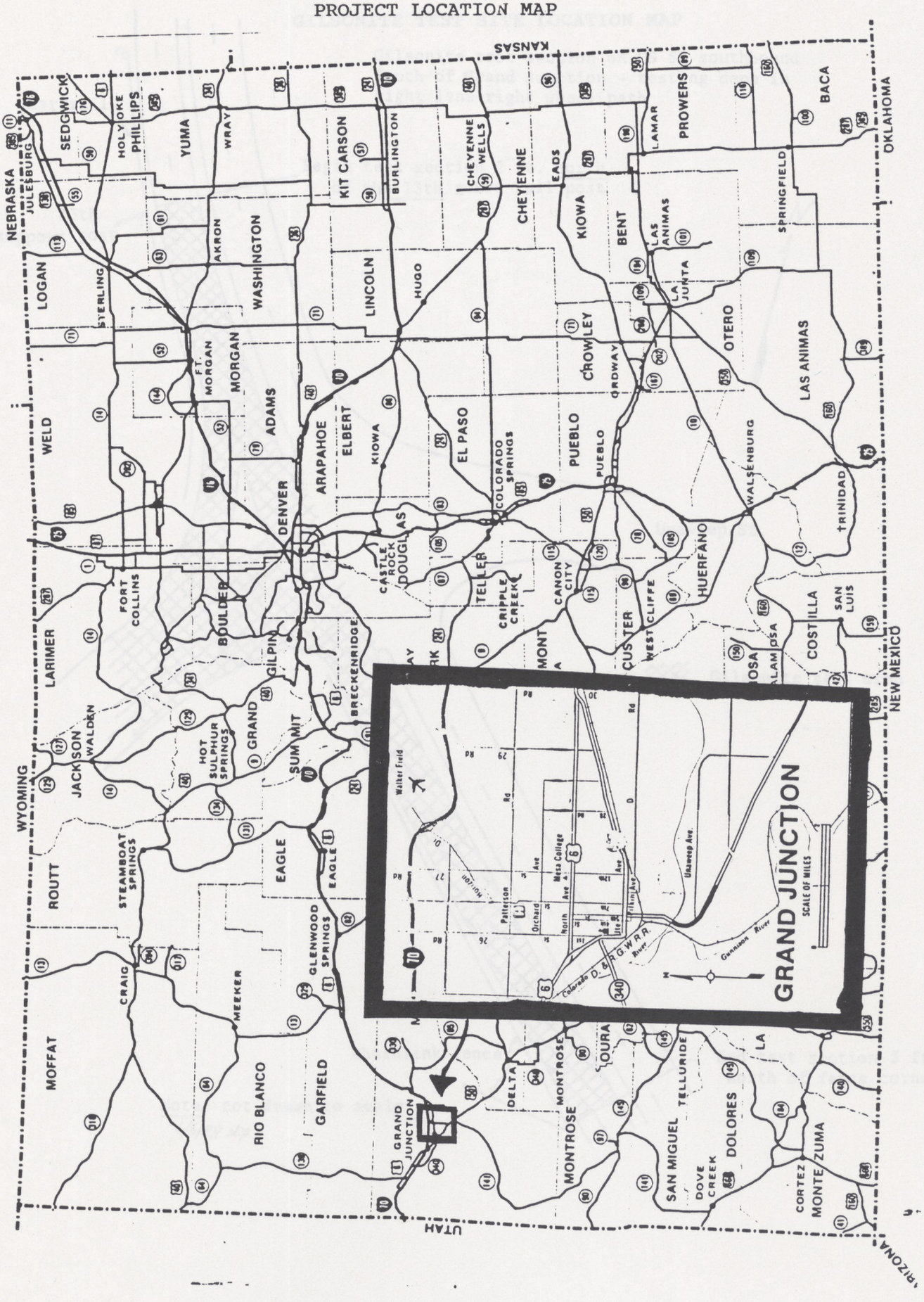


FIGURE 2

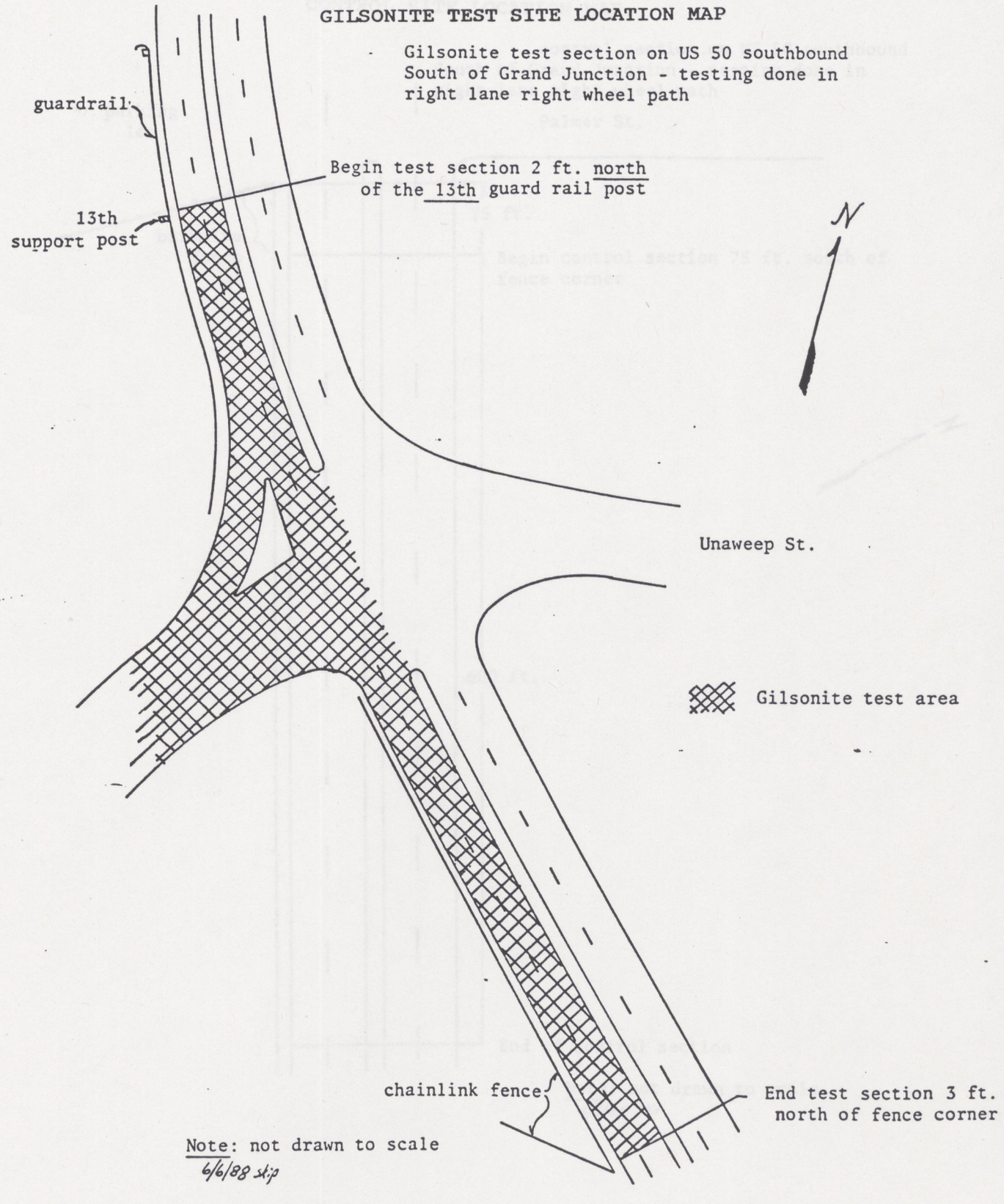
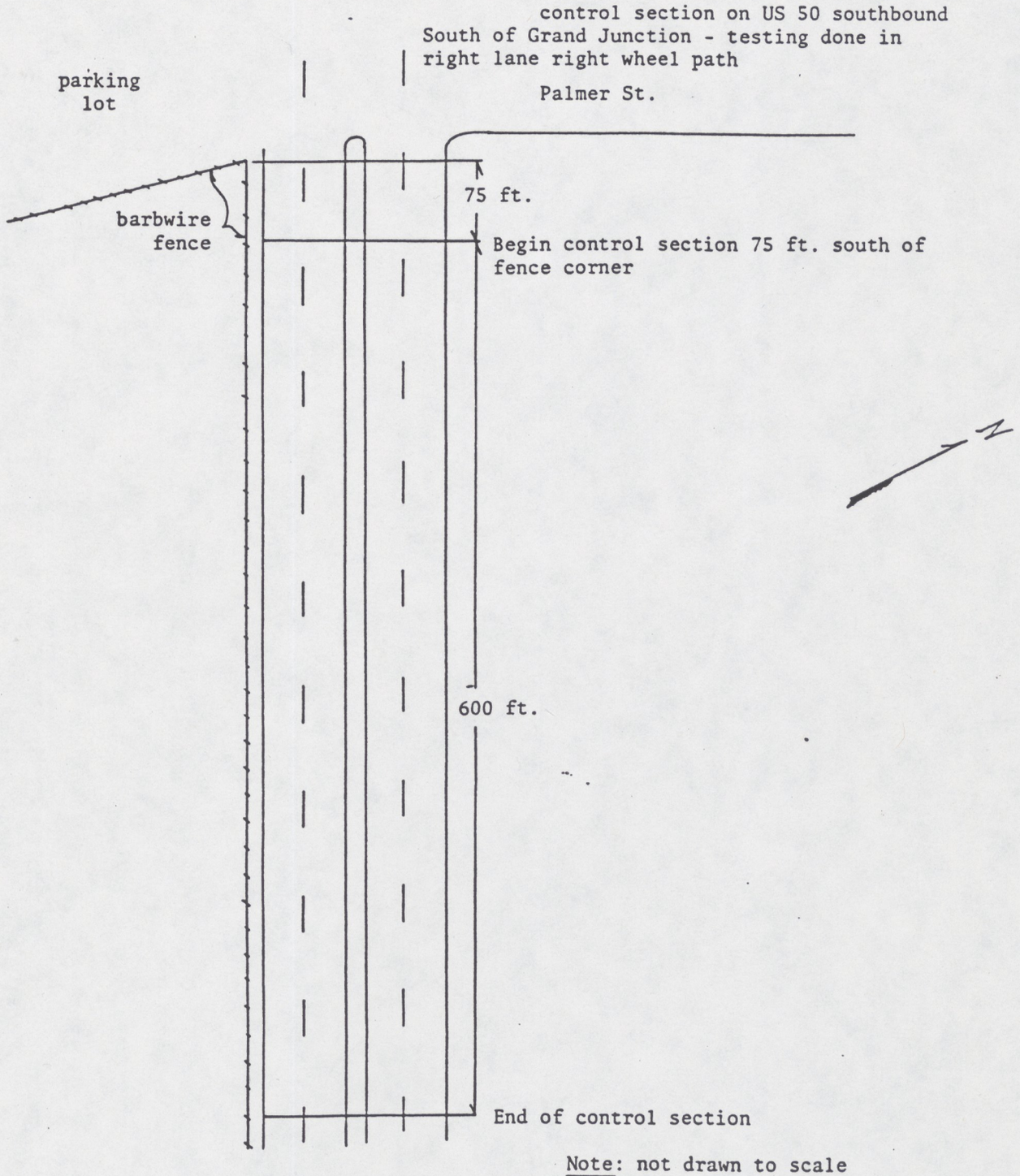

GILSONITE TEST SITE LOCATION MAP
Gilsonite test section on US 50 southbound
South of Grand Junction - testing done in
right lane right wheel path
guardrail
Begin test section 2 ft. north
of the 13th guard rail post
13th
support post
N
Unaweep St.
Gilsonite test area
chainlink fence
End test section 3 ft.
north of fence corner
Note: not drawn to scale
6/6/88 sjp

FIGURE 3

CONTROL SITE LOCATION MAP



Note: not drawn to scale

6/6/88 Skip

IV. PRE-CONSTRUCTION AND POST-CONSTRUCTION EVALUATIONS

Post-construction evaluations were performed immediately after construction and once a year for three years. The evaluations included deflection measurements (taken with a Dynaflect), rutting measurement (using a 6 foot straight edge), crack mapping, core sampling and a visual inspection of the overall pavement.

Deflection Measurements

The deflection measurements taken prior to construction and over the evaluation period indicate that the load carrying capacity of the pavement section increased slightly following construction. The pavement appeared to became stronger over the first year following construction and then leveled off. There was no significant difference in the overall strength of the pavement when comparing the control and test sections. A graph of the deflection basins for the test and control sections over the evaluation period can be found at the end of this section (figure 4).

Rutting Measurements

The rutting measurements taken prior to construction ranged between one-tenth of an inch to one-half of an inch. Typical rutting in the test and control sections was comparable prior to construction, except at the Unweep intersection where rutting was slightly higher.

Rutting measurements were taken each year. The rutting measurements taken during the last evaluation (spring 1991) indicate that rutting was not a significant problem in either section; however, the Gilsonite appears to be

