EVALUATION OF RECYCLED PROJECTS FOR PERFORMANCE

FINAL REPORT

By

HAROLD R. PAUL, P.E.
MATERIALS RESEARCH MANAGER

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LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
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ABSTRACT

Louisiana constructed two hot mix recycling projects in 1978 in order to determine the feasibility of this technology with respect to design and construction. In 1980-81 four recycled projects were constructed to examine the variations found in recycled asphaltic concrete mixtures based upon plant quality control data and verification testing. This report presents the results of a follow-up study which examined the performance of five of these projects with five conventional construction projects utilized as a control.

The five year laboratory and field evaluation examined performance from structural, serviceability and distress perspectives. Structural integrity was evaluated with the Dynaflect; the Mays Ridemeter determined the serviceability index; and, a pavement distress type and severity rating was conducted which included such indicators as rutting, ravelling, cracking and patching. Also, materials from each roadway were sampled to determine mix densification and the asphalt binder quality as measured by absolute viscosity, penetration and ductility.

After nine years (one project) and six years (four projects) of service life, the recycled pavements have demonstrated the ability to perform similarly to the conventional hot-mix.

IMPLEMENTATION STATEMENT

Specifications were prepared in 1982 for the use of reclaimed asphalt concrete mix in all pavement mixtures up to a maximum of 30 percent except wearing course which allowed 15 percent. This specification was later modified to 10 percent in the wearing course. Supplemental specifications in 1987 eliminated the use of reclaimed material in wearing course mix because more than half of these mixes exceeded the 12,000 poise viscosity limitation.

The findings of this study indicate that pavements containing reclaimed materials performed similarly to conventional mixtures for a period of six to nine years of service life. These findings support the continuation of this program. Further economies could be achieved with the re-introduction of reclaimed material in the wearing course mix. The report indicates that the substitution of up to 15 percent can provide acceptable performing pavements as long as the 12,000 poise viscosity limitation is maintained.

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INTRODUCTION

In 1978, Louisiana constructed two asphaltic concrete recycling projects as part of a study to determine the construction feasibility and to evaluate recycled mix quality, economics and energy conservation. The technological feasibility of producing a recycled asphaltic concrete in both a batch and a dryer drum plant was demonstrated. Material test results indicated that recycled mixes had properties similar to conventional mixes. Economic and conservation aspects were favorable. The recommendations of the published report [1] called for the department to consider further development of the recycling concept. It was believed that specifications could be developed which would permit the substitution of a recycled hot mix for a conventional hot mix.

With regard to this recommendation, the Department let four recycling projects in 1981. The intent of these projects was twofold: (1) to promote the recycling concept among the state's contractors, and (2) to document the quality control aspects associated with recycling efforts on a broader data base. The variations found in the recycled mixtures for these four projects were similar to those of conventional hot mix for all control and acceptance testing including gradation, asphalt cement content, Marshall properties and roadway compaction. Analysis of the quality of the asphalt cement recovered from samples of the in-place recycled mixtures indicated that in order to meet specification limits for the maximum allowable viscosity of plant produced mix, constraints would have to be placed on the allowable reclaim/virgin ratio [2].

On the basis of these findings, supplemental specifications were approved permitting the use of reclaimed asphaltic concrete materials in any mix included in the asphaltic concrete specifications, such that any mixtures incorporating reclaimed material would have to meet all control and acceptance requirements. Also, in order to achieve a desirable viscosity in the plant produced mix, restrictions were placed on the quantity of reclaimed material allowed and the consistency of the virgin asphalt cement. An AC-30 grade asphalt cement would be required for mixtures utilizing up to 20 percent reclaimed material and an AC-10 grade asphalt cement would be required for reclaimed materials between 20 and 30 percent. Upon implementation of these specifications, a further restriction was placed on wearing course mixes limiting the maximum allowable reclaimed asphaltic concrete to 15 percent. Subsequently this was reduced to 10 percent. Supplemental specifications in 1987 eliminated the use of reclaimed material in wearing course mixes. It was reported that the viscosities of recovered asphalt cement from recycled mixes were greater than the 12,000 poise limit. Since most projects were of small tonnage, projects were being completed prior to central lab testing to determine the plant produced viscosity. After the fact tests indicated recovered viscosities between 12,000 and 20,000 poises.

Within two years, 65 projects had been constructed which used reclaimed asphaltic concrete [3]. It was decided that a performance evaluation should be undertaken to determine the similarities in performance between recycled and conventional pavements. In 1983 a study was initiated to accomplish that task. A combination of ten recycled and conventional pavements were chosen for evaluation over a five year period. The criteria for evaluation was to include pavement condition ratings, serviceability, structural analysis and mixture and binder properties. This report presents the findings of that evaluation.

OBJECTIVES AND SCOPE

The objective of this project was to determine the performance of recycled asphaltic concrete pavements with respect to conventional asphalt pavement performance.

The scope of this study was confined to a performance evaluation of five recycled and five conventional asphaltic concrete pavements over a five year period. At each of ten sites on each project, data were collected to determine serviceability, pavement distress and structural properties. Roadway cores were taken at five sites on each project to obtain mixture and binder properties such as density, gradation, asphalt content, viscosity, penetration and ductility.

METHODOLOGY

RESEARCH APPROACH

Project Selection Criteria

The first five projects constructed in Louisiana which used reclaimed asphaltic concrete were selected for this study. Since these projects had been used for the earlier construction feasibility and quality control studies [1,2], data bases had already been established. In addition, the projects were distributed statewide and would, by the end of this study, provide performance data for service lives of six to nine years.

U.S. 84, constructed in 1978, had a control section included in the design for the purpose of comparing the recycled and conventional mixes. The next four projects constructed in the 1981-82 season, however, were initiated to examine the quality control of recycled mixes compared to the historical data base. As such, no control sections were included on those projects. In order to compare the relative performance of the recycled projects, it was decided to select four conventional projects which were constructed during this same time frame. Additional selection criteria for these projects included the same contractor, if possible, and similar mix design, section design and traffic. In each case an attempt was made to chose a project to be paired with the recycled projects in the same geographical location. Table 1 provides the paired projects selected.

Project Locations

Geographical locations of the nine projects (U.S. 84 having its own control section) are illustrated in Figure 1. Note that the paired sections were in the same locale and that the projects chosen were widely distributed throughout the state.

TABLE 1

STUDY CONSTRUCTION PROJECTS

PROJECT	TYPE MIX	NEW DESIGN	EXISTING PAVEMENT	PROJECT ACCEPT DATE	1982 AVERAGE DAILY TRAFFIC
U.S.84 RECYCLED	ACFC 1 WC	MILL 2" 2-2" LIFTS	3.5"HMAC 8-6-8 PCC	8/78	7055
U.S.84 CONTROL	ACFC 1 WC	MILL 2" 2-2" LIFTS	3.5"HMAC 8-6-8 PCC	8/78	7055
U.S.90 RECYCLED	1 WC	MILL 2.5" 2-1.5"LIFTS	5.5"HMAC 8-6-8 PCC	1/82	3768
LA. 26 CONTROL	3 WC 3 BC	1.5" LIFT 2" LIFT	3.5"HMAC 9-6-9 PCC	6/82	2861
LA. 21 RECYCLED	1 WC	MILL 2" 2-2" LIFTS	3.5"HMAC PCC	11/81	3727
LA. 25 CONTROL	3 WC 3 BC	1.5" LIFT 2" LIFT	3.5" HMAC 8.5" CTB	6/81	4140
U.S.80 RECYCLED	1 WC	MILL 2" 2-1.5"LIFTS	3.5"HMAC 8-6-8 PCC	7/81	1629
U.S.80 CONTROL	1 WC 1 BC	1.5" LIFT 2" LIFT	3.5"HMAC 8-6-8 PCC	5/82	1190
LA.01 RECYCLED	ACFC 3 WC	MILL 2" 2-1.5"LIFTS	7" HMAC 8" PCC	6/82	3860
U.S. 84 LA.01 CONTROL	ACFC 3 WC 3 BC	1.5" LIFT 2" LIFT	4" HMAC 4" SCG PCC	7/81	4012

Figure 1. Study Project Locations

CONSTRUCTION DATA

Construction data for the recycled projects was documented in references 1 and 2. The department's general files were searched for all data pertaining to the projects used as control sections. Tables A-1 through A-9 in Appendix A provide: Project Descriptions; Section Designs; Identification of Test Sections; and, Job Mix Formula (JMF) data. Statistical construction data including number of samples, mean, standard deviation and minimum and maximum values are provided in Tables B-1 through B-10 in Appendix B.

TRAFFIC ANALYSIS

Average daily traffic (ADT) for each test section was obtained from department records for the time period from construction to the final evaluation. In addition, average daily traffic (including vehicle type) was determined during the first two years of this study by visually counting vehicles at each roadway for two-4 hour counting periods. This manual count compared favorably to the recorded data. Average daily loads (ADL) were calculated using load factors for each vehicle type. The resulting data are presented in Tables 2 and 3 below with the ADL computed as cumulative 18 kip equivalent axle loads.

