THE EFFECT OF GILSONITE-MODIFIED ASPHALT ON HOT MIX ASPHALTIC CONCRETE MIXES USED IN DISTRICT 12, HOUSTON, TEXAS

DHT-22

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16. Abstract

Gilsonite is a naturally occurring black hydrocarbon from Utah with a high asphaltene content and an unusual amount of nitrogen compounds. Because of its composition, it is believed that the addition of gilsonite will increase the viscosity, stability, water susceptibility and durability of the asphalt mix. The District 12 laboratory conducted tests on two hot mix designs using gilsonite-modified asphalts. A control batch and batches containing 4%, 6% and 8% gilsonite by weight of asphalt were tested. The appropriate gilsonite-aggregate mixtures were molded and evaluated for stability, specific gravity, indirect tensile strength and water susceptibility. From the results of the laboratory tests, it was evident that gilsonite-modified asphalt mixes did increase dry and wet tensile strength but did not increase Hveem stability. Since there is no overwhelming proof of gilsonite's ability as an anti-stripping agent, it has been recommended that gilsonite be used with an anti-stripping agent to combat stripping and rutting. It is further recommended that the field performance of gilsonite be evaluated before approval is given for its use.

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The Effect of Gilsonite-Modified Asphalt on Hot Mix Asphaltic Concrete Mixes Used in District 12 Houston, Texas

By Constance Wong and Michael K. Ho, P.E.

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Summary

Two hot mix asphaltic concrete designs currently used in District 12 were evaluated using gilsonite-modified asphalt. The gilsonite was added to the asphalt by weight in percentages of 0%, 4%, 6% and 8%. It was mixed with the appropriate aggregates, molded, and evaluated for stability, specific gravity, indirect tensile strength and water susceptibility. The results indicated no increase in Hveem stability, a definite increase in dry tensile strength, and an increase in wet tensile strength ranging from slight to definite, depending on the mix design.

The Effect of Gilsonite-Modified Asphalt on Hot Mix Asphaltic Concrete Mixes Used in District 12, Houston, Texas

I. Introduction

Gilsonite is a naturally occurring, black hydrocarbon mined commercially in the Uintah Basin in Eastern Utah. Due to its high asphaltene composition (50%-65%), it is classified as an asphaltite. It has an unusual amount of nitrogen compounds (3.5%), which enhances its ability to adhere to aggregates. The addition of gilsonite to asphalt does a number of things, according to producer American Gilsonite. These include increasing viscosity, stability, water susceptibility and durability of the asphalt and mix. Appendix A summarized these findings.

In its search for products to improve the performance of hot mix asphaltic concrete, the District 12 Laboratory began an investigation of the effects of gilsonite-modified asphalt on mix characteristics. Gilsonite was supplied in granular form and would be used on two mix designs currently in use by the Highway Department in Houston. The mixes would be tested for stability, specific gravity, indirect tensile strength and water susceptibility, as all mixes are tested before being approved by the State. A control batch and batches containing 4%, 6% and 8% gilsonite by weight of asphalt would be tested.

II. Mix Design #1 — Proportions and Material Sources

Tables 1 and 2, below, show the type of materials used, their design percentages, their sources and the gradation for this mix.

Table 1. — Mix Design #1

Type of Material	Percentage	Source
"D" Sandstone	28%	Delta, Marble Falls, TX
"D" Limestone	32%	Parker Bros., New Braunfels, TX
Limestone Screenings	15%	Parker Bros., New Braunfels, TX
Field Sand	25%	Parker Bros., Brazos, TX
Asphalt (Grade 20)	4.8%	FINA, Port Arthur, TX
Gilsonite	0-8% by wt. of asphalt	American Gilsonite, Utah

Table 2. — Gradation for Mix Design #1

Sieve Size	Percentage Retained on Sieve
1/2" — 3/8"	5.4
3/8" — #4	37.8
#4 — #10	16.6
#10 — #40	11.6
#40 — #80	17.2
#80 — #200	8.6
Passing #200	2.8
	100.0

III. Overview of Methodology for Mix Design #1

1. For gilsonite-modified mixes, the gilsonite powder was weighed out and hand mixed slowly into the asphalt, which was heated to 350° F.
2. All aggregates were oven dried at 230° F.
3. Aggregates were weighed up according to design percentages. Sixteen samples weighed about 890 g each, and one sample weighed 2000 g.
4. Each sample was heated to 350° F and blended with 350° F asphalt by hand trowel over a continuously heated sand bath.
5. Four samples were air cured for 2.5 hours, heated back up to 250° F, molded to 93±1% theoretical density, and shipped to the Materials and Tests Division in Austin to have stabilities determined.
6. Twelve samples were cured for 24 hours at room temperature, heated back up to 250° F, and molded to 93±1% of theoretical density. Specific gravities and densities were then determined, as per Test Method Tex-207-F.
7. Out of the above 12 samples, eight with the closest densities were chosen for conditioning and indirect tensile strength testing, as per Test Method Tex-531-C. Four of these were stored in a desiccator. The other four were conditioned as follows:
    - Vacuum saturated to 60%-80% with water for 5 minutes or more
    - Frozen overnight
    - Conditioned in 140° F water bath for 24 hours
    - Restabilized in 77° F water bath for 3 to 4 hours