helping the pavement resist the rutting and shoving action placed on the pavement at the intersection.

A bar chart showing the rutting measurements for the test and control sections before construction and the measurements taken during the final evaluation (spring 1991) can be found at the end of this section (figure 5).

Rutting photos taken prior to construction and during the final evaluation are in Appendix B.

Cracking Evaluation

Prior to construction, the amount and type of cracking found in the control and test section was comparable. The cracking consisted mainly of alligator cracking, which was found in both wheel paths intermittently throughout the project.

Cracking maps were drawn for the test and control section during each post-evaluation. During the first year, the Gilsonite test section developed a longitudinal crack that extended along the center line for nearly one half the length of the test section. Longitudinal cracking did not appear in the control section until three years after construction. In the Gilsonite test section there was approximately six times more transverse cracking than in the control section after the first year.

Following the final evaluation, cracking in the control section was minimal compared to the Gilsonite test section. The total cracking in the Gilsonite test section was approximately three times the amount in the control section. In May 1991, the Gilsonite section had a total of 1864 linear of cracking of which 1240 feet was transverse. During the same evaluation the control section had 567

linear feet of which 399 feet was transverse. In addition, the cracks in the Gilsonite test section were wider and were deteriorating at a faster rate than the cracks in the control section. See photos on page B-5 in Appendix B.

A bar chart comparing cracking of the test and control sections over the evaluation period can be found at the end of this section (figure 6).