TABLE 2. AVERAGE DAILY TRAFFIC								
ROADWAY		**YEARS**						
		1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
LA01	R	4953	4012	4748	5618	6255	4770	7630
LA01/US84	C	5937	7055	6818	7803	7232	5772	6250
US90	R	2780	3768	3422	3610	3220	2840	6450
LA26	C	2767	2861	3239	3398	2485	3030	2400
LA21	R	4111	3727	3986	5509	5650	3890	6840
LA25	C	4044	4140	5191	4794	5280	4190	4420
US80	R	1502	1629	1922	1890	1140	1620	1730
US80	C	1208	1190	1483	1620	1210	1550	1620
US84	R&C	2913	3860	4223	4008	3525	2725	2630

TABLE 3. CUMULATIVE LOAD (18K EAL)						
ROADWAY						
		1983	1984	1985	1986	1987
LA01	R	12132	19913	28576	35182	45749
LA01/US84	C	33354	46492	58669	68387	78910
US90	R	2390	3590	4660	5604	7748
LA26	C	5573	7708	9270	11174	12682
LA21	R	11626	17042	22598	26423	33148
LA25	C	8804	11959	15435	18192	21102
US80	R	424	582	678	814	959
US80	C	2128	3418	4382	5616	6905
US84	R&C	31650	38003	43591	47911	52080

PERFORMANCE EVALUATIONS

The recycled and conventional asphaltic concrete pavements were examined to evaluate performance characteristics from both a structural and a serviceability aspect. In addition, roadway samples were obtained to determine materials properties with time. Ten evaluation sites on each project were monitored each year for five years. The locations of these sites and roadway core locations for each project are provided in Appendix A.

Serviceability was examined 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. The pavement serviceability index (PSI) derived from the Mays Ridemeter is based on a scale of 1 to 5 with 5 being a perfectly smooth ride. Pavement distress was monitored within a two hundred foot segment at each evaluation site. Each distress type was evaluated and assigned weighted deduct points based on severity and intensity of the distress. A sample distress rating form is provided in Figure 2. The total quantity of deduct points forms a pavement distress rating (PDR) by subtracting from 100 percent, weighting and then combining with a weighted Mays Ridemeter reading in terms of the pavement serviceability index in the following manner:

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

(A perfect score would be 50)

Figure 2. Pavement Distress Rating Form

Pavement structural strength was evaluated with the Dynamic Deflection Determination System (Dynaflect). Dynaflect testing was accomplished at each test site with three deflection measurements taken in the outside wheelpath. These measurements were then averaged for each site and converted at 15.6°C to equivalent deflections. Parameters including subgrade modulus (E_s), structural number (SN), surface curvature index (SCI), and corrected maximum deflection (CMD), expressing subgrade and upper pavement strengths were determined using established procedures [4].

In addition to roadway serviceability and structural testing, five 6-inch roadway cores were taken during each evaluation at each of the ten projects. Roadway cores were taken to the research laboratory where specific gravities were determined. Asphalt cement was extracted from the cores to determine the asphalt cement content and gradation testing was accomplished. The asphalt cement was then recovered from the extracted cores by the Abson process and tested for viscosity (60°C), penetration (25°C), and ductility (25°C).

DISCUSSION OF RESULTS

SERVICEABILITY

The average pavement serviceability indices for the recycled and the control pavements for each evaluation year are presented in Table 4. The values for the first evaluation represent not the "as constructed" condition but the condition after 2 to 5 years of service. There is essentially very little decline in performance from evaluation year one to five with the exception of year four. During this evaluation the Mays Ridemeter was found to be out of calibration after the majority of projects had been tested. These data should therefore be eliminated from consideration. The fifth year evaluation demonstrates that as a group the there is little difference in performance between the recycled and control sections. Generally, it is believed that a difference in PSI of 0.2 or less cannot be detected by an individual riding a pavement. Only one project pair, LA21 - LA25, had a difference greater than 0.2.

TABLE 4. PAVEMENT SERVICEABILITY INDEX

EVALUATION YEAR	RECYCLED	CONTROL
1	4.1	4.0
2	4.1	4.1
3	4.1	4.0
4	3.4	3.6
5	3.9	4.0

The average Pavement Distress Ratings, PDR, for the recycled and control pavements for each evaluation year are provided in Table 5. There is very little difference in performance between the recycled and control pavements. The principal forms of distress recorded on the rating forms were longitudinal and transverse cracking and rutting. On all but two of the projects the longitudinal cracking was less than 1/8-inch over less than 50 percent of the evaluation site. The recycled pavements experienced a moderate severity level of transverse cracking, whereas the control pavements exhibited a slight degree of transverse cracking. In all cases the transverse cracking was regular in nature reflecting from the jointed concrete pavement. The rutting experienced on these projects was less than 1/4-inch (0.15-inch recycled; 0.18-inch control) and is attributed to consolidation from traffic. There was little change in the measured rut depths from the first evaluation to the last evaluation. Slight ravelling was identified on less than 20 percent of 11 of 95 evaluation sites. Blow-ups were identified on three of the ten projects. Overall, the distress observed on these projects after six to nine years of life could be classified as slight.

TABLE 5. PAVEMENT DISTRESS RATING

EVALUATION YEAR	RECYCLED	CONTROL
1	23.5	23.8
2	22.7	22.9
3	22.4	22.6
4	21.9	22.2
5	21.5	21.9

Pavement Condition Ratings, PCR, are presented in Table 6. This parameter is a combination of the smoothness rating from the Mays Ridemeter, PSI, and the distress rating, PDR. Because each of these ratings was similar for the recycled and control pavements, it follows that the PCR would demonstrate little difference. Again, the dip in PCR in the fourth year is attributed to the out-of-calibration Mays Ridemeter.

TABLE 6. PAVEMENT CONDITION RATING

EVALUATION YEAR	RECYCLED	CONTROL
1	44.2	43.9
2	43.0	43.4
3	42.7	42.7
4	39.0	40.1
5	41.0	42.0

The serviceability data from the final evaluation were tested for statistical differences using T-Test methods at a 0.05 significance level. Table 7 provides a summary of the findings. In this table, the individual principal distresses observed are also included. The serviceability index measured by the Mays Ridemeter was not tested for significance because the Mays data were combined into a single rating per project (there was no variance). The mean values presented are only different by 0.1. This difference is not discernible to a passenger in a vehicle. Even though this variable is weighted heavier in the PCR, there is no significant difference in performance in the PCR between the recycled and control pavements. There is also a significant difference between the recycled and control pavements with respect to longitudinal cracking. Both pavement groups record distress as slight in this category. The rut depth measurements of the control pavements are slightly higher than the recycled, but demonstrate no significant difference.

TABLE 7. SERVICEABILITY T-TESTS

PARAMETER	RECYCLED MEAN	CONTROL MEAN	SIGNIFICANT DIFFERENCE
Mays Ridemeter	3.9	4.0	---
PCR	41.0	42.0	No
PDR	21.5	21.9	No
Longitudinal Cracking	3.1	2.1	Yes
Transverse Cracking	3.2	2.7	No
Rutting	0.15	0.18	No

STRUCTURAL

The mean deflections and other structural parameters determined by the Dynaflect are provided in Table 8. The temperature corrected maximum deflection and structural number are indicative of the total overall roadway section, while the subgrade modulus and surface curvature index measure the relative strengths of the subgrade and upper pavement layers, respectively. By the last evaluation, it is noted that most of the structural parameters are similar between the recycled and control pavements. While the structural numbers are almost identical, the maximum deflection is higher for the recycled pavements indicating a slightly weaker overall section. Consistent with this observation is the lower subgrade modulus for the recycled pavements and the slightly higher surface curvature index. For the US 84 project, where both the recycled and control pavements are at the same site and the subgrade modulus is the same, the structural number is higher, the maximum deflection and surface curvature index are lower for the recycled pavement. These parameters for the recycled section are indicative of a stiffer mix which is reasonable considering that both the recycled binder and wearing course mixtures contained 50 percent reclaimed material.

Table 9 presents a statistical T-test analysis of the data taking into account the variation in the data at a 0.05 confidence level. Only the last year data were used in this analysis to determine the study ending condition. The mean recycled and control pavement sections were significantly different for the parameters of corrected maximum deflection and subgrade modulus. Because the subgrade modulus for the control sections was technically significantly stronger than the recycled pavements, the maximum deflection which represents the overall pavement strength also reflects this difference. Again, the study had no control over the

TABLE 8. STRUCTURAL ANALYSIS						
PARAMETER	**R/C**	**EVALUATION YEAR**				
		1	**2**	**3**	**4**	**5**
Corrected Maximum Deflection, CMD	R	0.419	0.446	0.449	0.456	0.495
	C	0.370	0.376	0.368	0.381	0.420
Subgrade Modulus of Elasticity, E_S, PSI	R	17,015	15,026	14,124	16,915	13,803
	C	18,109	19,071	17,970	18,246	15,316
Surface Curvature Index, SCI	R	0.063	0.070	0.059	0.071	0.070
	C	0.053	0.057	0.055	0.065	0.055
Structural Number, SN	R	5.0	4.9	4.9	4.8	4.6
	C	5.2	5.2	5.1	5.0	4.7

TABLE 9. STRUCTURAL T-TESTS			
PARAMETER	**RECYCLED MEAN**	**CONTROL MEAN**	**SIGNIFICANT DIFFERENCE**
CMD	0.495	0.420	Yes
SN	4.6	4.7	No
E_S	13,803	15,316	Yes
SCI	0.070	0.055	No

existing subgrade strengths. The surface curvature index and the structuralnumber show no significant differences between the recycled and control pavements.

MATERIALS AND MIX ANALYSIS

Roadway cores were analyzed with respect to specific gravity, asphalt content, gradation and quality of the recovered asphalt cement. Table 10 presents the core properties. In reviewing the construction and roadway data from Appendix B, all pavements had increased densification from traffic beyond the initial construction compaction. Only three of the projects achieved the design air void level, US 80 control and recycled and LA 01 control. The other projects had in-place air voids in the range of 5.7 to 8.6 percent at the age of six to nine years. Similar findings have been reported in another study with mixtures designed under the same specifications [8]. In general, the asphalt contents determined from the extracted samples from the fifth year evaluation were slightly less than those determined during construction. This could occur from incomplete extraction of the oxidized asphalt cement or from stripping. Stripping was not observed during any of the field evaluations.

