This report documents a Chemkrete modified asphaltic concrete field trial construction and presents three year performance data. Normal plant and roadway operations were maintained throughout the production of the Chemkrete modified mix. Initial binder testing, however, indicated the possibility of non-uniform blending of the Chemkrete additive. An additional problem surfaced during production control and acceptance testing: stabilities below specification limits. While upon curing the mix attained stabilities greater than the control mix, the low initial stabilities may require changes in control and acceptance procedures.

Performance evaluations were conducted on an annual basis and included pavement condition ratings, structural evaluation and the examination of binder properties (as extracted and recovered from roadway samples). No discernable performance differences were observed on the basis of these parameters. Both the conventional AC-30 binder and the Chemkrete modified binder demonstrated excessive aging characteristics. The aged binders, both conventional and modified, have contributed to loss of surface fines and wider than normal reflected shrinkage cracking from the soil cement base. The benefits of Chemkrete could not be ascertained during this evaluation period.

CHEMKRETE MODIFIED ASPHALTIC CONCRETE
FIELD TRIAL

CONSTRUCTION AND THREE YEAR EVALUATION

by

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EXPERIMENTAL PROJECT PROGRAM
ASPHALT ADDITIVES

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INTRODUCTION

Background

From the late 1970's to the present, Louisiana has directed much of its bituminous research effort to the area of asphalt additives. These efforts were initiated in response to a steadily decreasing quality aggregate supply in several districts. The associated problems were reflected by deteriorating mix properties and the higher costs of transporting quality materials. A number of additives were examined in either the laboratory and/or field including sulphur, Styrelf 13 (a polymerized asphalt), latex, and Trinidad Lake Asphalt. Each of these products proclaimed mix enhancements such as increased strength and durability as reflected by fatigue resistance, improved temperature susceptibility, resistance to deformation and resistance to water susceptibility. These additives were examined in dense graded asphaltic concrete in order to obtain better mix properties. Also, several of these additives were utilized to upgrade sand/asphalt mixes to take advantage of marginal sand materials prevalent in those districts where gravel was in short supply or non-existent.

In 1979, the Department was approached by representatives of Chem-Crete Corporation (later changed to Chemkrete when acquired by Lubrizol Corporation). They had developed an asphalt additive (soluble manganese) which, when blended with asphalt cements, would improve asphaltic concrete properties such as strength, temperature susceptibility and water susceptibility. The increased structural capacity of Chemkrete mixes due to the improved strength characteristics would allow for the use of non-quality aggregates such as sand. According to the literature successful projects utilizing desert sand had been constructed in the Middle East and Nigeria. On this basis it was decided to examine Chemkrete in the laboratory.

this time period the manganese concentration was reduced along with the use of softer grades of asphalt. Upon acquisition of the U. S. patents by Lubrizol in 1982, Chemkrete Technologies Inc. was formed as a wholly owned subsidiary. The product was additionally modified and the blended ratio of asphalt cement to Chemkrete was increased. The newer field trials did not experience the extensive cracking and ravelling of the earlier projects. With this in mind, Louisiana decided to attempt a field trial.

In August 1983, a plan change was issued to an on-going contract to include the use of the Chemkrete additive for approximately 2.5 miles of a 10.2 mile reconstruction project. This report documents the construction of the Chemkrete field trial and presents three year performance data.

FIELD EXPERIMENTAL PROJECT

Location and Section Design

An agreement was made whereby the construction of the test section was made part of an on-going contract with Prairie Construction Company, Inc., Mr. L. L. James, President. This 10.2 mile project on La. 10 in St. Landry Parish from Palmetto to Melville, Louisiana, consisted of 3.5 inches of asphaltic concrete overlay over existing surfacing for 3.5 miles and 3.0 inches of asphaltic concrete over 8.5 inches of in-place cement stabilized base course for 6.7 miles. The change order provided for the addition of Chemkrete modifier in 2.5 inches of asphaltic concrete for 2.5 miles of the cement stabilized section. The Chemkrete modified mix was placed in a single lift, while the normal design called for two 1.5 inch lifts of binder and wearing course. Figure 1 presents a design typical section for the Chemkrete treated materials.

recommended by Chemkrete personnel. The location of this material is annotated in Figure 2 and consisted of the majority of the first day's production.