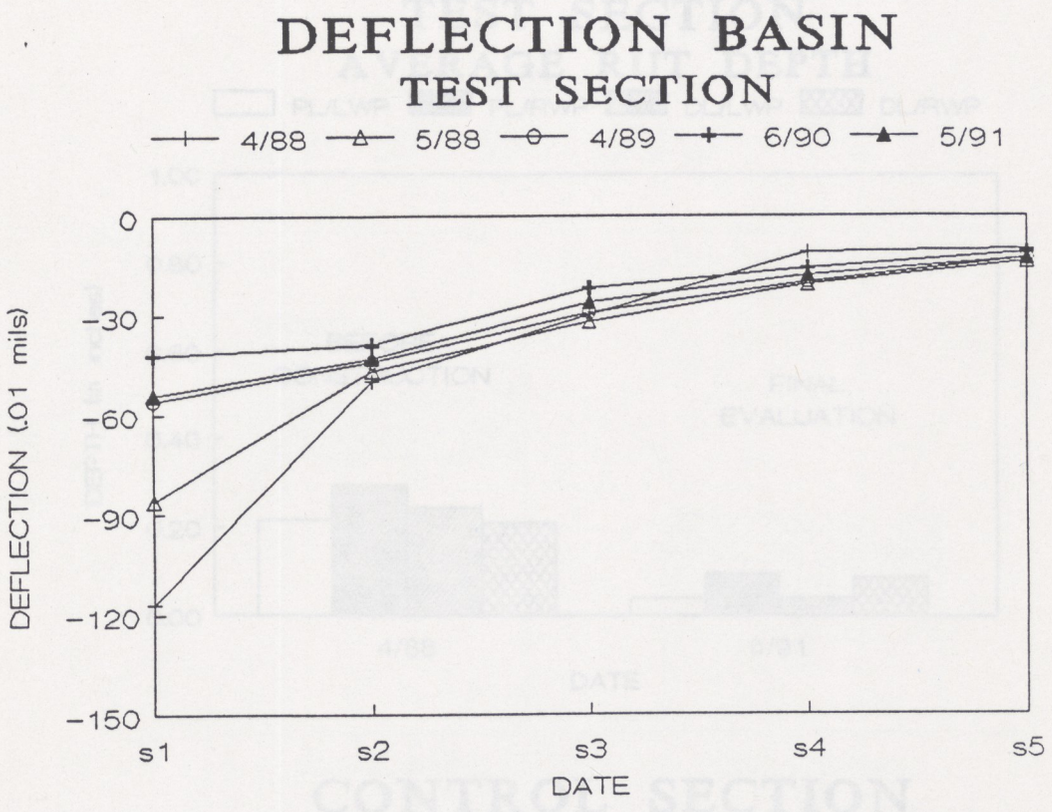
Photos taken prior to construction and over the evaluation showing the cracking patterns can be found in Appendix B.

Core Sampling

Each year cores were taken from both the test and control sections. Visual inspection indicated no signs of stripping in any of the cores. The cores revealed that the lower lift of the control section was about 1/2" greater than that of the test section. Laboratory tests performed on the cores taken in 1989, indicated that %AC, Lottman and stability values of the Gilsonite and control sections were comparable. See Appendix C.

FIGURE 4

DEFLECTIONS MEASUREMENTS



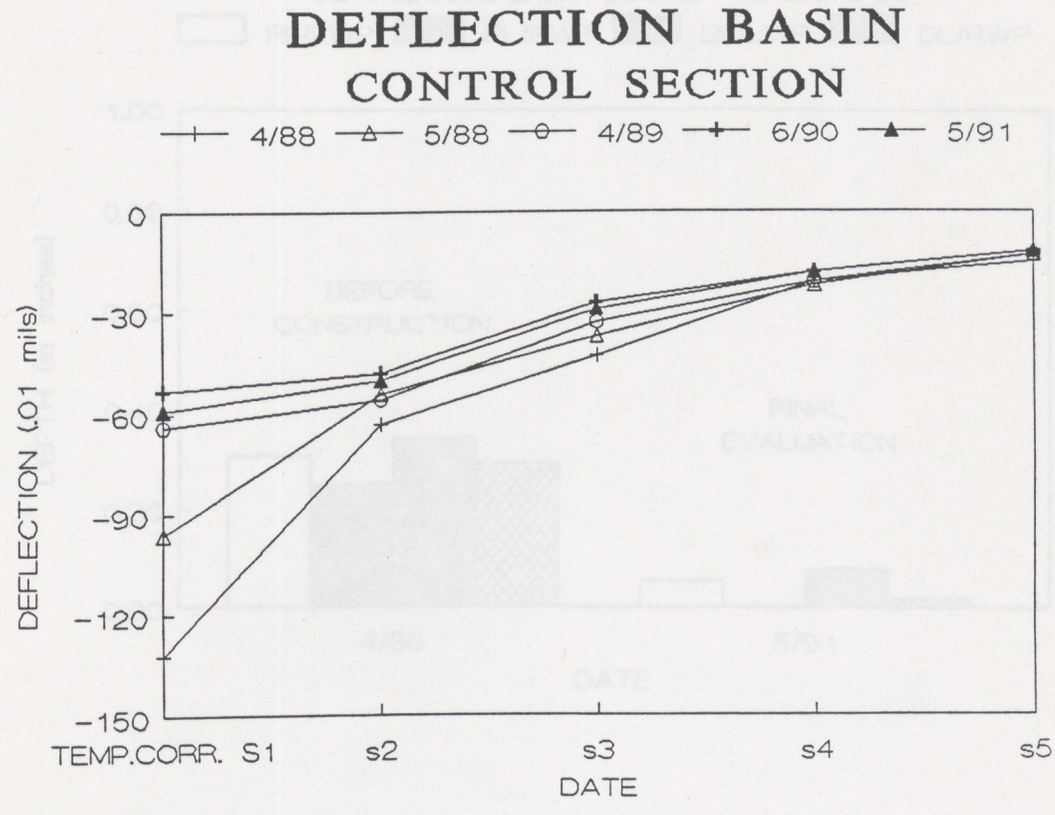
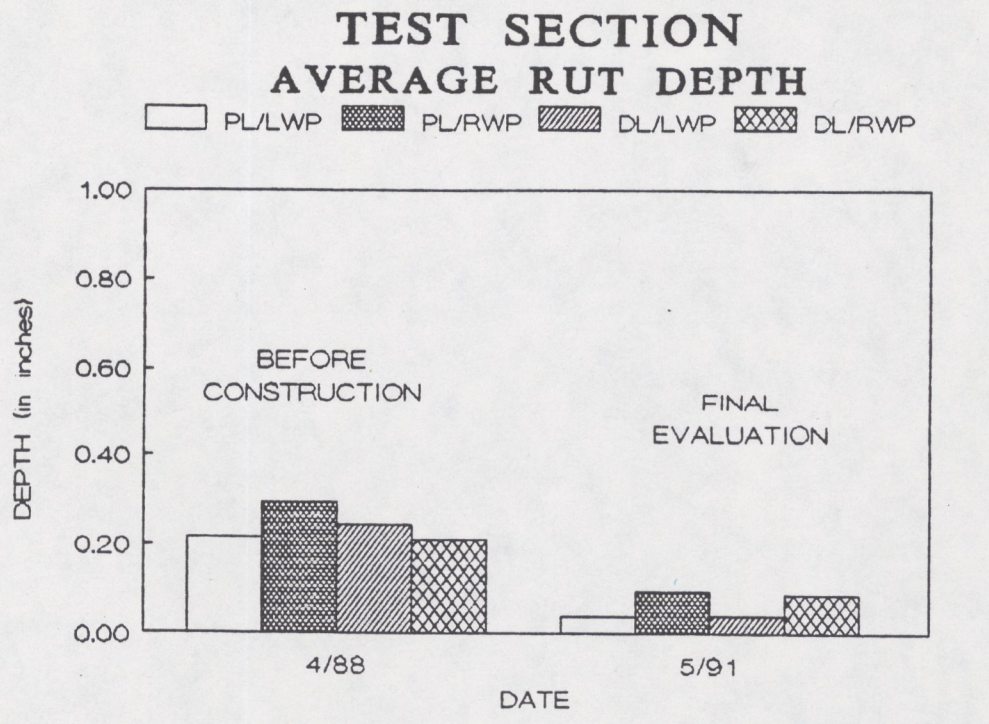