Gradation analysis of the extracted roadway cores is found in Table 11. A review of the construction data in Appendix B reveals that the gradations from the fifth year evaluation are similar to the construction data indicating little or no degradation of materials. Generally, the standard deviations for each sieve size were consistent with historical and Materials Test system (MATT) data. Exceptions included the US 84 recycled section, US 84 control section and the LA 01 recycled section where almost all sieves exceed normal standard deviations. Standard deviations for these projects were normal at the time of construction.

TABLE 10. ROADWAY CORE PROPERTIES						
PROJECT	R/C	%AC		SPECIFIC GRAVITY		
		AVG	STD	AVG	STD	AIR VOIDS
US 80	C	5.18	0.05	2.31	0.03	4.9
US 80	R	5.38	0.33	2.31	0.05	4.9
LA 01	C	4.75	0.1	2.34	0.06	4.5
LA 01	R	4.53	0.15	2.31	0.02	5.7
US 84	C	4.96	0.54	2.30	0.07	5.7
US 84	R	4.85	0.29	2.27	0.02	6.2
LA 25	C	4.48	2.34	2.24	0.03	7.1
LA 21	R	5.68	0.19	2.28	0.04	6.2
LA 26	C	5.1	0.17	2.29	0.01	6.9
US 90	R	5.02	0.36	2.22	0.03	8.6

TABLE 11. GRADATION ANALYSIS																	
PROJ	R/C	3/4 INCH		1/2 INCH		3/8 INCH		NO. 4		NO. 10		NO. 40		NO. 80		NO. 200	
		AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD	AVG	STD
US 80	C	97.5	1.7	86.5	3.4	73.8	2.9	56.5	2.1	46.8	0.9	29.5	1.3	16.0	1.4	7.3	1.3
US 80	R	99.6	0.5	93.2	1.5	76.6	2.3	56.0	1.9	44.2	1.5	28.8	1.1	15.0	0.7	6.2	0.4
LA 01	C	100	0.0	93.5	1.0	79.3	2.2	56.3	2.9	38.0	2.2	21.8	1.7	13.8	0.9	7.5	0.6
LA01	R	100	0.0	91.3	0.6	75.7	5.5	52.7	5.5	40.0	4.0	26.0	2.0	17.3	1.5	8.7	0.6
US 84	C	98.6	2.2	89.4	6.0	78.6	7.2	56.6	5.8	40.4	6.8	21.2	3.5	13.8	2.1	8.8	1.8
US 84	R	99.0	1.4	91.3	3.6	82.0	7.0	59.3	7.8	40.0	5.2	20.8	4.3	12.0	3.4	6.8	2.5
LA 25	C	99.8	0.5	93.4	2.2	84.8	3.6	61.4	3.4	39.6	2.2	23.4	1.7	12.0	0.7	6.6	0.6
LA 21	R	100	0.0	91.8	1.6	81.4	2.4	59.8	2.2	45.2	1.8	27.2	0.8	11.6	0.6	6.6	0.6
LA 26	C	97.7	0.6	89.3	1.5	79.7	4.7	54.3	4.0	34.7	2.3	18.3	1.1	8.3	0.6	6.3	0.6
US 90	R	99.6	0.5	92.4	1.3	82.4	1.5	62.4	1.8	46.6	1.5	29.6	1.3	17.0	1.2	7.4	0.9

TABLE 12. ASPHALT CEMENT PROPERTIES							
PROJECT	R/C	VISCOSITY		PENETRATION		DUCTILITY	
		AVG	STD	AVG	STD	AVG	STD
US 80	C	30365	3790	21.3	2.1	26.0	4.2
US 80	R	66026	26310	18.4	5.2	9.5	4.9
LA 01	C	12085	9629	42.5	22.6	121	41.0
LA 01	R	52628	30490	18.7	6.0	13.5	4.95
US 84	C	40766	29710	28.4	16.9	40.5	44.5
US 84	R	61696	82511	21.5	7.8	55.0	49.5
LA 25	C	200000	0	16.2	3.35	5.0	0.0
LA 21	R	40250	29628	24.4	7.0	36.0	31.0
LA 26	C	70392	10314	17.7	1.15	12.5	2.12
US 90	R	79508	24164	19.0	1.87	10.0	1.41

The extracted asphalt cement was further tested for physical properties including viscosity, penetration and ductility. Descriptive statistics are provided in Table 12 from the last evaluation for each project. The asphalt cement properties were consistent with typical findings; the higher viscosity corresponded to lower penetrations and ductilities. On some projects the controlpavements had higher viscosities than the recycled pavements, while on other projects the reverse was found. The most oxidized asphalt was found on a control pavement which was only six years of age.

The asphalt cement properties were tested to determine significant differences in the mean values. According to the results provided in Table 13, there were no statistical differences between the recycled and control pavements evaluated as a group. Actually, the overall mean viscosity of the control pavements was higher than the recycled because all cores from one control pavement exceeded 200,000 poises after six years.

TABLE 13. ASPHALT CEMENT PROPERTIES T-TESTS

PROPERTY	RECYCLE MEAN	CONTROL MEAN	SIGNIFICANT DIFFERENCE
Viscosity	60,618	75,467	No
Penetration	20.5	25.5	No
Ductility	24.8	41.0	No

Reference 3 examined the question of the quality of recycled asphalt cement. Specifically, Louisiana requires the plant produced recycled mix to have a viscosity no greater than 12,000 poises. This limit was instituted to prohibit the over oxidation of the asphalt cement in conventional mixes during normal plant production. It was reasoned that recycled mixes should meet the same specifications as conventional mixes. This reference indicates that two of the recycled projects exceeded that viscosity limit during plant production. These projects, US 80 and US 90, had recovered mean viscosities of 18,096 and 13,684 poises, respectively. Whether or not such viscosities were tolerable was left unanswered until performance could be determined.

A review of section design and all structural, serviceability and materials properties indicates that the recycled pavements with mean viscosities exceeding the 12,000 poise limit experienced a greater degree of cracking than their paired control pavements. These pavements experienced moderate (>1/8-inch to <1-inch) rather than slight (<1/8-inch) cracking. The differences in structural properties can be related to overall section design or mix type. It is noted that on US 84 where 50 percent reclaimed material was used in the wearing course and the control was built on the same project, the properties demonstrating statistical differences in the means provided superior values for the recycled mix after nine years of performance. Further, the cracking distress did not cause a difference in smoothness or rideability which could be detected by a passenger in the Mays vehicle.

Halstead [7] provided a performance relationship using the parameters of penetration and ductility. AASHTO specifications for penetration and ductility of thin film oven aged samples are predicated on this critical relationship. He determined a critical penetration-ductility line, below which pavements displayed poor performance with respect to cracking. Based on experience from a number of field projects, he determined that an asphalt with a penetration of 30-50 was capable of performing unless the ductility decreased below this critical line. In that case cracking and ravelling could develop. When both penetration and ductility were low (<20 and <10, respectively) the oxidized asphalt became brittle and caused extensive cracking. The mean data from the fifth year evaluation are presented in Figure 3 for each project. The LA 25 control pavement falls into the zone where oxidation, brittleness and cracking should be experienced. The distress data from this project do not indicate such failures. Both the US 80 and US 90 recycled projects were noted as having a moderate cracking level and are noted to be approaching the critical zone. The LA 01 recycled and LA 26 control pavements are also approaching this zone but have not yet demonstrated increased distress. Again, as assessed through the Mays serviceability data, the cracking evident in this evaluation has not affected the ride characteristics.

All projects evaluated for this study used reclaimed material from 20 to 50 percent in the wearing course. The mean recovered asphalt cement viscosities were under the 12,000 poise limit for all but the two projects mentioned. Those pavements, using these higher percentages of reclaimed material, performed similarly to the control pavements when the viscosity limitation was not exceeded. It appears from the data presented herein that the significant parameter affecting cracking is the viscosity. When the viscosity was maintained under 12,000 poises, the cracking in the recycled pavements was slight as with the control pavements. The department's original position of allowing reclaimed material in wearing course mixes at the rate of 15 percent and meeting the 12,000 poise limit seems justified.

Figure 3. Critical Penetration-Ductility Relationship

CONCLUSIONS

In general, this study found that recycled pavements containing reclaimed asphalt concrete materials in the range of 20 to 50 percent by weight of the mixture in both binder and wearing course mix performed similarly to conventional pavements for a period of six to nine years after construction. These findings are based on the selection of five recycled pavements and five conventional pavements selected to be of similar section and mix design, traffic and (if possible) constructed by the same contractor. Only one pavement contained a recycled section and a control section on the same project. Specific findings are offered as follows:

1. Performance as measured by a pavement condition rating indicates that there is no significant difference between the recycled and control pavements evaluated. The recycled pavements did exhibit slightly more distress with respect to longitudinal cracking.

2. Significant differences in maximum deflection between the recycled and control pavements (which are representative of overall section strength) were related to differences in subgrade support. No significant differences were found in the upper pavement strength or structural numbers.

3. Roadway cores demonstrated additional compaction from traffic for the first several years of the study. Only three of the pavements achieved design air voids. Extraction results indicated no degradation of the mixtures. Generally, the recovered asphalt cement contents were lower

than those measured during construction. This was attributed to incomplete extraction of the oxidized asphalt.