III. Overview of Methodology for Mix Design #1 (continued)

8. The conditioned and unconditioned molds were tested for indirect tensile strength.

9. The 2000 g sample was reduced to 1000 g and the actual specific gravity was determined, as per Test Method Tex-227-F:

   - Cured 24 hours and hand/trowel crushed
   - Put in a flask, covered with 77° F water, and vacuum saturated for 15 minutes at 30" mercury
   - Weighed and specific gravity calculated

IV. Results From Mix Design #1

Group	Average Stability	Average Indirect Tensile Strength		Ratio Wet/Dry
		Dry (psi)	Wet (psi)	
Control 1	37	124.10	40.53	0.33
4% Gilsonite	41	171.78	62.36	0.36
6% Gilsonite	36	178.30	51.50	0.29
8% Gilsonite	41	169.10	50.50	0.30

IV. Results from Mix Design #1

Figure 1
Stability vs. Percent Gilsonite in Asphalt
Mix Design #1 — Parker Bros. Brittmore

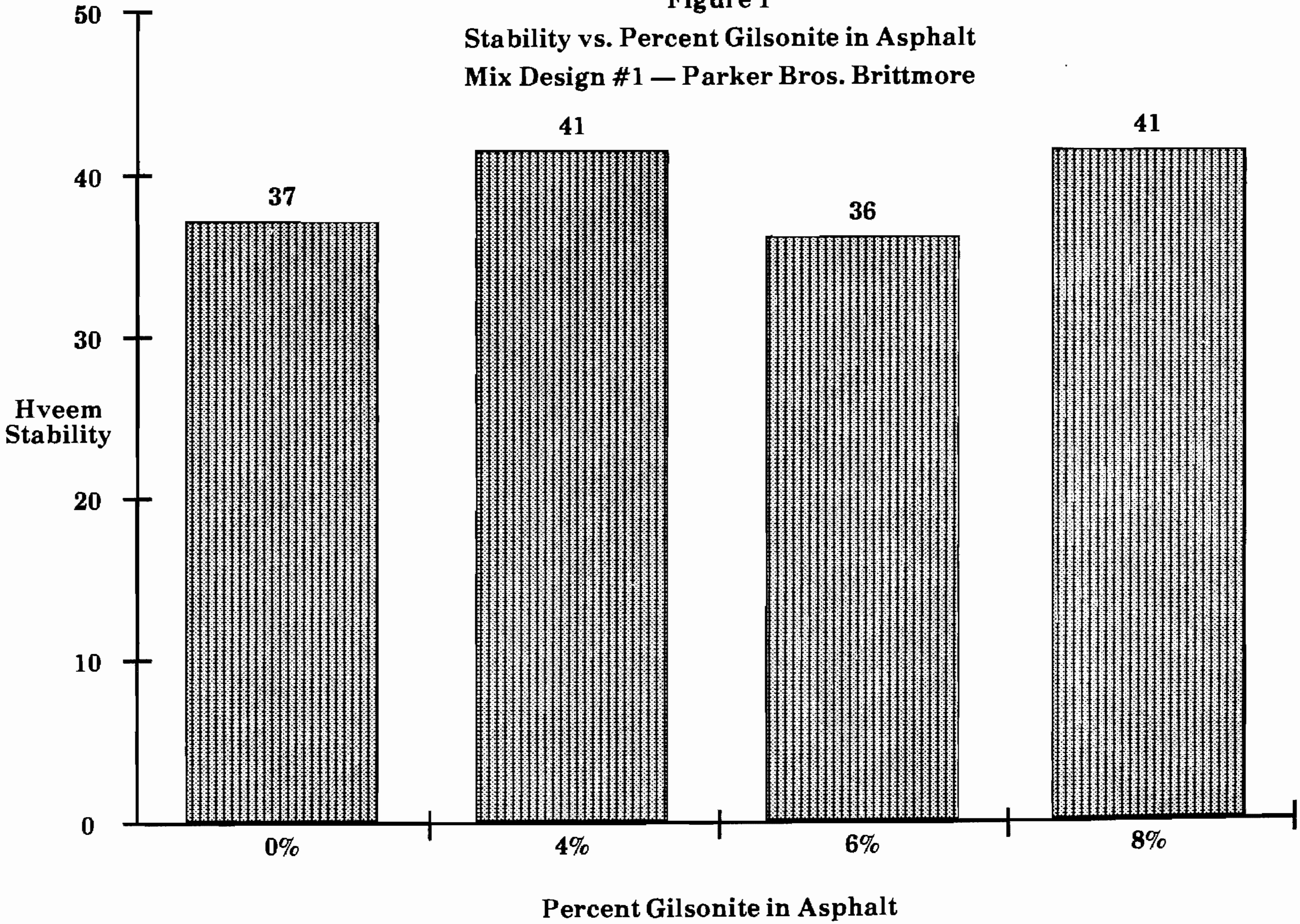
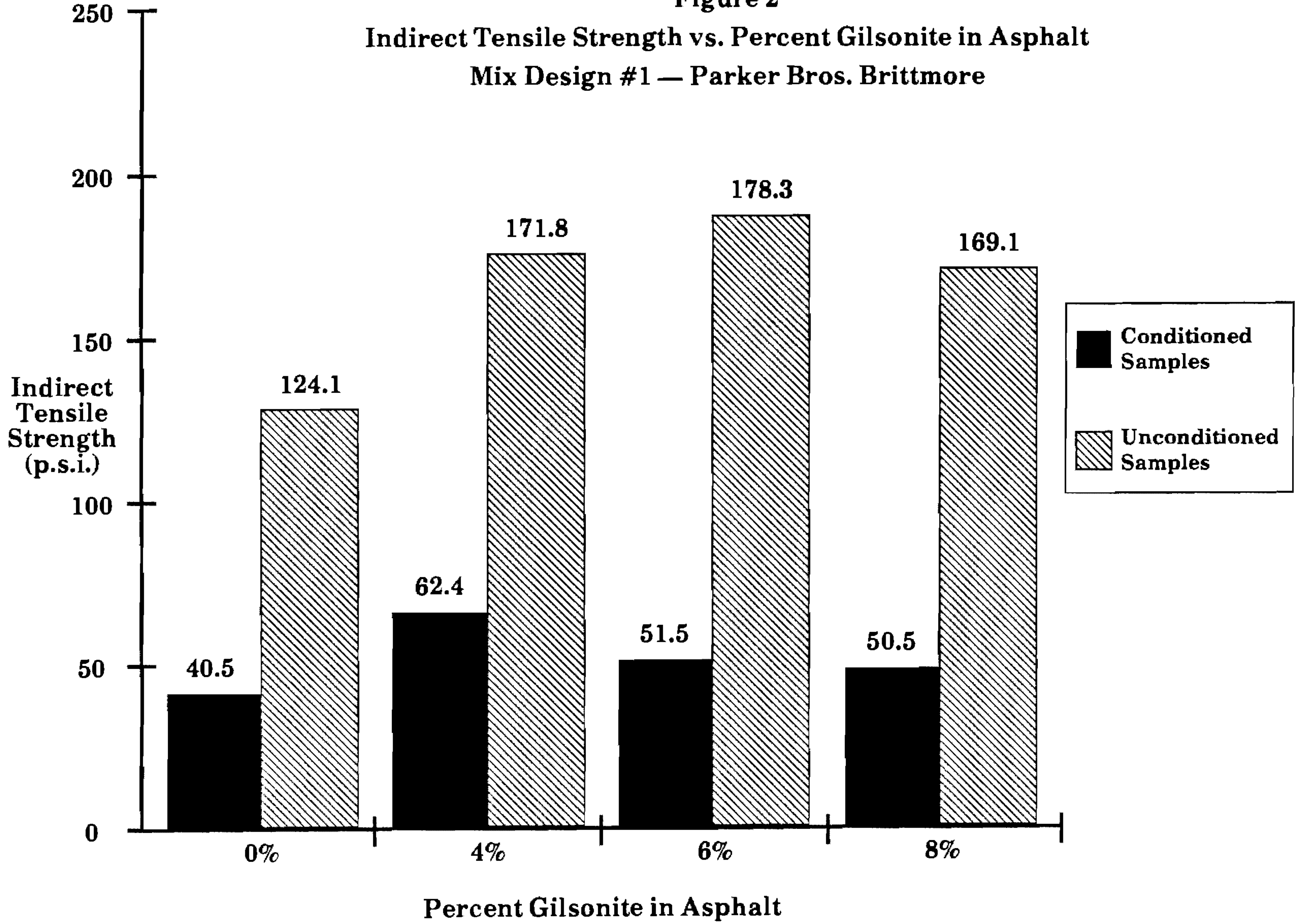
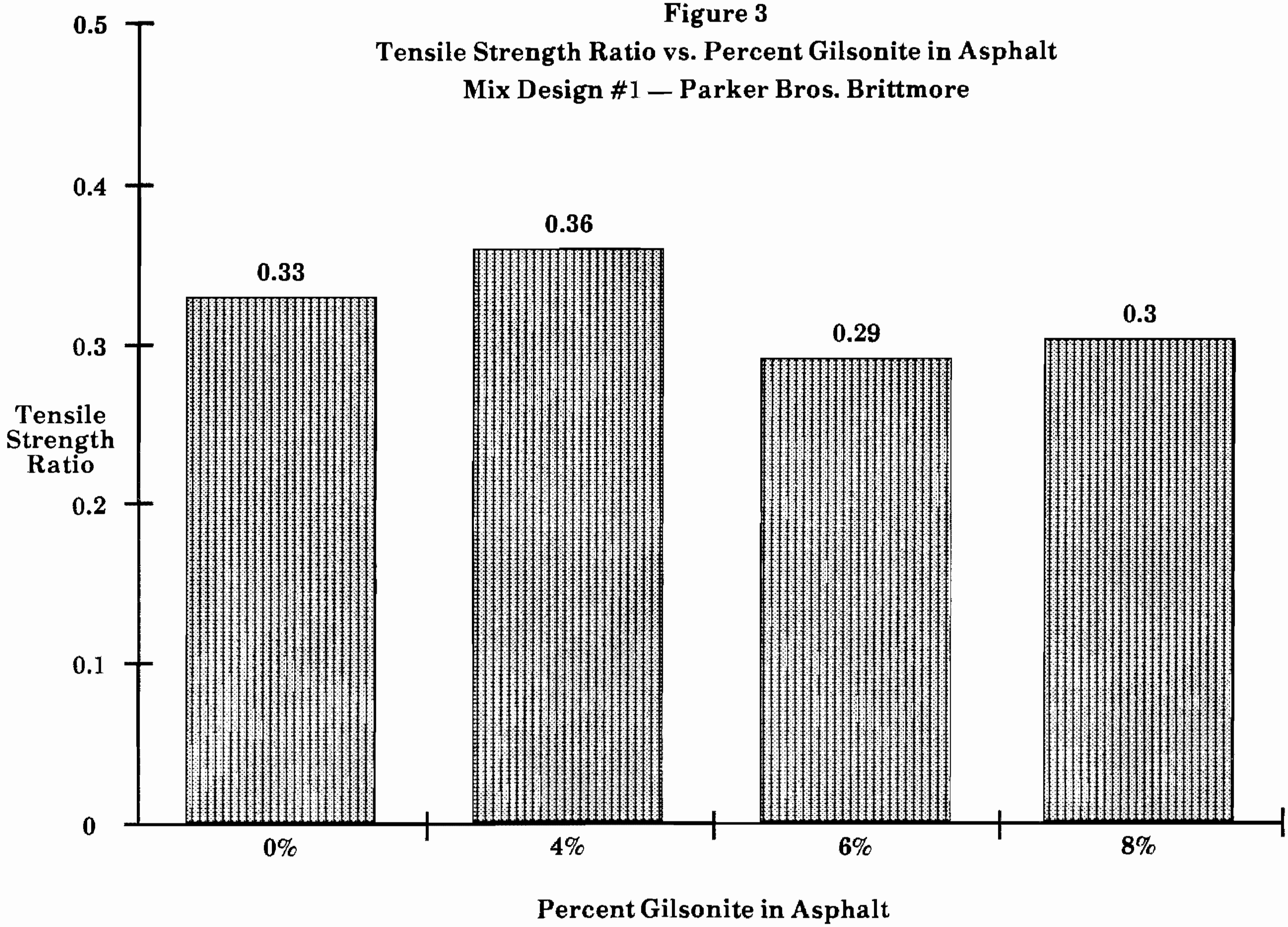