FIGURE 5

RUTTING MEASUREMENTS



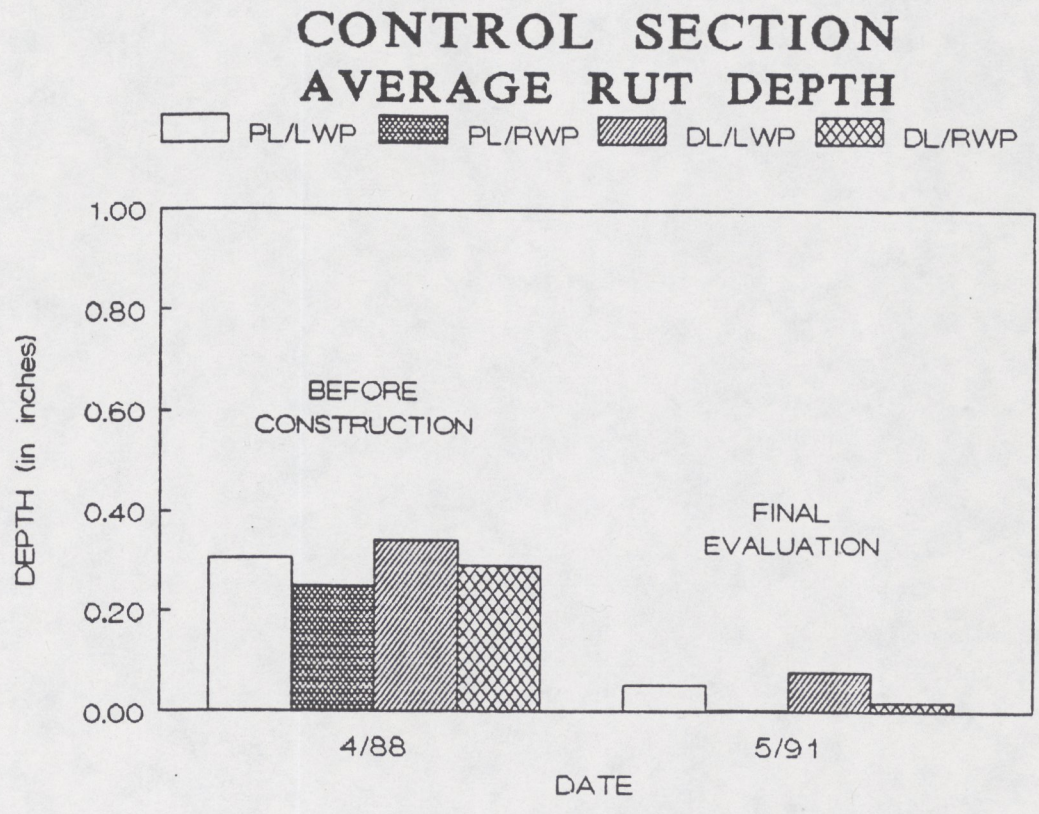
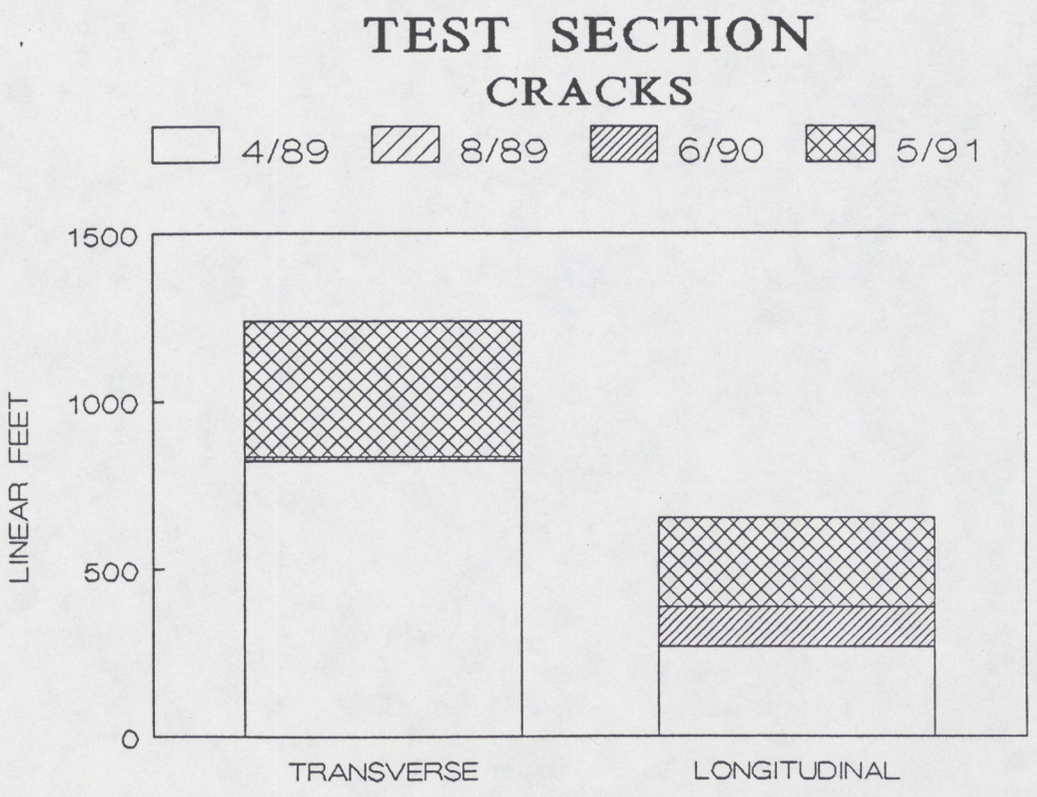
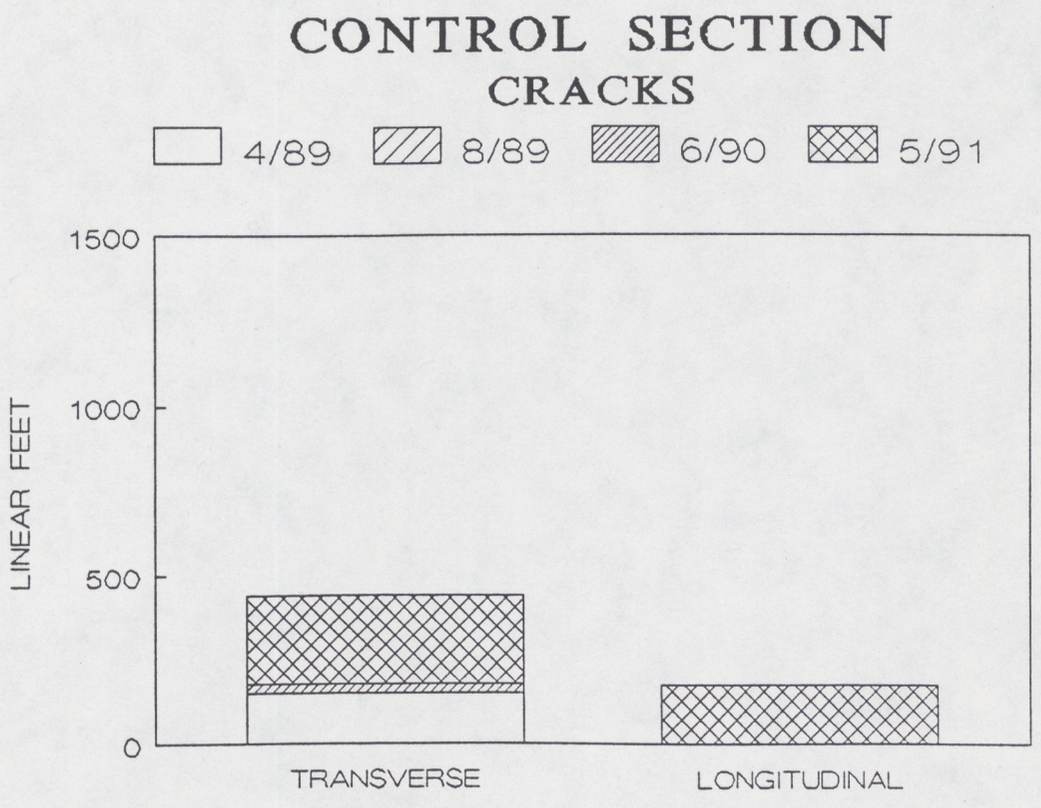