4. There were no significant differences in recovered asphalt cement properties including viscosity, penetration and ductility.

5. Those recycled pavements which exceeded the 12,000 poises viscosity limit for plant produced mix had a greater degree of cracking than the paired control pavements. These pavements experienced a moderate level of cracking.

RECOMMENDATIONS

The findings of this study indicate that recycled pavements using up to 50 percent reclaimed asphalt concrete material in both wearing and binder course mixes perform similarly to pavements constructed with conventional materials. The department's more conservative approach in allowing a maximum of 30 percent reclaimed material should, therefore, continue to provide Louisiana with good performing pavement materials while taking advantage of the economics of a salvageable material.

The department has eliminated the use of reclaimed material in wearing course mixtures because of testing constraints; on short tonnage projects, the projects are usually completed prior to obtaining viscosity testing results. The results of this study show that the 12,000 poise limitation produces a mix which is less subject to cracking. If the test time constraint can be corrected, the department's original position of permitting 15 percent reclaimed material in the wearing course and requiring the 12,000 poise limitation should be reconsidered.

REFERENCES

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3. Carey, D.E., and Paul, H.R., "Quality Control of Recycled Asphaltic Concrete," Final Report, Louisiana Department of Transportation and Development, Research Report No. 158, July, 1982.

4. Kinchen, R.W., and Temple, W.H., "Asphaltic Concrete Overlays of Rigid and Flexible Pavements," Final Report, Louisiana Department of Transportation and Development, October 1980.

5. Vaswani, N.K., "Method for Separately Evaluating Structural Performance of Subgrades and Overlying Flexible Pavements," Virginia Highway Research Council, May 1972.

6. Littell, R.C., and Schlotzhauer, S.D., System for Elementary Statistical Analysis, SAS Institute Inc., 1987.

7. Halstead, W.J., The Relation of Asphalt Ductility to Pavement Performance, AAPT, Vol 32, 1963.

8. Paul, H.R., "Identification and Quantification of the Extent of Asphalt Stripping in Flexible Pavements - Phase II Field Evaluation," April 1985.

APPENDICES

APPENDIX A
PROJECT DATA

APPENDIX B
MEAN PLANT AND ROADWAY ACCEPTANCE DATA

TABLE A1

DESCRIPTION AND JOB MIX FORMULA - US 84 RECYCLED AND CONTROL

ROUTE - LA-US 84

BEGINNING POINT - JUNCTION WITH LA-US 71 IN CLARENCE, NATCHITOCHES PARISH

ENDING POINT - WINN PARISH LINE

TYPE CONSTRUCTION: RECONSTRUCTION - HMAC OVERLAY WITH ACFC

CONTRACTOR: LA PAVING COMPANY, INC

PLANT TYPE: BATCH

NUMBER LANES - 2 | LANE WIDTH - 12 FT

SHOULDER TYPE - OTHER | SHOULDER WIDTH - varies

TOTAL LENGTH - 4.8 | ACCEPTANCE DATE - 10 AUG 78

AVERAGE DAILY TRAFFIC - 2097 | IN THE YEAR - 1978

DESIGN SECTION: MILL 2", PLACE TWO 2" LIFTS AND 5/8" ACFC

EXISTING SECTION: 8-6-8 CONCRETE PAVEMENT - 1934
TOP W/ 3-1/2" ASPHALT CONCRETE OVERLAY - 1959

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	1	2	3
GRADATION % PASSING			
U.S. SIEVE SIZE			
3/4"	100	97	---
1/2"	90	90	100
3/8"	---	---	95
NO. 4	58	58	28
NO. 10	42	40	9
NO. 40	23	22	---
NO. 80	12	12	---

NO. 200	6	6	2
<u>MIX DESIGN</u>			
%RECLAIM/%VIRGIN	50/50	---	---
% CRUSHED	---	83.0	---
% AC (NEW)	4.8	4.8	6.0
% AC (MIX)	5.2	4.8	6.0
MIX TEMPERATURE (F)	325	325	260
<u>MIX USE</u>			
TYPE	1 W.C.	1 W.C.	SLAG A.C.F.C.
USE	ROADWAY	ROADWAY	ROADWAY
<u>MARSHALL PROPERTIES</u>			
SPEC. GRAVITY	2.34	2.34	---
THEO. GRAVITY	2.42	2.44	---
% THEORETICAL	96.8	95.9	---
% VOIDS	3.2	4.1	---
% V.F.A.	78.0	74.0	---
STABILITY (LBS)	2179	1678	---
FLOW	8	12	---

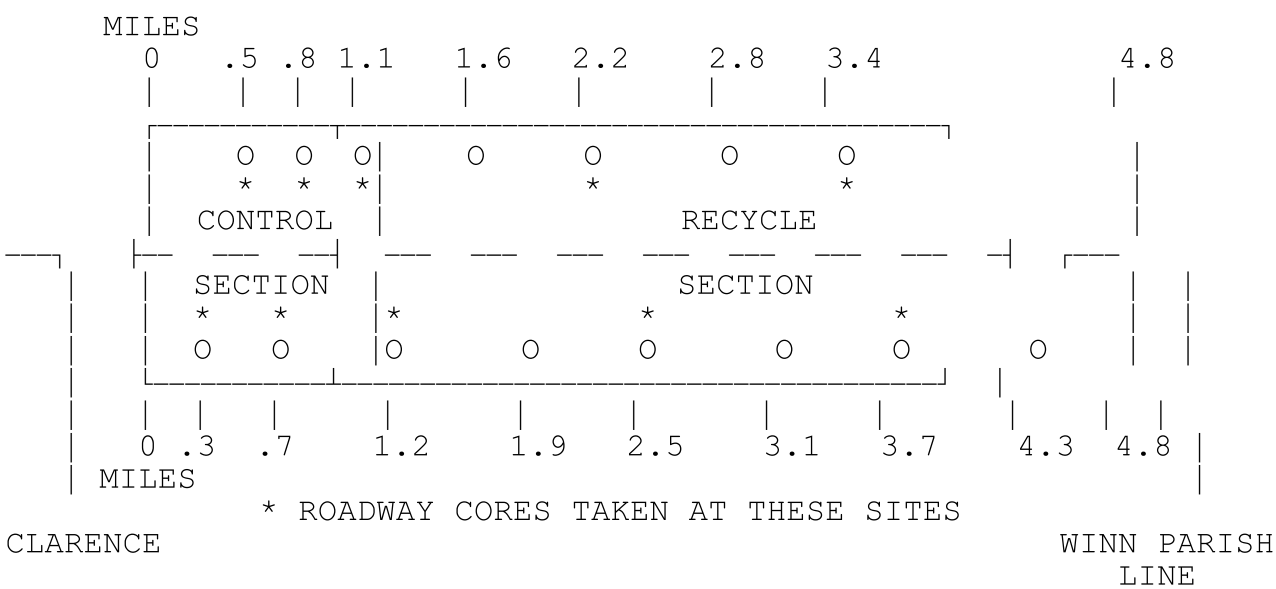


TABLE A2
DESCRIPTION AND JOB MIX FORMULA - US 90 RECYCLED

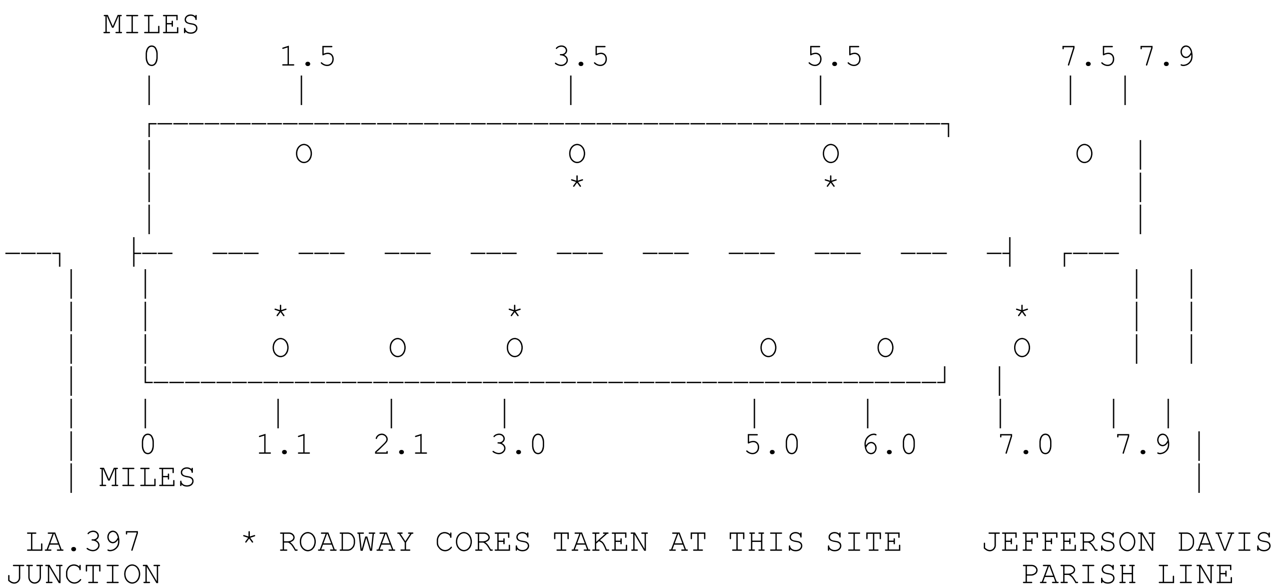
ROUTE - LA-US 90
BEGINNING POINT - JUNCTION LA 397, CALCASIEU PARISH
ENDING POINT - JEFFERSON DAVIS PARISH LINE
TYPE CONSTRUCTION: RECONSTRUCTION - HMAC OVERLAY
CONTRACTOR: R.E. HEIDT
PLANT TYPE: BATCH
NUMBER LANES - 2
LANE WIDTH - 12 FT
SHOULDER TYPE - HMAC
SHOULDER WIDTH - UNKNOWN
TOTAL LENGTH - 7.89
ACCEPTANCE DATE - 29 JAN 82
AVERAGE DAILY TRAFFIC - 3768
IN THE YEAR - 1982