Figure 2
Indirect Tensile Strength vs. Percent Gilsonite in Asphalt
Mix Design #1 — Parker Bros. Brittmore



0.5

Figure 3
Tensile Strength Ratio vs. Percent Gilsonite in Asphalt
Mix Design #1 — Parker Bros. Brittmore



V. Mix Design #2 — Proportions and Material Sources

Tables 3 and 4, below, show the type of materials used, their design percentages, their sources and the gradation for this mix.

Table 3. — Mix Design #2

Type of Material	Percentage	Source
"D" Sandstone	38%	Delta, Marble Falls, TX
"F" Limestone	20%	Pioneer, Burnet, TX
Limestone Screenings	19%	Pioneer, Burnet, TX
Sand	23%	Pioneer, San Jacinto River
Asphalt (Grade 20)	5.4%	EXXON
Gilsonite	0-8% by wt. of asphalt	American Gilsonite, Utah

Table 4. — Gradation for Mix Design #2

Sieve Size	Percentage Retained on Sieve
1/2" — 3/8"	8.2
3/8" — #4	34.9
#4 — #10	15.7
#10 — #40	13.0
#40 — #80	17.4
#80 — #200	6.4
Passing #200	4.4
	100.0

VI. Overview of Methodology for Mix Design #2

1. For gilsonite-modified mixes, the gilsonite powder was weighed out and mixed into the asphalt using a paint mixer attached to a drill.
2. All aggregates were oven dried at 230° F and heated up to 350° F.
3. Total weight of aggregates was calculated for 16 molds and one actual specific gravity sample. These were then weighed and added to a commercial mixing bowl heated to 350° F.
4. The heated asphalt and aggregates were mixed in the bowl with a heated whip on a Hobart mechanical mixer for approximately five minutes over continuous heat.
5. Sixteen 940 g samples and one 2000 g sample were weighed.
6. Four 940 g samples were air cured for 2.5 hours, heated back up to 250° F, molded to 93±1% theoretical density, and shipped to the Materials and Tests Division in Austin to have stabilities determined.
7. Twelve 940 g samples were cured for 24 hours at room temperature, heated back up to 250° F and molded to 93±1% of theoretical density. Specific gravities and densities were then determined, as per Test Method Tex-207-F.
8. Out of the above 12 samples, eight with the closest densities were chosen for conditioning and indirect tensile strength testing, as per Test Method Tex-531-C. Four of these were stored in a desiccator. The other four were conditioned as follows:
    - Vacuum saturated to 60%-80% with water for 5 minutes or more
    - Frozen overnight
    - Conditioned in 140° F water bath for 24 hours
    - Restabilized in 77° F water bath for 3 to 4 hours
9. The conditioned and unconditioned molds were tested for indirect tensile strength.
10. The 2000 g sample was reduced to 1000 g and the actual specific gravity was determined, as per Test Method Tex-227-F:
    - Cured 24 hours and hand/trowel crushed
    - Put in a flask, covered with 77° F water, and vacuum saturated for 15 minutes at 30" mercury
    - Weighed and specific gravity calculated

VII. Results From Mix Design #2

Group	Average Stability	Average Indirect Tensile Strength		Ratio Wet/Dry
		Dry (psi)	Wet (psi)	
Control 1	40	74.50	47.90	0.64
4% Gilsonite	38	103.70	87.60	0.84
6% Gilsonite	39	121.30	80.60	0.66
8% Gilsonite	33	153.30	138.00	0.90

Figure 4
Stability vs. Percent Gilsonite in Asphalt
Mix Design #2 — Pioneer Goodnight Trail