FIGURE 6

CRACKING MEASUREMENTS





V. CONCLUSION

There were several factors that had to be considered when evaluating the performance of the Gilsonite test section compared to the control section.

The overlay in the control section was slightly thicker than the plans called for. The thicker pavement in the control section could have slowed the process of reflective cracking. The control section also had a plant mixed seal coat (PMSC). Plant mixed seal coats have been shown to help retard reflective cracking early in the life of the overlay. Although the Gilsonite test section was located in the Unweep intersection, where increased rutting was expected, neither section had significant rutting yet, the Gilsonite section had more cracking.

After considering these factors, the data collected over the evaluation period indicated the addition of Gilsonite appeared to reduce or retard rutting, however it tended to harden the pavement creating a structure that was more susceptible to premature cracking. The cracking appeared at a much faster rate and the cracks tended to deteriorate quicker and to a greater extent.

VI. IMPLEMENTATION AND RECOMMENDATIONS

Based on the performance of this test section, the addition of Gilsonite cannot be justified. The consequence of increased cracking is much more severe than the benefit of the potential reduction in rutting.

APPENDIX A

PROJECT SPECIFICATIONS
AND
GILSONITE INFORMATION

Sept. 4, 1987

REVISION OF SECTION 403
HOT BITUMINOUS PAVEMENT (GRADING E)
COLORADO PROJECT NO. CX 08-0050-10

Section 403 of the Standard Specifications is hereby revised for this project as follows:

Subsection 403.02 shall include the following:

The hot bituminous mix shall conform to the following:

TABLE 403-1

PROPERTY	TEST METHOD	*VALUE
Voids, percent	CPL 5105	4-8
Stability, minimum	CPL 5105	37
Strength Coefficient, minimum	CPL 5105	.44
Accelerated Moisture Susceptibility Tensile Strength Retained, minimum	CPL 5109	60
Maximum aggregate size		5/8"
Minimum Optimum Laboratory Asphalt Content	CPL 5105	5.3%

*These values apply to acceptance of the source or design mix.

The asphalt cement for this grading shall be AC-10F.

The top lift of the hot bituminous pavement shall not contain any reclaimed material.

The hot bituminous mix delivered to the project site shall be sampled in accordance with CP-41 by the Contractor at the direction and in the presence of the Engineer.

Subsection 403.03 shall include the following:

When ordered by the Engineer, a tack coat shall be applied between pavement courses and paid for in accordance with Section 407.

Hot bituminous pavement shall not be placed between Oct. 1st and April 1st, unless otherwise approved by the Engineer. If this item is to be placed between these dates, an approved rejuvenating agent shall be used when directed by the Engineer.

The Contractor shall use an approved anti-stripping additive.

The Contractor shall arrange his work such that all roadway pavement is placed prior to the time paving operations are specified to end for the year shall be to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods he intends to use to conform to this requirement.

In Subsection 403.05, delete the last paragraph and replace with the following:

Haul, aggregate, asphalt cement, rejuvenating agent, additives, and all other work necessary to complete the item will not be paid for separately but shall be included in the unit price bids.

Aug. 17, 1987

REVISION OF SECTIONS 410 and 703
PLANT MIXED SEAL COAT (TYPE B)
COLORADO PROJECT NO. CX 08-0050-10

Section 410 of the Standard Specifications is hereby revised for this project as follows:

Subsection 410.02 shall include the following:

The job mix formula for Plant Mixed Seal Coat (Type B) shall be as follows:

Passing 1/2" Sieve	100%
Passing 3/8" Sieve	97-100%
Passing #4 Sieve	52%
Passing #8 Sieve	33%
Passing #50 Sieve	11%
Passing #200 Sieve	5%

The range of tolerances of Bitumen shall be ± 0.3%.

Asphalt cement (AC-20)(Rubberized) 7.5% by Weight of Mix.

Subsection 410.03(b) shall include the following:

A tack coat shall be applied prior to placement of the PMSC.

Subsection 410.03, Paragraph (d), is hereby deleted and replaced with the following:

(d) DUMPING AND SPREADING. The plant mixed seal coat mixture shall be dumped directly into the lay-down machine hopper. Dumping the mixture onto the pavement ahead of the lay-down machine will not be permitted.

In Subsection 410.05, delete the last paragraph and replace with the following:

Haul, aggregate, additives, and all other work necessary to complete the item will not be paid for separately but shall be included in the unit price bid.

Section 703 of the Standard Specifications is hereby revised for this project as follows:

Subsection 703.10 is hereby revised for this project as follows:

100% by weight of the particles retained on the No. 4 Sieve shall have at least two fractured faces when tested in accordance with Colorado Procedure 45.

Aggregate passing the No. 4 Sieve shall be the dust of fracture of crushing rock larger than 1/2 inch.

The aggregate shall have a percentage of wear of not more than 35 when tested in accordance with AASHTO T-96.

Aug. 17, 1987

REVISION OF SECTION 411
GILSONITE RESIN MODIFIED ASPHALT
COLORADO PROJECT NO. CX 08-0050-10

Section 411 of the Standard Specifications is hereby revised for this project as follows:

Subsection 411.03 shall include the following:

A single 2-inch layer of Hot Bituminous Pavement, using "Gilsonite" Resin modified asphalt will be placed on the "test section" noted in the plans. This will replace the Hot Bituminous Pavement, Plant Mixed Seal Coat and asphaltic materials shown on the plans.

Gilsonite resin, as supplied by American Gilsonite Company, will be added to the asphalt cement prior to making the hot mix. The material will be supplied to the contractor free of charge by American Gilsonite Company, Salt Lake City, Utah. It will be added to the asphalt following the procedure outlined below:

1. The material is to be added to liquid asphalt at the tank so that a final concentration of 8% by weight Gilsonite is achieved. Job should be planned so that there is the right amount of asphalt in the tank so that when the Gilsonite is added, the 8% concentration is achieved.

2. Asphalt temperature during Gilsonite addition should be maintained at a minimum of 345°F. If higher temperatures are possible, they are recommended as they will speed up the rate of solutions.

3. There should be recirculation of the asphalt in the tank all during the mixing process. If piping is available so that the asphalt can be recirculated above the liquid level, the splashing action will assist in the wetting of the Gilsonite.

4. A lightning mixer with 3/4 HP or larger motor, and with a long shaft should be used at the point where the Gilsonite is added. This mixer should provide sufficient agitation to form a vortex. This will insure proper dispersion of the granules. To insure maximum safety, use a mixer with an explosion proof motor.