DESIGN SECTION: MP 0-6.1, MILL 2.5", PLACE TWO 1.5" LIFTS, RECONSTRUCT SHOULDERS
MP 6.1-7.89 MILL 1.5", PLACE 2" & 1.5" LIFTS, 1.5" SHOULDER OVERLAY
EXISTING SECTION: 8-6-8 CONCRETE PAVEMENT - 1930
TOP W/ 5-1/2" ASPHALT CONCRETE OVERLAY - BETWEEN 1930 & 1966

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	6	7	8
GRADATION % PASSING U.S. SIEVE SIZE			
3/4"	99	99	98
1/2"	94	94	93
3/8"	---	---	---
NO. 4	61	61	61
NO. 10	48	48	48
NO. 40	27	27	29
NO. 80	17	17	16
NO. 200	8	8	7
MIX DESIGN			
%RECLAIM/%VIRGIN	30/70	30/70	20/80
% CRUSHED	78.0	78.0	80.0
% AC (NEW)	3.7	3.7	4.2
% AC (MIX)	5.2	5.2	5.2

MIX TEMPERATURE (F)	300	300	300
<u>MIX USE</u>			
TYPE	1 W.C	1 W.C.	1 W.C.
USE	ROADWAY	ROADWAY	ROADWAY
<u>MARSHALL PROPERTIES</u>			
SPEC. GRAVITY	2.35	2.33	2.34
THEO. GRAVITY	2.43	2.43	2.44
% THEORETICAL	96.8	95.8	96.0
% VOIDS	3.2	4.2	4.0
% V.F.A.	78.8	76.1	74.7
STABILITY (LBS)	1770	1636	1565
FLOW	7	7	8



* ROADWAY CORES TAKEN AT THIS SITE

TABLE A3
DESCRIPTION AND JOB MIX FORMULA - LA 26 CONTROL

ROUTE - LA 26
BEGINNING POINT - JENNINGS
ENDING POINT - ELTON HIGHWAY IN JEFFERSON DAVIS PARISH
TYPE CONSTRUCTION: COLD PLANING ASPHALT
CONTRACTOR: T & M CONSTRUCTION Co.
PLANT TYPE: DRYER DRUM
NUMBER LANES - 2 — LANE WIDTH - 12 FT
SHOULDER TYPE - UNKNOWN — SHOULDER WIDTH - 8 FT
TOTAL LENGTH - 9.6 — ACCEPTANCE DATE - JUNE 82
AVERAGE DAILY TRAFFIC - 2861 — IN THE YEAR - 1982
DESIGN SECTION:

SECTION OF DESIGN	*BINDER COURSE LIFT THICKNESS (INCHES)	*WEARING COURSE LIFT THICKNESS (INCHES)
1	2	2
2	---	2
3	2	1-1/2
4	2	1-1/2

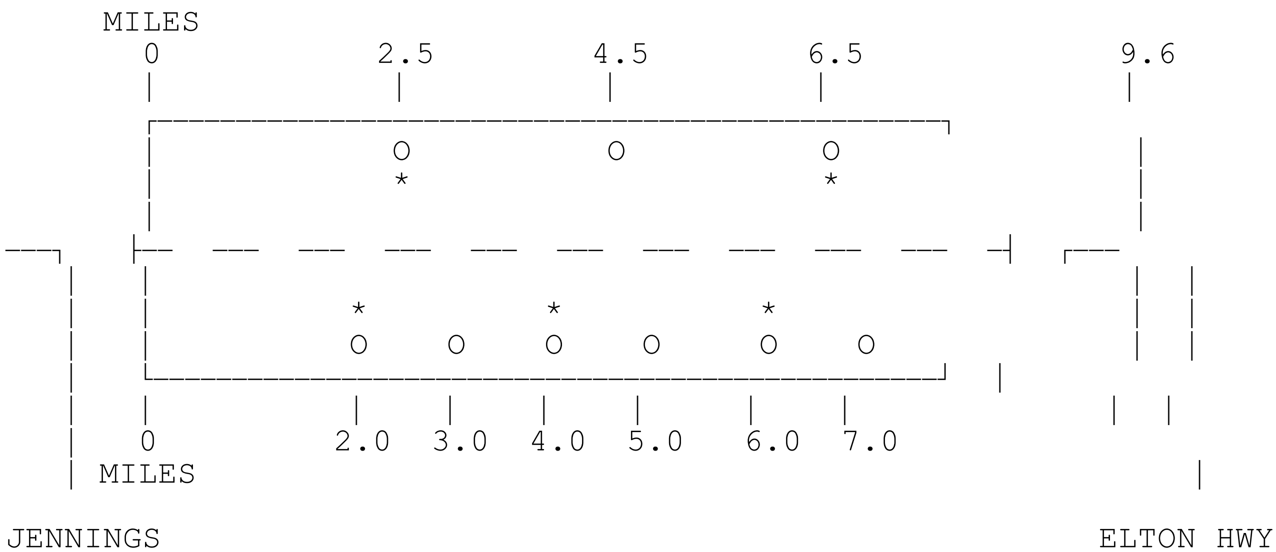
* PLACED IN ONE LIFT

EXISTING SECTION: 9-6-9 CONCRETE PAVEMENT TOP W/ 3-1/2" ASPHALT CONCRETE OVERLAY

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	3	5
GRADATION % PASSING U.S. SIEVE SIZE		
3/4"	99	100
1/2"	85	90
3/8"	---	---
NO. 4	51	49
NO. 10	42	31
NO. 40	24	16
NO. 80	7	8
NO. 200	5	5

<u>MIX DESIGN</u>		
%RECLAIM/%VIRGIN	---	---
% CRUSHED	100	84.0
% AC (NEW)	4.3	5.3
% AC (MIX)	4.3	5.3
MIX TEMPERATURE (F)	315	315
<u>MIX USE</u>		
TYPE	3 B.C.	3 W.C.
USE	ROADWAY	ROADWAY
<u>MARSHALL PROPERTIES</u>		
SPEC. GRAVITY	2.43	2.34
THEO. GRAVITY	2.53	2.46
% THEORETICAL	96.0	95.2
% VOIDS	4.0	4.8
% V.F.A.	72.0	72.0
STABILITY (LBS)	1600	2000
FLOW	9	10



* ROADWAY CORES TAKEN AT THESE SITES

TABLE A4
DESCRIPTION AND JOB MIX FORMULA - LA 21 RECYCLED

ROUTE - LA 21
BEGINNING POINT - .4 MILES NORTH OF JUNCTION LA 10 IN BOGALUSA, WASHINGTON PARISH
ENDING POINT - JUNCTION WITH LOCAL ROAD IN VARNADO
TYPE CONSTRUCTION: RECONSTRUCTION - HMAC OVERLAY
CONTRACTOR: BOH BROTHERS CONSTRUCTION Co.
PLANT TYPE: ASTEC DRYER DRUM
NUMBER LANES - 2
LANE WIDTH - 12 FT
SHOULDER TYPE - HMAC
SHOULDER WIDTH - 10 FT
TOTAL LENGTH - 6.9
ACCEPTANCE DATE - 12 NOV 81
AVERAGE DAILY TRAFFIC - 5026
IN THE YEAR - 1981

DESIGN SECTION: MILL 2", PLACE TWO 2" LIFTS ON ROADWAY
PLACE ONE 2" LIFT ON SHOULDERS
EXISTING SECTION: 3-1/2" asphaltic pavement over a P.C.C. pavement

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	4
GRADATION % PASSING U.S. SIEVE SIZE	
3/4"	97
1/2"	91
3/8"	81
NO. 4	59
NO. 10	44
NO. 40	25
NO. 80	11
NO. 200	6
MIX DESIGN	
%RECLAIM/%VIRGIN	25/75
% CRUSHED	80.0
% AC (NEW)	4.2
% AC (MIX)	5.4
MIX TEMPERATURE (F)	305
MIX USE	
TYPE	1 W.C.