No modifications or changes in production were necessary for the 400 ton per hour capacity dryer drum plant.

Materials and Mix Design

The source of coarse aggregate was a river gravel from Red Stick No. 1 (Bayville) while the sources for the coarse and fine sands were Trinity (Longville) and Mamou Pit, respectively. Texaco supplied both the AC-30 and AC-20 asphalt cements from their plant at Port Neches, Texas. Perma-Tac antistrip agent from Dasch Oil and Chemical Company was utilized at a rate of 0.5% by weight of the asphalt cement according to specifications.

Job Mix Formulas for the binder and wearing course mix used on this project are shown in Table 1. The Chemkrete mixes utilized the same JMF as the control mix wearing course.

Construction

Plant production of the Chemkrete modified asphaltic concrete began on September 2, 1983 and continued on September 8-9, 1983, under fair to cloudy skies with daytime temperatures in the mid nineties and nighttime temperatures in the high seventies. There were no modifications to normal plant or roadway procedures during the three days of production of the Chemkrete mix. Table 2 presents production data for the Chemkrete mix. Data for the conventional mix used as a control is also provided. It should be noted that the control wearing course was not placed until March 1984.

TABLE 1

PROJECT JOB MIX FORMULAS

Sequence No.	1	4
Mix Use	Binder	Wearing

Recommended Formula
<u>Percent Passing</u>

U. S. Sieve Size		
1-1/4"	100	100
1"	99	100
3/4"	94	97
1/2"	86	91
No. 4	57	57
No. 10	44	45
No. 40	28	28
No. 80	14	14
No. 200	7	7
% AC	5.0	5.5
% Crushed	80	80
Mix Temp.	300	300

<u>Marshall Properties</u>

Specific Gravity	2.33	2.33
Theoretical Grav.	2.44	2.43
% Theoretical	95.5	95.9
% Voids	4.5	4.1
% V.F.A.	72.0	75.2
Marshall Stability	1400	1400
Flow	6	8

The Marshall briquettes brought back to and tested at the research section indicate that, when cured, the Chemkrete mix does develop the additional strength associated with the additive. Generally the data follows the trend established in the earlier laboratory study with strengths leveling off in approximately two weeks. Figure 3 presents this relationship.

Fortunately, the lower than anticipated plant stabilities did not pose a problem at the roadway. In fact when queried, roadway personnel, both department inspectors and contractor, replied that the Chemkrete modified mix was easier to lay and compact than the conventional mix. These results seem to be substantiated by the roadway core data as presented in Table 6, wherein the Chemkrete modified mix had higher specific gravities than the conventional mix.

In addition to normal quality control tests, several samples of the asphalt cement/Chemkrete binder were returned to the Department's materials laboratory to determine manganese content (manganese content being the Chemkrete identifier). These samples, tested according to procedures established by the manufacturer, registered manganese contents of 0.012 and 0.022. The manufacturer's representative indicated that the level of manganese should be approximately 0.1.

THREE YEAR PERFORMANCE EVALUATION

Chemkrete modified and conventional asphaltic concrete sections were examined to evaluate performance characteristics from both a structural and serviceability aspect. Serviceability was monitored with a pavement condition rating (PCR) which incorporates Mays Ridemeter measurements for smoothness and different types of pavement distress such as bleeding, block, transverse and longitudinal cracking, corrugations, patching, rutting and ravelling. Each distress type is evaluated and assigned weighted deduct points based on severity and intensity of the distress. A sample rating form is presented in Figure 4. The sum total of deduct points forms a pavement distress rating, PDR, by substracting from 100 percent, weighting and then combining with a weighted Mays reading in PSI in the following manner to provide the pavement condition rating.

$$PCR = [(100 - \text{Deduct Total Points})/4] + (\text{Mays PSI}) \times 5$$

(A perfect pavement score would be 50)

The Dynamic Deflection Determination System (Dynaflect) was used to evaluate the relative strengths of both the modified and conventional pavements. In addition, roadway cores were examined for further densification due to traffic and the quality of the asphalt cement. Performance evaluations were conducted at six sites on the project with each site encompassing approximately 200 feet. These sites were located as follows (also designated on Figure 2, page 7, by Site ID).