5. The Gilsonite should be added via a funnel with approximately 2 ft^2 opening at the top and 4-6" opening a the bottom. For this job, if needed, American Gilsonite Company will provide this unit on a loan basis.

6. Allow 2 to 3 hours for adding the material (3-5 minutes per bag) and an additional one hour minimum for mixing and recirculating after all the material has been added. If desirable, some or all of the Gilsonite may be added to the asphalt the day before. Gilsonite in asphalt forms a true solution and does not separate once dissolved.

Subsection 411.05 shall include the following:

Payment will be made under:

Pay Item	Pay Unit
Asphalt Cement (AC-10) (Fortified)	Ton

Gilsonite is a registered trademark of American Gilsonite Company.

Hot Bituminous Pavement will be paid for in accordance with Section 403.

Gilsonite® Information Bulletin

GILSONITE GP GRADE

PRINCIPAL APPLICATIONS

Asphalt Modification and Improvement
Asphalt Pavement Sealer
Explosives
Briquette or Pellet Binder

TYPICAL PROPERTIES

Softening Point, ASTM E28-51T	330-350°F
Ash	0.6-1.0%
Color In Mass	Black
Penetration @77°F, 100 gm, 5 sec.	0
Moisture	0.3%
Flash Point, COC	600°F
Sulfur	0.3%
Specific Gravity	1.05

PARTICLE SIZING

	% Retained (Cumulative)	
	Small Lump	Pulverized
+ 10 mesh	3	0
+ 20 mesh	15	0
+ 35 mesh	40	Trace
+ 65 mesh	50	2
+100 mesh	65	6
+200 mesh	-	20

SOLUBILITY

Gilsonite GP Grade is soluble in aromatic solvents (Benzene, Toluene, Xylene) and in most chlorinated solvents. It is also soluble without heating in aliphatic and low aromatic solvents (VM&P Naptha, Mineral Spirits), but mixing time is longer. Without heating, the pulverized grade is recommended. Upon aging, liquid solutions may thicken, and gelling can occur in solutions using aliphatic solvents. Gilsonite GP Grade can be hot fluxed with asphalt to improve ductility and weathering properties. It is also compatible with waxes for special uses. Gilsonite is either insoluble or has limited solubility in most alcohols and ketones.

PACKAGING

Gilsonite GP Grade is available in 50 lb. net multi-ply paper bags which may be palletized and stretch wrapped. It is also available in bulk loaded trucks.

HEALTH & SAFETY

Gilsonite is a naturally occurring hydrocarbon. There is no known history of dermatitis, lung disease or other health problems associated with handling of Gilsonite as supplied. Dusts are subject to combustion. Normal precautions used with flammable materials apply.

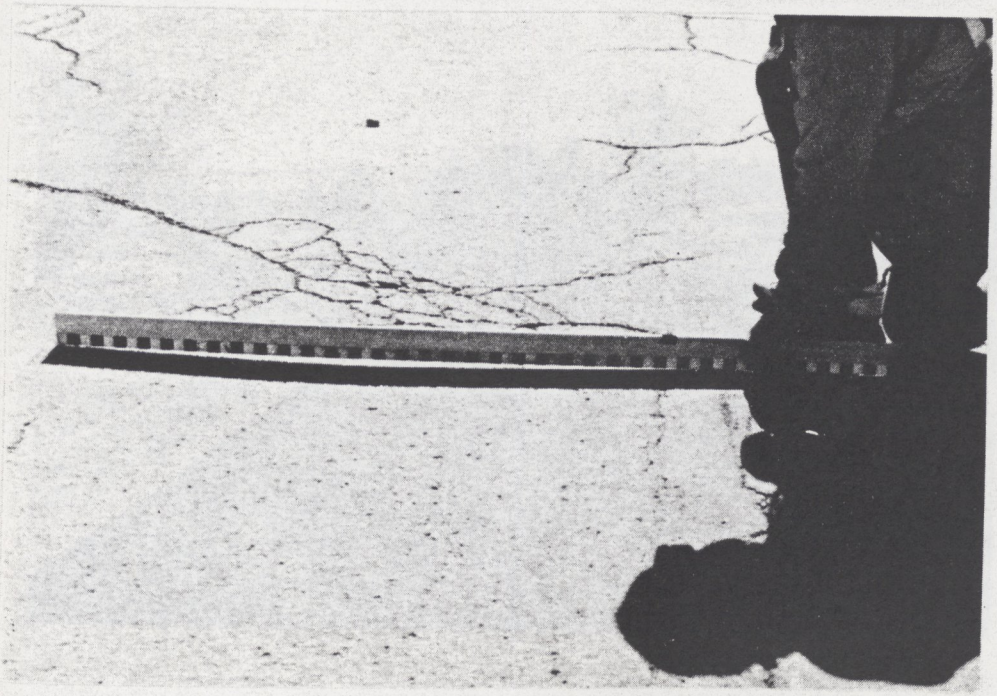
American Gilsonite Company
A Chevron Company
1150 Kennecott Building, Salt Lake City, UT 84133, U.S.A.
Phone (801) 328-0311 TWX (910) 925-5658

B-040-0886

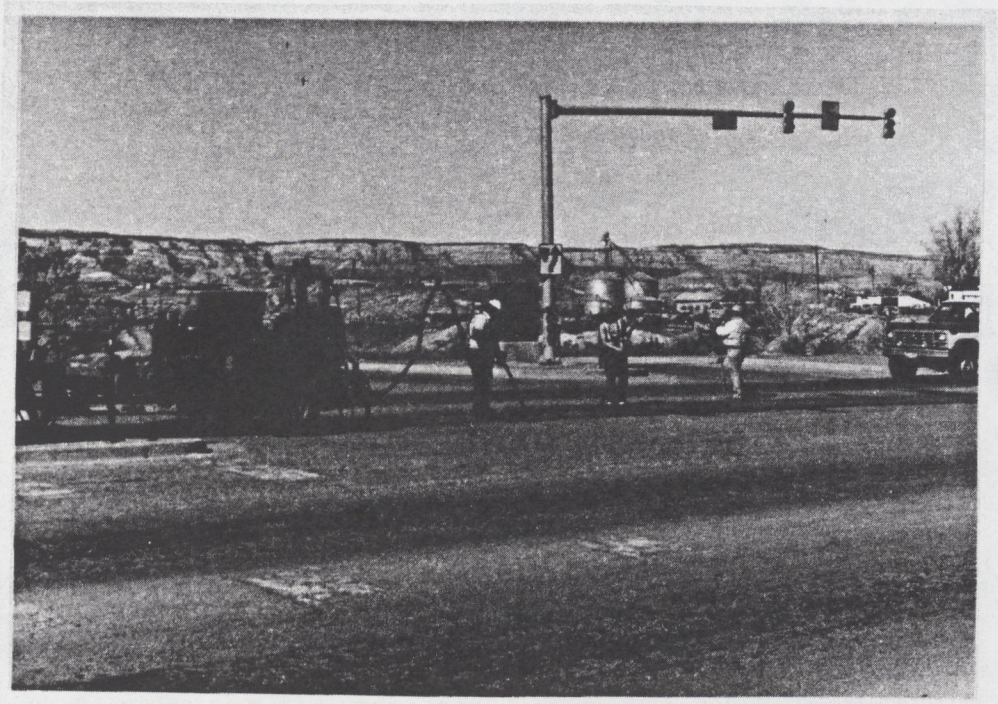
APPENDIX B

PHOTOGRAPHS

Prior to construction alligator cracking was found intermittently in both wheel paths of the driving lane. This cracking pattern was found in the test and control sections.