USE	ROADWAY

<u>MARSHALL</u>
<u>PROPERTIES</u>

SPEC. GRAVITY	2.33
THEO. GRAVITY	2.43
% THEORETICAL	95.9
% VOIDS	4.1
% V.F.A.	75.0
STABILITY (LBS)	1900
FLOW	10

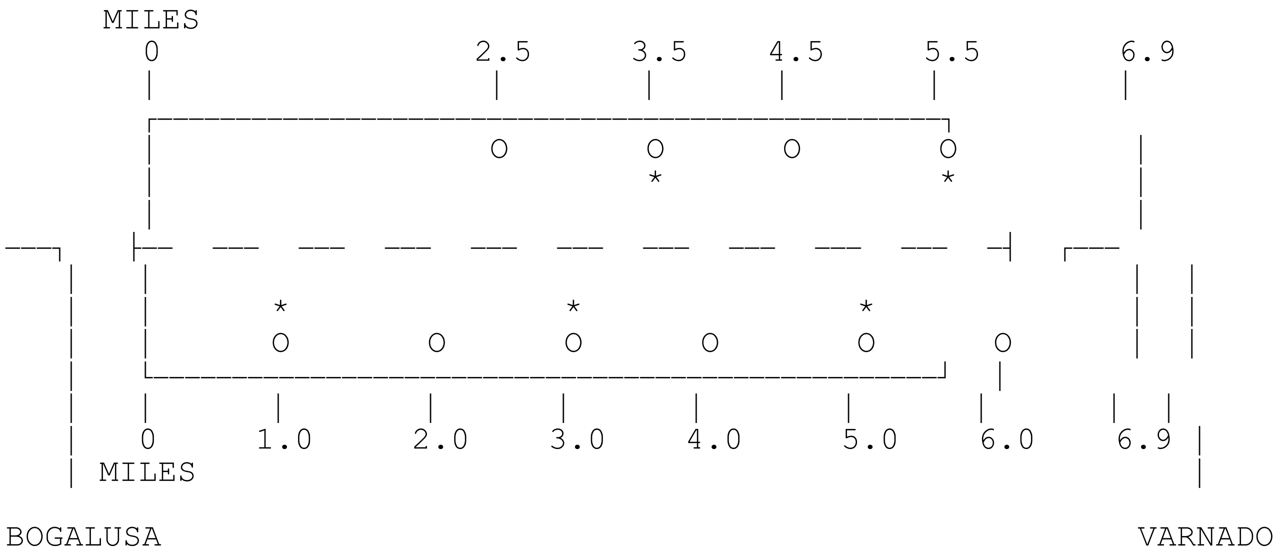


TABLE A5
DESCRIPTION AND JOB MIX FORMULA - LA 25 CONTROL

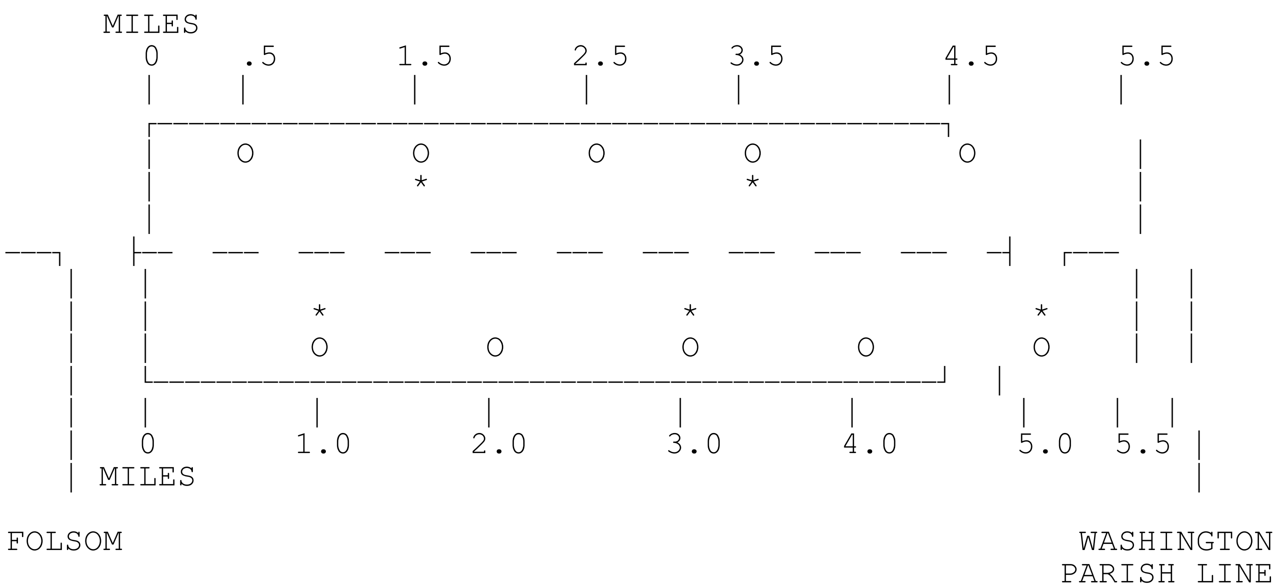
ROUTE - LA 25
BEGINNING POINT - Folsom Parish Line
ENDING POINT - Washington Parish Line
TYPE CONSTRUCTION:
CONTRACTOR: L.H. BOSSIER, Inc.
PLANT TYPE: UNKNOWN
NUMBER LANES - 2
LANE WIDTH - 12 FT
SHOULDER TYPE - EXISTING
SHOULDER WIDTH - VARIES
TOTAL LENGTH - 5.5
ACCEPTANCE DATE - JULY 1981
AVERAGE DAILY TRAFFIC - 4044
IN THE YEAR - 1981
DESIGN SECTION: TYPE 3 BINDER & WEARING COURSE MIX

EXISTING SECTION: 3-1/2" ASPHALTIC CONCRETE OVER STABILIZED BASE COURSE

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	1	2
GRADATION % PASSING U.S. SIEVE SIZE		
3/4"	99	98
1/2"	88	92
3/8"	---	---
NO. 4	47	60
NO. 10	32	42
NO. 40	18	24
NO. 80	9	10
NO. 200	5	7
MIX DESIGN		
%RECLAIM/%VIRGIN	---	---
% CRUSHED	60.0	80.0
% AC (NEW)	4.8	5.6
% AC (MIX)	4.8	5.6
MIX TEMPERATURE (F)	325	325
MIX USE		
TYPE	3 B.C.	3 W.C.

USE	ROADWAY	ROADWAY
<u>MARSHALL PROPERTIES</u>		
SPEC. GRAVITY	2.32	2.32
THEO. GRAVITY	2.45	2.41
% THEORETICAL	94.9	96.5
% VOIDS	5.1	3.5
% V.F.A.	68.0	78.0
STABILITY (LBS)	1650	1850
FLOW	9	13



* ROADWAY CORES TAKEN AT THESE SITES

TABLE A6
DESCRIPTION AND JOB MIX FORMULA - US 80 RECYCLED

ROUTE - LA-US 80
BEGINNING POINT - AT EAST CITY LIMITS OF SIMSBORO ON US 80, LINCOLN PARISH
ENDING POINT - 1.62 MILES WEST OF JUNCTION W/ LA-US 167 IN RUSTON
TYPE CONSTRUCTION: RECONSTRUCTION - HMAC OVERLAY
CONTRACTOR: MADDEN CONTRACTING
PLANT TYPE: MODIFIED STANDARD HAVENS DRYER DRUM
NUMBER LANES - 2
LANE WIDTH - 12 FT
SHOULDER TYPE - HMAC
SHOULDER WIDTH - 7 FT
TOTAL LENGTH - 7.12
ACCEPTANCE DATE - 28 JULY 81
AVERAGE DAILY TRAFFIC - 1681
IN THE YEAR - 1981
DESIGN SECTION: MILL 2", PLACE TWO 1.5" LIFTS ON ROADWAY
PLACE 2" RECOVERED MATERIAL ON SHOULDERS

EXISTING SECTION: 8-6-8 CONCRETE PAVEMENT CONSTRUCTED IN 1930
3-1/2" ASPHALT CONCRETE OVERLAY CONSTRUCTED 1952

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	4	5
GRADATION % PASSING U.S. SIEVE SIZE		
3/4"	100	100
1/2"	90	91
3/8"	---	---
NO. 4	56	54
NO. 10	46	44
NO. 40	28	29
NO. 80	15	16
NO. 200	5	6
MIX DESIGN		
%RECLAIM/%VIRGIN	25/75	30/70
% CRUSHED	79.0	77.0
% AC (NEW)	3.5	3.5
% AC (MIX)	4.8	5.0
MIX TEMPERATURE (F)	310	310
MIX USE		
TYPE	1 W.C.	1 W.C.

USE	ROADWAY	ROADWAY

MARSHALL PROPERTIES		
SPEC. GRAVITY	2.36	2.36
THEO. GRAVITY	2.44	2.43
% THEORETICAL	96.5	96.9
% VOIDS	3.5	3.1
% V.F.A.	76.0	79.0
STABILITY (LBS)	1750	1750
FLOW	5	6