Site I.D.	Mix Type	Location
A	Modified W. C. (AC-30)	RL MP 5.5
B	Wearing Course	RL MP 0.3
C	Modified W.C. (AC-20)	RL MP 9.3
D	Modified W.C. (AC-20)	LL MP 9.1
E	Wearing Course	LL MP 1.05
F	Modified W.C. (AC-20)	LL MP 5.8

As the control section was constructed six months after the experimental Chemkrete sections, those sites representing the conventional mix, B and E, were evaluated separately with a six month lay time.

Pavement Condition Rating

The pavement distress, Mays Ridemeter and overall pavement condition ratings are provided in Table 7. It is noted that the Mays readings for the second year Chemkrete evaluation and consequently the pavement condition ratings are missing. This was due to the loss of the Mays equipment for major overhaul.

It would appear that the control sections were performing better than the Chemkrete sections from the third year data. However, a look at the PDR shows very little difference in distress between the sections. While the Mays rating for section E is similar to previous ratings, section B at 4.8 appears to be rather high. In fact, with 5.0 being a perfect rating the 4.8 reading seems erroneous in light of the previous Mays ratings and the distress rating.

For all sections, the distress deduct points were related to either cracking or rutting. Rutting was measured at five locations in the outside wheelpath each 200 foot designated evaluation site. All sections with the exception of "C" displayed up to 0.1 inch rutting measurements after the first year. Section C reached that level at year three. No rut depths exceeded 0.2-inch by the third year. Measurements of 0.1-0.2 inch are common in Louisiana mixes and are assumed to be caused by additional densification by traffic.

Generally, block and transverse cracking due to reflected soil cement shrinkage cracks were observed during the second year evaluation at all sites. The severity and extent were equivalent for the conventional and Chemkrete sections. Wheel path cracking was apparent in all sections except B by the first year evaluation. The severity of this distress mode was greatest for sections A and F. As of the third evaluation, section B did not have any wheel path cracking, while the other conventional section, E, had cracking similar to the Chemkrete sections.

Although it was not noted on the distress rating forms, a loss of surface fines was observed throughout the project on both the experimental and conventional sections. Loss of surface fines is not common for Louisiana pavements for this term of service.

Structural Evaluation

Dynaflect testing was accomplished at each site. A temperature deflection adjustment procedure was applied to each section, converting all deflections to their equivalent deflection at 60°F. Deflection data and corresponding structural numbers are included in Table 8.

The data seems to indicate two levels of performance on this roadway. However, these levels are not distinguishable as conventional versus experimental. For the Chemkrete sections, A and F demonstrate higher deflections and lower structural numbers (SN) than C and D. Referring to Figure 2 (page 7) it is found that these paired sections are separated by approximately three miles. Inherent in the SN and maximum deflection would be the amount of support provided by the subgrade and the soil cement base. Certainly, there could be differences in the uniformity of the mixed-in-placed soil cement base between these two areas. Also, the subgrade modulus indicates a lower level of performance for sections A and F. It is noted that A and F are located in an area subject to flooding so that moisture could be affecting the performance of these sections.

The conventional sections performed similarly to the Chemkrete sections with B providing lower deflections and a higher SN than E. Subgrade modulus indicates a difference in the level of support which along with the possibility of nonuniformity of the soil cement base seems to account for the differences.