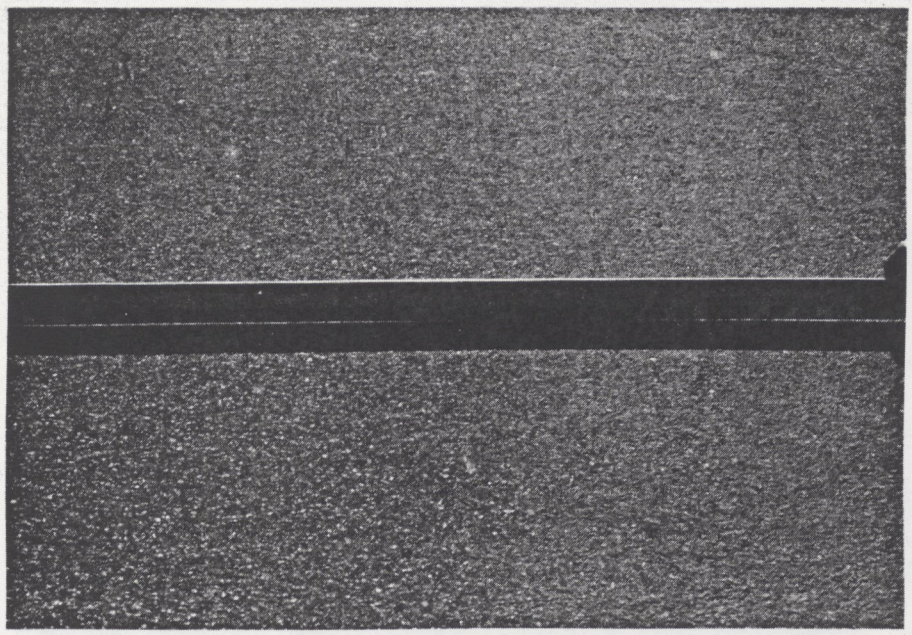


Rutting on the pavement prior to construction ranged from 1/10 of an inch to 1/2 of an inch.

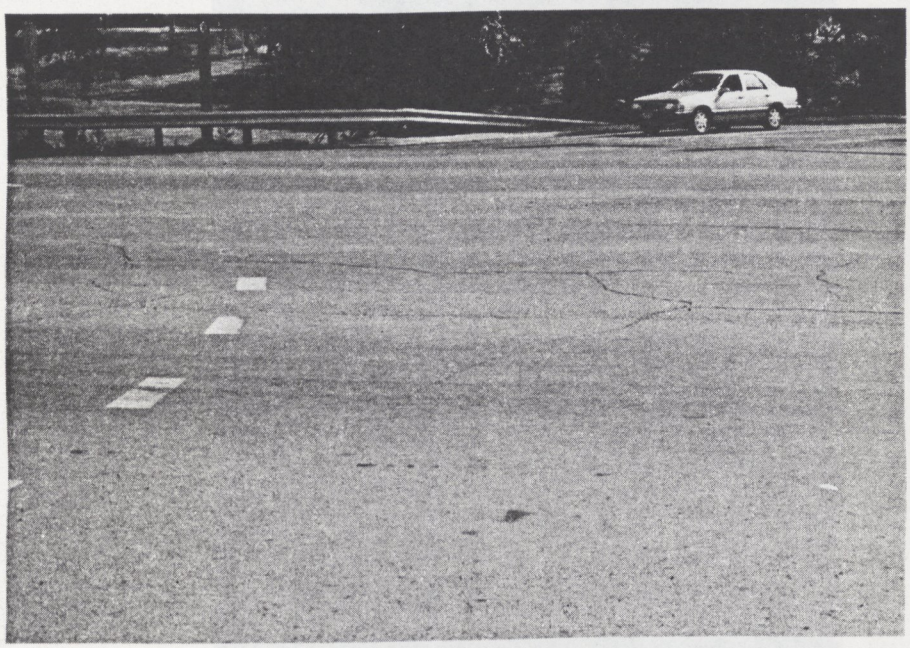


Prior to construction the cracks were cleaned and filled with a scrap rubber crack filler material.

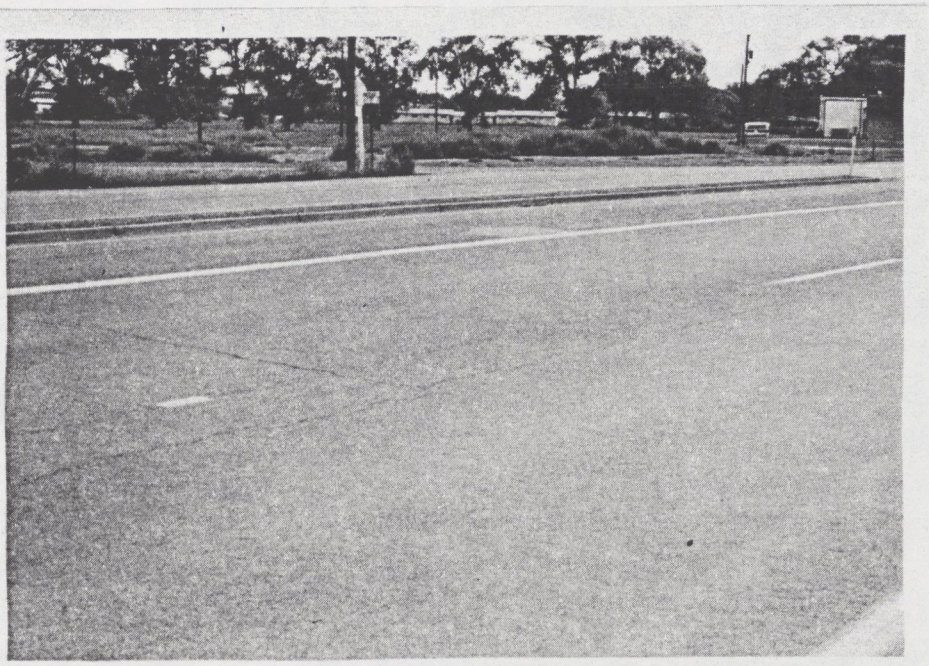
The Gilsonite test section was placed at the Unaweep intersection.



Rutting in the test and control section during the last evaluation was not significant.



This photo shows the amount of cracking in the Gilsonite test section at the last evaluation. August 1991



This photo shows a section where cracking has begun to appear in the control section. Photo taken August 1991.

August 1991
control section

The cracks in the Gilsonite section are much wider than the cracks in the control section. August 1991 Gilsonite section

The cracks in the Gilsonite section are also deteriorating faster.

APPENDIX C

LABORATORY RESULTS FROM CORES

LABORATORY RESULTS FOR TEST SECTION CORES

Division of Highways
State of Colorado
Form DOH 360 Rev. 11/88

Date Received 10/02/89

Project No: Gilsonite
Location: Grand Jct.
District # 3 Subaccount: 89001
Lab # B 64
Field Sample # 50907

PROJECT PRODUCED HOT BITUMINOUS PAVEMENT

Item 403 Grading E Cores G1, G2, G3, G4
Pit name: CONTRACTOR:

	Test Results	Job Mix	
% Moisture	0.00	--	See sample #
% Asphalt	5.74	0.00	Project
1 1/2	100		
1	100		
3/4	100		
5/8	100		See DOH No. 43 dated / /
1/2	99		
3/8	87		
4	59		Sampling: CP 41 C
8	44		Extraction: T 164B
16	36		Gradation: T30
30	31		
50	20		
100	13		
200	9.7		

TEST RESULTS:

Max Sp. Gr. T209	0.00
Bulk Sp. Gr. T166	2.36
% Voids CPL 5105	0.0
Stability CPL 5105	28
Modulus CPL 5110	2143
Strength coefficient	0.40
VMA (% voids in Agg)	0.0
% of VMA filled	0.
Dust / AC ratio	1.61

IMMERSION-COMPRESSION CPL 5104		LOTTMAN CPL 5109	
PSI Wet		138	Wet D.T.St
PSI Dry		152	Dry D.T.St
% Absorption		0.00	% Voids
% Swell		0.90	% Perm Vds
% Ret. Strength		90	% T.S.Ret.