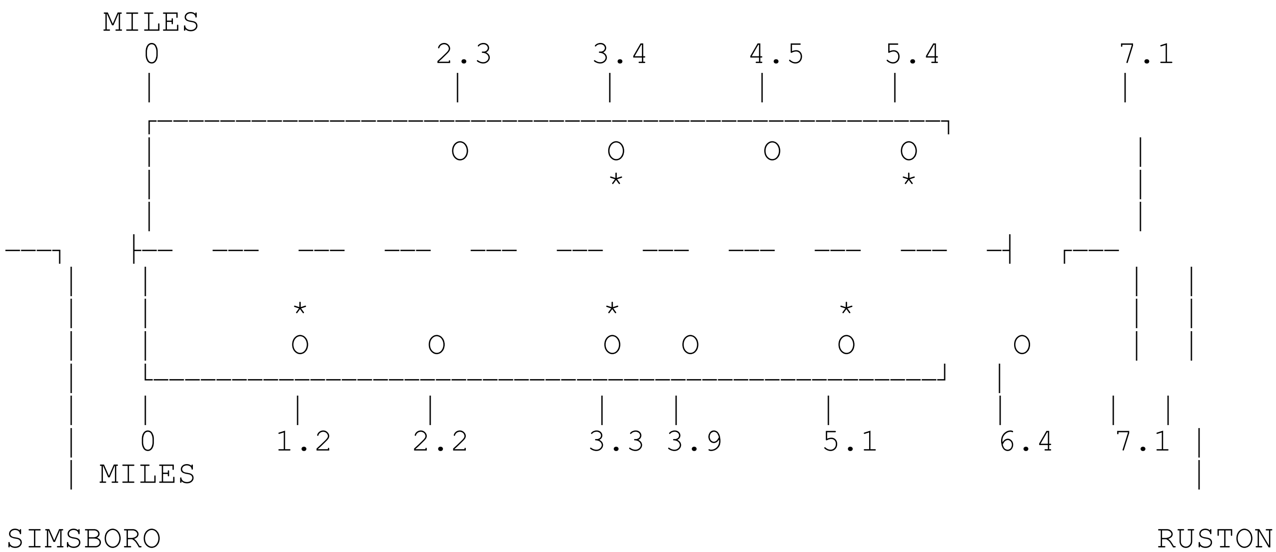


TABLE A7
DESCRIPTION AND JOB MIX FORMULA - US 80 CONTROL

ROUTE - LA-US 80
BEGINNING POINT - BIENVILLE PARISH LINE
ENDING POINT - SIMSBORO HIGHWAY - LINCOLN PARISH
TYPE CONSTRUCTION: ASPHALTIC CONCRETE OVERLAY
CONTRACTOR: D & J CONSTRUCTION Co, Inc.
PLANT TYPE: BATCH HOT BIN
NUMBER LANES - 2 | LANE WIDTH - 12 FT
SHOULDER TYPE - EXISTING | SHOULDER WIDTH - VARIES
TOTAL LENGTH - 4.8 | ACCEPTANCE DATE - MAY 82
AVERAGE DAILY TRAFFIC - 1190 | IN THE YEAR - 1982
DESIGN SECTION: BINDER COURSE MIX IN 2-1/2" LIFT & WEARING COURSE MIX IN SINGLE 1-1/2" LIFT

EXISTING SECTION: 8-6-8 CONCRETE PAVEMENT CONSTRUCTED IN 1930
3-1/2" ASPHALT CONCRETE OVERLAY CONSTRUCTED 1952

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	3	7
GRADATION % PASSING U.S. SIEVE SIZE		
3/4"	94	94
1/2"	89	84
3/8"	---	---
NO. 4	54	53
NO. 10	45	45
NO. 40	30	28
NO. 80	14	14
NO. 200	8	7
MIX DESIGN		
%RECLAIM/%VIRGIN	---	---
% CRUSHED	80.0	65.0
% AC (NEW)	5.2	4.9
% AC (MIX)	5.2	4.9
MIX TEMPERATURE (F)	325	325
MIX USE		
TYPE	1 W.C.	1 B.C.

USE	ROADWAY	ROADWAY
<u>MARSHALL PROPERTIES</u>		
SPEC. GRAVITY	2.32	2.33
THEO. GRAVITY	2.43	2.46
% THEORETICAL	95.7	94.7
% VOIDS	4.3	5.3
% V.F.A.	73.0	68.0
STABILITY (LBS)	1603	1524
FLOW	9	8

```
     MILES
       0  .3       1.1         2.1         3.2       4.1     4.8
       |  |         |           |           |         |       |
       ┌───────────────────────────────────────────┐
       |  O         O           O           O         O        |
       |            *                       *                  |
       |                                                       |
───┐  ├──  ───  ───  ───  ───  ───  ───  ───  ───  ───  ─┤  ┌───
   |   |                                                    |   |
   |   |    *                        *                  *   |   |
   |   |    O          O             O      O           O   |   |
   |   └───────────────────────────────────────────┘   |
   |   |    |          |             |      |           |  |  |
   |   0    .5         1.5           2.8    3.4       4.5 4.8|
   | MILES                                                    |

BIENVILLE                                                SIMSBORO
PARISH LINE                                                HWY
```

TABLE A-8
DESCRIPTION AND JOB MIX FORMULA - LA O1 RECYCLED

ROUTE - LA 01
BEGINNING POINT - RED RIVER PARISH LINE, CADDO PARISH
ENDING POINT - JUNCTION WITH LA 175
TYPE CONSTRUCTION: RECONSTRUCTION - HMAC OVERLAY WITH ACFC
CONTRACTOR: MADDEN CONTRACTING
PLANT TYPE: MODIFIED STANDARD HAVENS DRYER DRUM
NUMBER LANES - 2 LANE WIDTH - 11 FT
SHOULDER TYPE - HMAC SHOULDER WIDTH -8 FT
TOTAL LENGTH - 10.16 ACCEPTANCE DATE - 1 JUN 82
AVERAGE DAILY TRAFFIC - 4012 IN THE YEAR - 1982
DESIGN SECTION: MILL 2", PLACE TWO 1.5" LIFTS
RECONSTRUCT SHOULDERS WITH RECLAIMED MATERIAL

EXISTING SECTION: 8" CONCRETE PAVEMENT CONSTRUCTED IN 1956 TOPPED WITH 7" ASPHALT CONCRETE BETWEEN 1957 AND 1970

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	1	2
GRADATION % PASSING U.S. SIEVE SIZE		
3/4"	100	100
1/2"	92	100
3/8"	---	95
NO. 4	54	38
NO. 10	42	9
NO. 40	26	---
NO. 80	17	---
NO. 200	7	4
MIX DESIGN		
%RECLAIM/%VIRGIN	30/70	---
% CRUSHED	83.0	100
% AC (NEW)	3.4	6.5
% AC (MIX)	4.9	6.5
MIX TEMPERATURE (F)	300	290

MIX USE		
TYPE	1 W.C.	SLAG A.C.F.C.
USE	ROADWAY	ROADWAY

MARSHALL PROPERTIES		
SPEC. GRAVITY	2.37	---
THEO. GRAVITY	2.45	---
% THEORETICAL	96.9	---
% VOIDS	3.4	---
% V.F.A.	76.8	---
STABILITY (LBS)	1959	---
FLOW	9	---

```
     MILES
       0         2.0     3.5               7.0  8.0        10.2
       |         |       |                 |    |          |
       ┌─────────────────────────────────────────┐
       |         O       O                 O    O           |
       |                 *                 *                |
       |                                                    |
───┐   ├──  ───  ───  ───  ───  ───  ───  ───  ───  ───  ─┤   ┌───
   |   |                                                       |  |
   |   |    *                        *  *          *           |  |
   |   |    O         O    O         O  O    O     O           |  |
   |   └─────────────────────────────────────────┘  |
   |   |    |         |    |         |  |    |      |      |  |
   |   0   1.0       3.0  4.0       6.0 6.5 7.6    9.0   10.2  |
   | MILES                                                      |
```

RED RIVER
PARISH LINE

LA.175
JUNCTION

TABLE A9
DESCRIPTION AND JOB MIX FORMULA - US 84/LA01 CONTROL

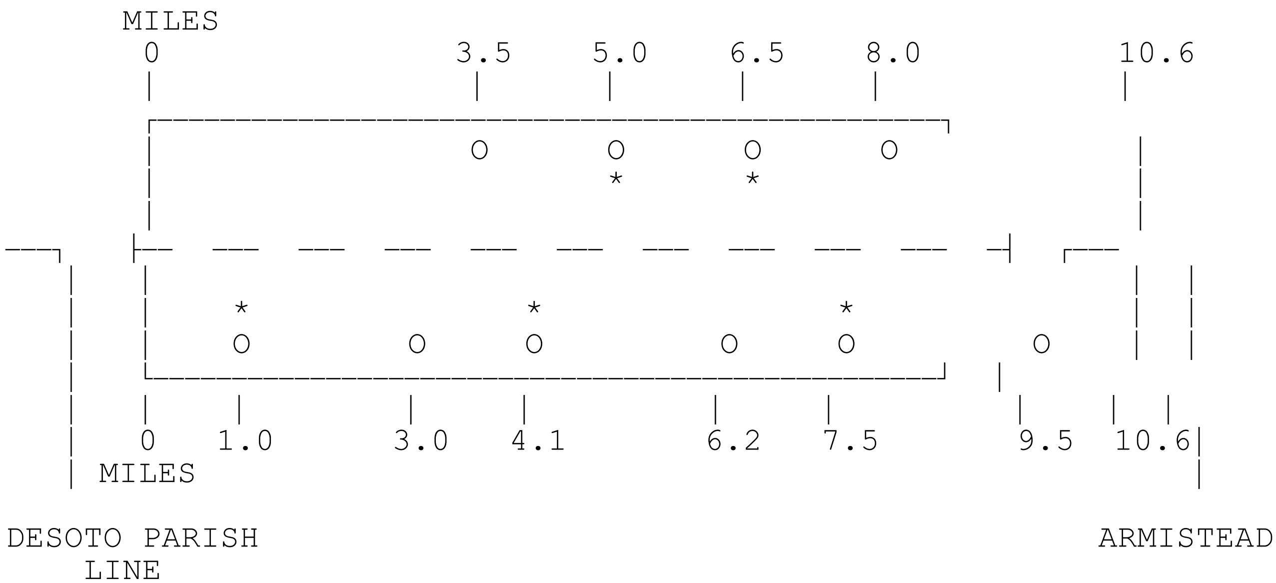
ROUTE - LA 1/US 84
BEGINNING POINT - DESOTO PARISH LINE
ENDING POINT - ARMISTEAD HIGHWAY - RED RIVER PARISH
TYPE CONSTRUCTION:
CONTRACTOR: SOUTHERN EXCAVATION, Inc.
PLANT TYPE: BATCH HOT BIN
NUMBER LANES - 2 LANE WIDTH - 11 FT
SHOULDER TYPE - HMAC SHOULDER WIDTH - 8 FT
TOTAL LENGTH - 2.4(US84) + 8.2(LA1) ACCEPTANCE DATE -JULY 81
AVERAGE DAILY TRAFFIC - 4953 IN THE YEAR - 1981
DESIGN SECTION: TYPE 3 2" BINDER COURSE LIFT, 1-1/2" WEARING COURSE LIFT, 5/8" CRUSHED STONE ACFC (8.2 MI OF LA 1).
EXISTING SECTION: US84 8-1/2" CEMENT STABILIZATION BASE COURSE LA1 P.C.C. PAVEMENT COVERED W/ 4" SAND, CLAY, GRAVEL, & 4" ASPHALTIC CONCRETE OVERLAY