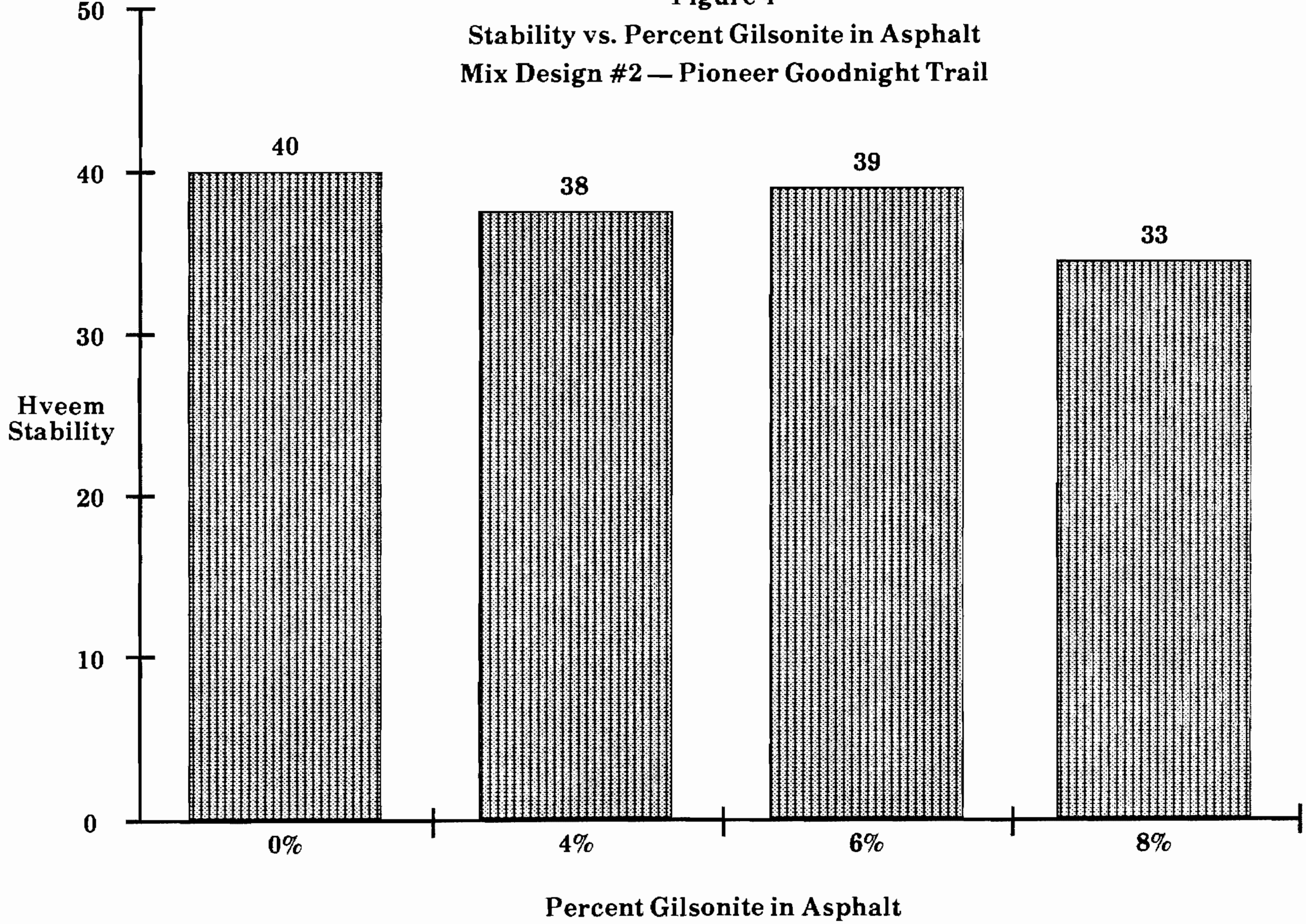
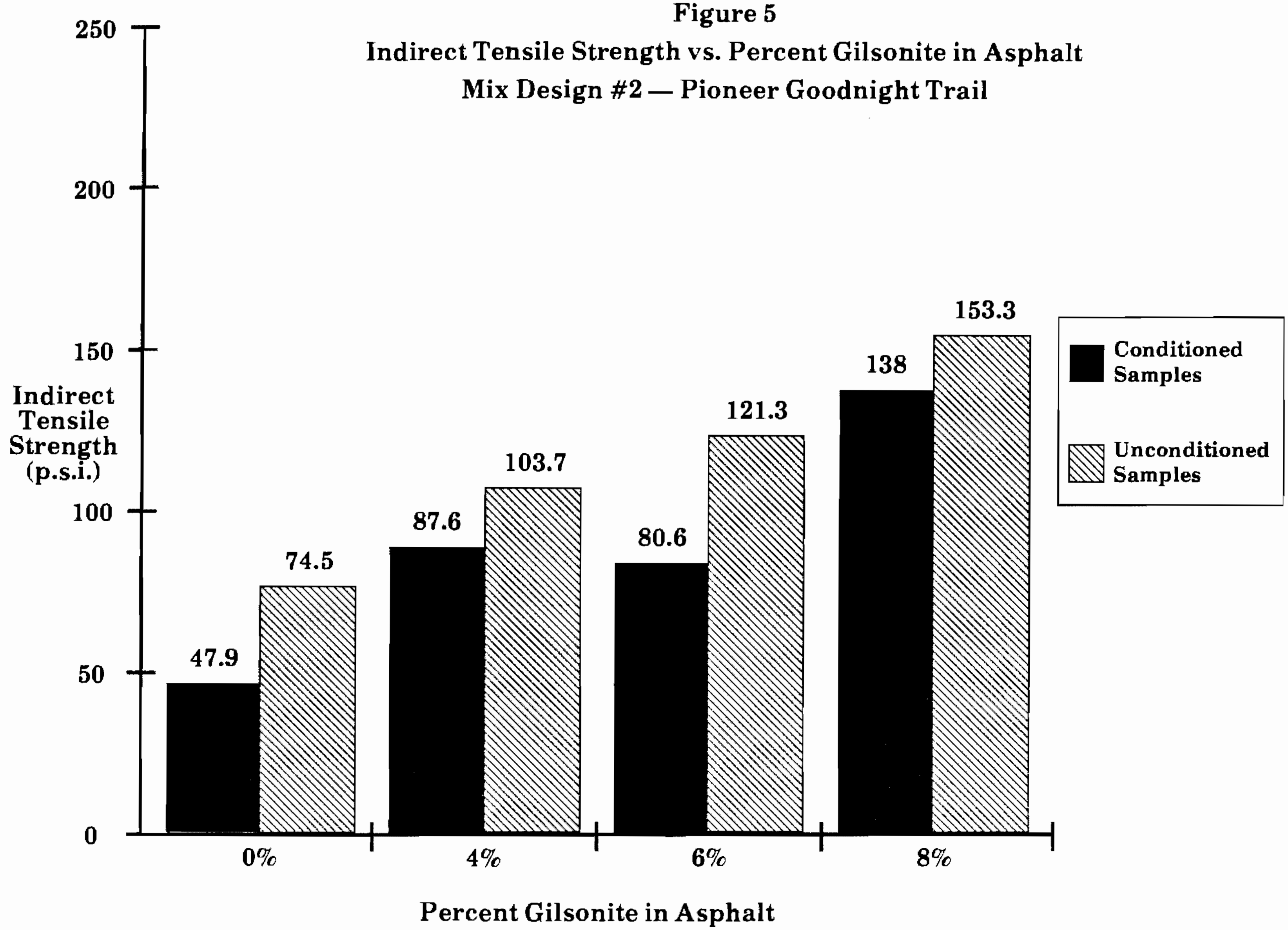