Roadway Cores

One six-inch diameter roadway core was taken at each site during each evaluation. The specific gravity of each core was determined and then the asphalt cement was extracted. The binder content was determined and gradations were run on the aggregate samples. An Abson process was used to recover the binder for viscosity (140°F), penetration (77°F) and ductility (77°F) testing.

Specific Gravities and extraction analysis results are presented in Table 9. The specific gravities obtained after year one are greater than those achieved immediately after pavement construction

(Table 6, page 16) confirming the additional densification noted by the distress ratings. Unlike most Louisiana mixes no further densification due to traffic was noted after years two and three. This lack of additional densification may be caused by excessive binder hardening as found during binder properties testing.

All of the Chemkrete sections approach the design air void content with the exception of C. It is noted that the gradations obtained for C are finer than the other sections with a binder content on the low side of the job mix formula. This factor could contribute to the higher void level. The same reasoning would apply to the conventional sections, where low binder contents were found in three of the four extractions presented. Also, it is noted that the original construction compaction level was lower (Table 6) for the conventional mix.

Table 10 presents the properties of the recovered binder including results from loose mix and roadway cores sampled during construction. The properties obtained from the binder recovered from the loose mix and field cores was representative of mix placed from the particular lot containing each sample site. The lack of construction properties for the conventional mix was due to miscommunication and the delayed construction of those sections.

Sites A, C and F provide values which would be consistent with laboratory experience of the Chemkrete additive, in that large increases in viscosity and decreases in penetration and ductility were observed. Certainly, the 200,000+ poise viscosity attained by the third evaluation would be consistent for a Chemkrete binder. There does appear to be some unaccountable variation in binder properties during the earlier evaluations. For instance the AC-30 plus Chemkrete would be expected to have aged faster than those blends with AC-20, while at site D the viscosity is much lower after the first year and much higher after the second year than the other sections with supposedly the same binder. Such findings lead to suspicion of inadequate blending at the plant which was supported by the lower than anticipated manganese content found in binder samples tested during construction.

An unexpected hardening was found in the binder extracted from the conventional sections. In fact, the AC-30 from sites B and E hardened at a rate which was atypical for Louisiana asphalts and was greater than the Chemkrete materials. The excessive oxidation of this AC-30 is most likely due to one of the crudes used in its blend.

It is known that Texaco was utilizing a Maya crude source during this time period. The actual percentage of Maya utilized was not known. Several experimental field installations constructed with an AC-30 which was composed of 100 percent Maya crude (by a different refiner) have demonstrated a similar tendency. However, to our knowledge, blends of maya and other crude sources utilized in Louisiana have not oxidized as quickly as the AC-30 encountered on this project.
It is not known whether or not the AC-20 blended with the Chemkrete also utilized Maya as a blend stock. If so, then the hardening of the binder in the Chemkrete sections could be attributed to the asphalt and possibly only partially to the Chemkrete. Such assumptions would be consistent with the lower than expected manganese content found in the binder sampled during construction.

General Discussion

To date the Chemkrete sections are performing as well as the conventional hot-mix control section. No differences in performance have been noted. There are, however, several inconsistencies noted during the conduct of this study which could preclude the use of this field trial as justification for implementing the use of the Chemkrete product at this time.

Demonstration projects utilizing Chemkrete additive constructed prior to this installation displayed extensive cracking and ravelling which in some cases resulted in additional overlays. Such was not the case in the Louisiana field trial. The cracking that occurred on this project is typical reflected shrinkage cracking observed whenever a flexible surfacing is placed on soil cement. The crack width, though, was greater than that seen on pavements of this type and age. However, this was true for both the control and the experimental mix. The excessive hardening found in the conventional AC-30 binder would contribute to such a state. Likewise, a loss of surface fines could also be attributed to hardened asphalt cement. An assumption that the AC-20 used in the Chemkrete sections was derived from the same crude sources as the AC-30 and the finding of low manganese content in the construction samples would confuse conclusions with respect to the cause of distress in the Chemkrete sections.