RECOMMENDED JOB MIX FORMULA

JOB SEQUENCE NO.	6	7	9	10
GRADATION % PASSING U.S. SIEVE SIZE				
3/4"	100	100	100	100
1/2"	86	92	100	100
3/8"	---	---	95	95
NO. 4	52	53	43	33
NO. 10	39	39	10	10
NO. 40	22	24	---	---
NO. 80	14	14	---	---
NO. 200	6	6	4	4
MIX DESIGN				
%RECLAIM/%VIRGIN	---	---	---	---
% CRUSHED	90	90	100	100
% AC (NEW)	4.6	4.8	6.0	6.0
% AC (MIX)	4.6	4.8	6.0	6.0
MIX TEMPERATURE (F)	325	325	280	290
MIX USE				
TYPE	3 B.C.	3 W.C.	STONE	STONE
USE	ROADWAY	ROADWAY	A.C.F.C.	A.C.F.C.

ROADWAY ROADWAY

MARSHALL PROPERTIES				
SPEC. GRAVITY	2.34	2.34	---	---
THEO. GRAVITY	2.45	2.44	---	---
% THEORETICAL	95.7	96.0	---	---
% VOIDS	4.3	4.0	---	---
% V.F.A.	72.0	73.5	---	---
STABILITY (LBS)	1765	1836	---	---
FLOW	8	7	---	---



* ROADWAY CORES TAKEN AT THESE SITES

TABLE B1

PLANT AND ROADWAY ACCEPTANCE DATA - U.S. 84 RECYCLED

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	18	1821.11	169.32	1494.00	2076.00
SPGR	18	2.33	0.01	2.31	2.35
VOIDS	18	4.41	0.42	3.70	5.30
GRTF	18	99.28	0.89	98.00	100.00
GROH	18	91.33	2.00	86.00	93.00
NO 4	18	57.28	3.37	52.00	64.00
NO 10	18	41.67	3.41	37.00	51.00
NO 40	18	22.94	2.31	18.00	28.00
NO 80	18	12.44	1.58	9.00	15.00
NO 200	18	6.33	1.08	4.00	8.00
%AC	18	5.09	0.33	4.50	5.90
RDSPGR	18	2.28	0.01	2.26	2.30
%COMP	18	97.79	0.78	96.60	99.60

TABLE B2

PLANT AND ROADWAY ACCEPTANCE DATA - U.S. 90 RECYCLED

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	85	1532.97	169.00	1052.00	2013.00
SPGR	85	2.33	0.01	2.30	2.36
VOIDS	85	4.32	0.50	2.90	5.70
GRTF	49	99.85	0.45	97.00	100.00
GROH	49	92.95	2.59	83.00	97.00
NO 4	49	63.06	3.32	53.00	69.00
NO 10	49	48.13	2.61	40.00	53.00
NO 40	49	28.29	2.03	24.00	34.00
NO 80	49	16.26	1.98	12.00	21.00
NO 200	49	6.60	1.12	4.00	10.00
%AC	49	5.15	0.21	4.80	5.70
RDSPGR	150	2.25	0.04	2.11	2.35
%COMP	150	96.63	1.53	90.20	100.00

TABLE B3PLANT AND ROADWAY ACCEPTANCE DATA - LA 26 RECYCLED

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	12	2024.17	98.43	1914.00	2299.00
SPGR	12	2.35	0.01	2.34	2.36
VOIDS	12	4.64	0.31	4.10	4.90
GRTF	12	100.00	0.00	100.00	100.00
GROH	12	89.42	1.38	87.00	92.00
NO 4	12	50.08	2.78	46.00	54.00
NO 10	12	32.75	1.22	30.00	34.00
NO 40	12	16.92	0.90	16.00	18.00
NO 80	12	6.92	0.79	6.00	8.00
NO 200	12	4.75	0.62	4.00	6.00
%AC	12	5.36	0.17	5.20	5.60
RDSPGR	12	2.26	0.01	2.25	2.27
%COMP	12	96.08	0.66	95.30	97.50

TABLE B4

PLANT AND ROADWAY ACCEPTANCE DATA - LA 21 RECYCLED

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	72	1904.96	219.63	1417.00	2412.00
SPGR	72	2.33	0.01	2.30	2.34
VOIDS	72	4.27	0.04	3.70	5.30
GRTF	37	99.92	0.36	98.00	100.00
GROH	37	91.32	2.87	82.00	97.00
NO 4	37	59.73	3.70	52.00	66.00
NO 10	37	44.95	2.68	40.00	50.00
NO 40	37	26.57	1.61	22.00	29.00
NO 80	37	10.70	0.81	9.00	12.00
NO 200	37	6.62	0.83	4.00	8.00
%AC	37	5.12	0.27	4.40	5.60
RDSPGR	100	2.26	0.03	2.16	2.33
%COMP	100	97.31	1.24	93.10	100.00

TABLE B5

PLANT AND ROADWAY ACCEPTANCE DATA - LA 25 CONTROL

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	8	1955.38	100.28	1778.00	2082.00
SPGR	8	2.33	0.01	2.32	2.33
VOIDS	8	3.49	0.20	3.20	3.80
GRTF	8	99.38	0.74	98.00	100.00
GROH	8	93.88	1.81	91.00	96.00
NO 4	8	62.50	3.07	58.00	66.00
NO 10	8	41.00	2.62	37.00	44.00
NO 40	8	24.13	2.10	21.00	28.00
NO 80	8	11.88	0.99	10.00	13.00
NO 200	8	7.00	0.76	6.00	8.00
%AC	8	5.74	0.09	5.60	5.90
RDSPGR	8	2.24	0.01	2.23	2.24
%COMP	8	96.06	0.58	95.00	96.70

TABLE B6PLANT AND ROADWAY ACCEPTANCE DATA - U.S. 80 RECYCLED

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	34	1719.29	162.99	1386.00	2094.00
SPGR	34	2.36	0.01	2.32	2.38
VOIDS	34	3.10	0.46	2.50	4.50
GRTF	18	99.67	0.59	98.00	100.00
GROH	18	90.61	1.91	88.00	94.00
NO 4	18	54.94	2.65	50.00	62.00
NO 10	18	44.44	2.66	40.00	52.00
NO 40	18	28.61	1.79	26.00	34.00
NO 80	18	14.72	1.02	13.00	17.00
NO 200	18	5.83	0.51	5.00	7.00
%AC	18	5.04	0.27	4.60	5.60
RDSPGR	45	2.28	0.03	2.19	2.34
%COMP	45	96.58	1.31	92.40	99.20

TABLE B7PLANT AND ROADWAY ACCEPTANCE DATA - U.S. 80 CONTROL

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	7	1491.00	146.83	1218.00	1637.00
SPGR	7	2.33	0.00	2.32	2.33
VOIDS	7	4.23	0.16	4.00	4.50
GRTF	7	98.86	1.57	96.00	100.00
GROH	7	85.14	1.86	82.00	87.00
NO 4	7	55.71	2.63	53.00	61.00
NO 10	7	47.71	1.25	46.00	50.00
NO 40	7	29.00	1.52	28.00	32.00
NO 80	7	14.57	0.79	14.00	16.00
NO 200	7	6.14	0.38	6.00	7.00
%AC	7	5.14	0.21	5.00	5.60
RDSPGR	7	2.24	0.00	2.23	2.24
%COMP	7	96.16	0.53	95.40	97.00

TABLE B8PLANT AND ROADWAY ACCEPTANCE DATA: LA 01 RECYCLED

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	41	1762.71	171.38	1239.00	2131.00
SPGR	41	2.37	.02	2.32	2.39
VOIDS	41	3.24	.71	1.60	5.30
GRTF	26	100.00	0.00	100.00	100.00
GROH	26	92.85	2.11	89.00	96.00
NO 4	26	55.00	2.23	51.00	59.00
NO 10	26	42.04	1.66	39.00	45.00
NO 40	26	26.00	1.30	23.00	28.00
NO 80	26	60.65	1.16	14.00	19.00
NO 200	26	7.00	1.39	2.00	9.00
%AC	25	4.90	0.19	4.50	5.20
RDSPGR	65	2.27	0.04	2.16	2.34
%COMP	65	95.84	1.70	91.50	99.20

TABLE B9

PLANT AND ROADWAY ACCEPTANCE DATA - US 84/LA 01 CONTROL

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
STAB	9	1888.56	164.36	1687.00	2159.00
SPGR	9	2.35	0.02	2.32	2.37
VOIDS	9	3.62	0.62	2.80	4.70
GRTF	9	100.00	0.00	100.00	100.00
GROH	9	91.33	3.04	85.00	95.00
NO 4	9	53.00	3.32	48.00	57.00
NO 10	9	38.11	2.62	34.00	42.00
NO 40	9	22.33	2.06	20.00	26.00
NO 80	9	12.89	1.05	11.00	14.00
NO 200	9	6.33	0.71	6.00	8.00
%AC	9	4.78	0.14	4.60	5.00
RDSPGR	9	2.27	0.02	2.24	2.29
%COMP	9	96.47	0.79	95.60	98.10