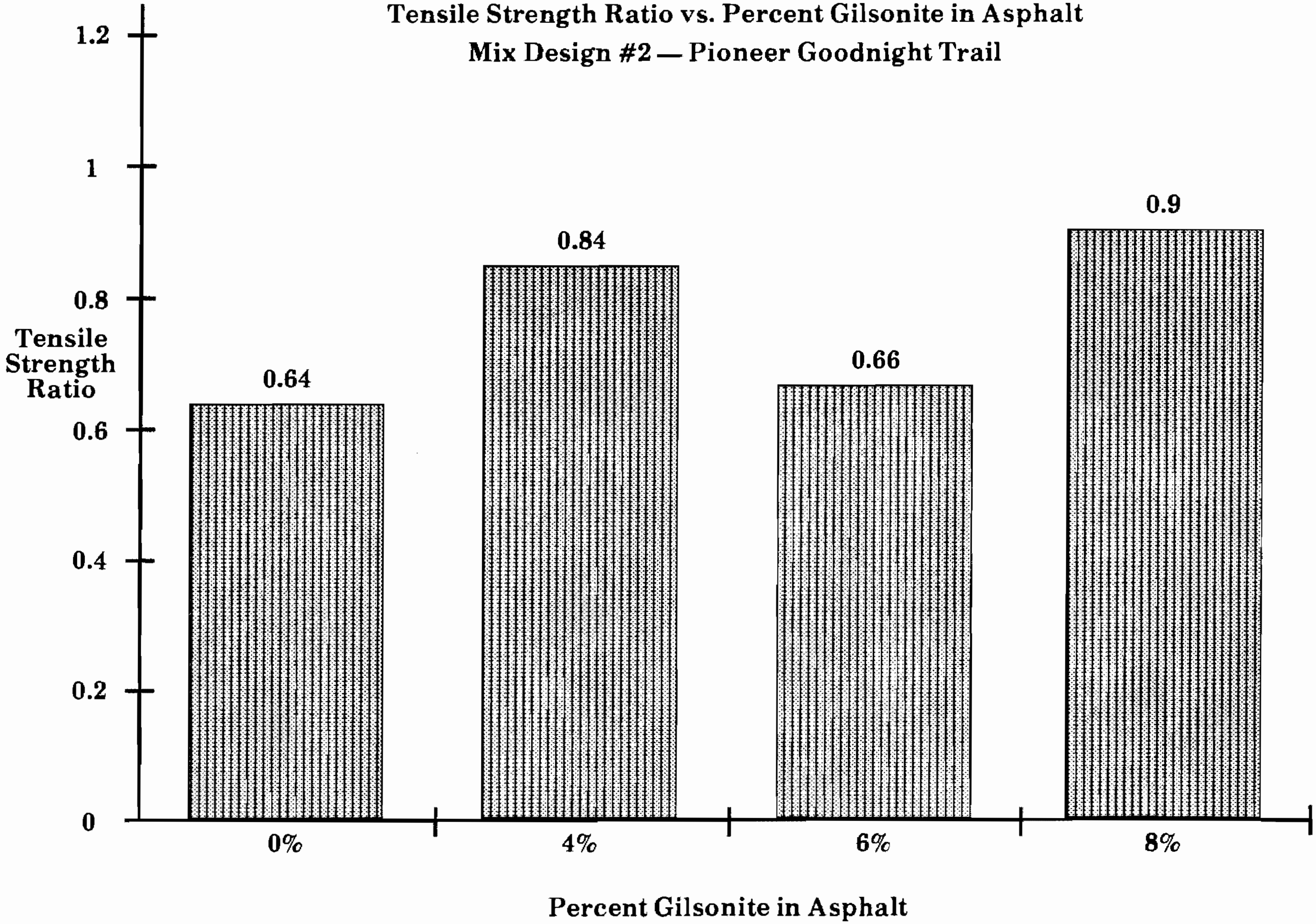