Due to the increase in binder consistency in both the Chemkrete and control sections, it is also difficult to assess the manufacturer's claim that Chemkrete will provide additional pavement strength. The structural analysis indicates two levels of performance on this project which cannot be relegated to a Chemkrete/conventional difference. Generally, the two distinct levels of deflection and SN can be attributed to subgrade support. Chemkrete sites C and D (log mile 9.0-9.5) have markedly higher elastic moduli than Chemkrete sections A and F (logmile 5.5-6.0). Likewise, the control sections demonstrated two levels of SN (at the same magnitudes as the Chemkrete sections) which seem to be related to a difference in subgrade support. It could be argued, though, that the Chemkrete mix does provide greater strength as those sections were constructed at 2.5-inch thickness as opposed to the 3.0-inch thick control section; ie., discounting the affect of subgrade support the higher level Chemkrete sites C and D and control site B with similar SN's of 4.2-4.6 would indicate that on a per inch basis, the Chemkrete mix would have a higher structural coefficient. The same situation occurs at the lower level SN, 3.4-3.5 (sites A, F and B). This point could be confounded by the air void analysis as it was found that generally, the conventional mix was not as dense as the Chemkrete mix. Such a disparity in air void content could act to nullify the apparent strength advantage attributed to Chemkrete.

CONCLUSIONS

1. After three years of age, there was no discernable difference in the performance parameters investigated between the Chemkrete modified and control sections. Various factors addressed in other conclusions leave doubt as to the value of this project for assessing the benefits of Chemkrete modified asphaltic concrete.

2. Binder samples tested during construction indicated that the Chemkrete additive was either non-uniformly blended or was present at a lower than expected concentration since the major component, soluble manganese, was found at 0.1 of the projected level.

3. Excessive hardening of the binder was found in both the Chemkrete and control sections. The cause of this hardening in the conventional AC-30 is probably due to one of the crude feed stocks which has previously demonstrated similar characteristics. Laboratory experience with Chemkrete modified binders showed that this type of accelerated hardening is characteristic of the additive. However, as the feed stocks for the AC-20 used to blend with the Chemkrete were probably the same as those that produced the AC-30 and in light of the lower than expected concentration of manganese in the binder samples, the hardening of the Chemkrete modified binder cannot necessarily be attributed to the Chemkrete.

4. Wider than expected reflective cracks and loss of surface fines were the manifestation of the excessively hardened binder for both modified and control sections.

5. Normal control and acceptance testing may need modification to accommodate the inherent "curing" properties of Chemkrete modified mix.

6. Greater than normal Marshall strengths were attained in Chemkrete modified asphaltic mixtures upon curing.

IMPLEMENTATION STATEMENT

As the conclusions of this report state there are no discernable differences in performance between the Chemkrete modified and control sections. It is further suggested that inconsistencies in the data obtained leave doubt as to the value of this project to evaluate the potential benefits of the Chemkrete additive. With this in mind the use of Chemkrete could not be recommended at this time.

TABLE 10

BINDER PROPERTIES

Section	A	C	D	F	B	E
Viscosity (140ºF) (Poise)						
Loose Mix	5,451	2,048	2,048	1,840	-	-
Field Core	3,501	2,077	2,077	2,066	-	-
Year 1	25,059	30,052	10,361	25,016	47,887	54,911
Year 2	53,163	63,567	119,246	81,091	200,000+	200,000+
Year 3	200,000+	200,000+	200,000+	200,000+	200,000+	200,000+
Penetration (77ºF) (cm/cm)						
Loose Mix	57	88	88	87	-	-
Field Core	65	87	87	83	-	-
Year 1	31	27	41	29	23	19
Year 2	22	21	18	18	12	15
Year 3	15	15	12	11	14	12
Ductility (77ºF) (cm)						
Loose Mix	150+	150+	150+	150+	-	-
Field Core	150+	150+	150+	150+	-	-

Year 1	26	21	134	31	14	12
Year 2	8	12	7	9	6	6
Year 3	7	7	6	6	7	6