Date Reported 4/4/90

Dick Hines 757-9724
Flexible Pavement Engineer

LABORATORY RESULTS FOR CONTROL SECTION CORES

Division of Highways
State of Colorado
Form DOH 360 Rev. 11/88

Date Received 10/02/89

Project No: Gilsonite
Location: Grand Jct.
District # 3 Subaccount: 89001
Lab # B 65
Field Sample # 50907

PROJECT PRODUCED HOT BITUMINOUS PAVEMENT

Item 403 Grading E Cores G5, G6, G7, G8
Pit name: CONTRACTOR:

	Test Results	Job Mix	
% Moisture	0.00	--	See sample #
% Asphalt	5.82	0.00	Project
1 1/2	100		
1	100		
3/4	100		
5/8	100		See DOH No. 43 dated / /
1/2	100		
3/8	89		
4	61		Sampling: CP 41 C
8	46		Extraction: T 164B
16	37		Gradation: T30
30	31		
50	20		
100	13		
200	8.8		

TEST RESULTS:

Max Sp. Gr. T209	0.00
Bulk Sp. Gr. T166	2.34
% Voids CPL 5105	0.0
Stability CPL 5105	34
Modulus CPL 5110	582
Strength coefficient	0.44
VMA (% voids in Agg)	0.0
% of VMA filled	0.
Dust / AC ratio	1.46

IMMERSION-COMPRESSION CPL 5104		LOTTMAN CPL 5109	
PSI Wet		78	Wet D.T.St
PSI Dry		93	Dry D.T.St
% Absorption		0.00	% Voids
% Swell		1.29	% Perm Vds
% Ret. Strength		83	% T.S.Ret.

Date Reported 4/4/90

Dick Hines 757-9724
Flexible Pavement Engineer

PUBLICATION
Department of Highways-State of Colorado
Division of Transportation Planning

91-1 *Dynamic Measurements on Penetrometers for Determination of Foundation Design Parameters
91-2 *Geotextiles in Bridge Abutments
91-3 Industrial Snow Fence vs. Wooden Fences
91-4 Rut Resistant Composite Pavement Design (Final Report)
91-5 Reflective Sheeting (Final)
91-6 Review of Field Tests and Development of Dynamic Analysis Program for CDOH Flexpost Fence
91-7 Geotextile Walls For Rockfall Control (CANCELLED)
91-8 Fly Ash in Structural Concrete
91-9 Polyethylene Pipes for Use as Highway Culverts
91-10 Ice-Detection System Evaluation
91-11 Evaluation of Swareflex Wildlife Warning Reflectors
91-12 Analysis and Design of Geotextile-Reinforced Earth Walls, Vol. III Parametric Study and Preliminary Design Method

92-1 Colorado Department of Transportation Asphalt Pavement White Paper
92-2 Expansive Soil Treatment Methods in Colorado
92-3 *Gilsonite An Asphalt Modifier
92-4 *Avalanche Characteristics and Structure Response - East Riverside Avalanche Shed Highway 550, Ouray County Colorado
92-5 *Special Polymer Modified Asphalt Cement - Interim Report

*Reports soon to be published

PUBLICATION
Department of Highways-State of Colorado
Division of Transportation Planning

89-1 Truck Tire Pressures in Colorado
89-2 Rockfall Modeling and Attenuator Testing
89-2B Colorado Rockfall Simulation Program
Users Manual f Version 2.1 (Reprint 11/5/91)
89-3 Frost Heave Control With Buried Insulation
89-4 Verglimit Evaluation (Boulder)
89-5 Use of Road Oils by Maintenance
89-6 Accelerated Rigid Paving Techniques
89-7 IBC Median Barrier Demonstration
89-8 Monitoring of Nondurable Shale Fill in Semi-Arid Climate
89-9 Resilient Properties of Colorado Soils
89-10 Consolidation Testing Using Triaxial Apparatus
89-11 Reactive Aggregate in Structures
89-12 Five Inch Asphalt Overlay
89-13 Avalanche - Interim Report
89-14 Sawed Joints in AC Pavements
89-15 Mirimat Erosion Control Fabric
89-16 Use of Spirolite Plastic Pipe

90-1 Pretreatment of Aggregates
90-2 Experimental Gravel Shoulders
90-3 Cold Recycling of Asphalt Pavement, US 24, Proj. CX-04-0024-25
90-4 Pavement Marking Materials
90-5 Geotextiles in Landfills
90-6 Criblock Retaining Wall
90-7 Project Level Pavement Management
90-8 A Peak Runoff Prediction Method For Small Watersheds in Colorado
90-9 Research Status Report
90-10 Public Perception of Pavement Rideability
90-11 Bridge Deck Repair Demonstration
90-12 Highway Rockfall Research Project
90-13 In-Service Evaluation of Highway Safety Devices, Exp. Proj. No. 7
90-14 Study of Urban Interchange Performance

PUBLICATION
Department of Highways-State of Colorado
Division of Transportation Planning

87-01	Finite Element Analysis of Twin-T Test Walls in Glenwood Canyon, CO
87-02	Flow Conflict Study
87-03	Epoxy Thermoplastic Pavement Marking Demonstration Project 60
87-04	Elastometric Concrete End Dams Used in Conjunction With Bridge Deck Expansion Devices
87-05	Colorado Reactive Aggregate
87-06	Bridge Approach Settlement
87-07	
87-08	Third Party Construction Engineering
87-09	Preloading of Sanitary Landfills
87-10	Frost Heave Control With Buried Insulation (Interim)
87-11	AC Gauge "Between Operator" Precision Experiment
87-12	Long-Term Creep of Geotextile in the Confinement of Soils Under Sustained Loading - Phase I
87-13	Dynaflect Benkelman Beam Correlation
87-14	Cathodic Protection
87-15	Rubber Modified Asphalt Concrete
87-16	Concrete Pavement Repair Bennett to Strasburg

88-1	Pavement Profile Measurement Seminar Proceedings, Vol. I, Seminar Overview
88-2	Pavement Profile Measurement Seminar Proceedings, Vol. II, Data Collection Equipment
88-3	Pavement Profile Measurement Seminar Proceedings, Vol. III, Workshop Summaries
88-4	Micro Computers in Project Field Offices
88-5	Development of a Risk Cost Methodology for Detour Culvert Design
88-6	Concrete Pavement Restoration Demonstration
88-7	Inservice Evaluation of Highway Safety Appurtenances, FHWA Experimental Project No. 7
88-8	Embankment Settlement in Glenwood Canyon
88-8	Rehabilitation of Concrete Pavements Follow-Up Study
88-10	Effectiveness of Geogrids and Geotextiles in Embankment Reinforcement
88-11	Spring Breakup Study
88-12	Plastic Pipe Use Under Highways
88-13	Geothermal Space Heating
88-14	
88-15	Tapered Asphalt Shoulders
88-16	Development of a Retrievable Test Rig for Drilled Pier Bridge Foundations
88-17	Flexible Roadside Delineator Post Evaluation
88-18	Long Term Pavement Monitoring
88-19	Expandable Membrane Ground Anchors in Talus
88-20	Research Status Report