Figure 5
Indirect Tensile Strength vs. Percent Gilsonite in Asphalt
Mix Design #2 — Pioneer Goodnight Trail



Percent Gilsonite in Asphalt

Figure 6
Tensile Strength Ratio vs. Percent Gilsonite in Asphalt
Mix Design #2 — Pioneer Goodnight Trail



VIII. Conclusions

1) The addition of gilsonite to the asphalt did not significantly increase stabilities in either mix design #1 or mix design #2, as shown in Figure 1 and Figure 4.

2) The addition of gilsonite to the asphalt in mix design #1 increased the dry tensile strength by more than 45 psi, but only increased the wet tensile strength by 10 to 12 psi, as shown in Figure 2.

3) The addition of gilsonite to the asphalt in mix design #1 did not increase the tensile strength ratio at 6% or 8% gilsonite, but did increase it at 4%, as shown in Figure 3.

4) The addition of gilsonite to the asphalt in mix design #2 increased both the wet and dry tensile strengths by as much as 90 psi and 78 psi, respectively, as shown in Figure 5. As the test results indicate, Gilsonite performs better in mix design #2. Apparent causes for this are the more uniform mixing of the gilsonite powder with asphalt by use of the high speed paint mixer, and the changes in the mix design itself and in the aggregates and source of asphalt.

5) The addition of gilsonite to the asphalt in mix design #2 increased the tensile strength ratio at 4% and 8%, but did not increase it at 6%, as shown in Figure 6.

IX. Recommendation

As indicated in our laboratory investigations, Gilsonite demonstrates its ability to increase the dry tensile strength of hot mix asphaltic concrete mixtures. Accordingly, the increase of tensile strength (cohesion) of the HMAC will reduce the possibility of rutting. However, our laboratory investigation does not clearly indicate that gilsonite is an anti-stripping agent. Therefore, gilsonite should be used with an anti-stripping agent to improve resistance to stripping and rutting.

Since our investigation was performed solely in the laboratory and without field evaluation, it is imperative that the field performance of gilsonite-modified hot mix asphaltic concrete be fully investigated in the high temperature, heavy rainfall environment of this District before it is approved for use on our projects.

Appendix A
Gilsonite Properties and Mix Test Results

I. Properties of Gilsonite

Softening Point	350° F
Specific Gravity	1.05
Volatiles	2%
Ash	0.6% – 1.0%

Gradation

Sieve Size	Percentage Retained
10 mesh	3
20 mesh	12
35 mesh	25
65 mesh	10
100 mesh	15
Passing #200	35

II. Properties of Gilsonite-Modified Asphalt and Mix

Viscosity – 3% gilsonite by weight of asphalt doubled viscosity.

Brittel Point – was not raised with the addition of gilsonite.

Marshall Stability – 8% gilsonite in the asphalt increased stability by 25%

Water Susceptibility – was reduced in a granite gneiss mixture which was tested after a 24-hour immersion in 140° F water. After the immersion, control mixes fell apart, but mixes with 4% or 8% gilsonite by weight of the asphalt increased in stability by 2700 Newtons.

Dynamic Modulus – at various frequencies and temperatures above room temperature, a 10% gilsonite mix doubled the modulus.

Wheel Track Testing – penetration was lowered by 30 dmm for mixes with 4% or 8% gilsonite when a 70 kg load was passed over the pavement sample at 21 reciprocations/minute for 1 hour at 140° F.

Fatigue Life – of mixes was increased by 34% when 10% gilsonite was used.

Appendix A (Continued)

III. Some Results From Roadway Testing

- A 5% gilsonite mix used in Australia to alleviate rutting problems is reported to be in good shape.
- An 8% gilsonite mix laid down in the Port of Seattle to alleviate rutting problems is reported to be holding up.
- 10% gilsonite was added to a hard bitumen to double the stability of a mix placed on the New Jersey Turnpike, which has held up.