PERFORMANCE EVALUATION OF LOUISIANA'S AASHO SATELLITE TEST SECTIONS

Final Report

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INTRODUCTION

The AASHO Road Test provided a data base which was subsequently used in developing pavement design criteria and pavement design procedures in Louisiana. It has been necessary to make assumptions in applying the Road Test equations to mixed traffic conditions and to those situations where soil, materials and climate differ from those that prevailed at the test site. The AASHO Interim Guides enumerated the assumptions and limitations associated with each design procedure, and emphasized that "the Guide is interim in nature and subject to adjustment based on experience and additional research." (1)

The current research is an attempt to determine where we now stand with respect to pavement design life and actual service life in the field. The sources of information used in the study were those which were readily available. They include maintenance and construction records, cumulative traffic data, visual condition surveys, and data from Louisiana's AASHO Satellite Study. (2)

SCOPE

It is beyond the scope of this study to attempt to isolate the effect of individual design assumptions on pavement life.

A performance evaluation (to determine present serviceability, end of life, etc.) of selected Portland Cement Concrete (P.C.C.) and hot mixed asphaltic concrete (H.M.A.C.) pavements would seem to be a more straightforward means of determining whether or not design life is being realized. If a majority of the pavements evaluated have not failed prior to carrying their designed Σ loads, the design system could be deemed adequate. On the other hand, if pavement failures are evidenced prior to the accumulation of design traffic loads, more conservative design assumptions could help extend pavement service life.

PROJECT SELECTION

During Louisiana's AASHO Road Test Satellite Study (1966-1969) a detailed performance evaluation was conducted on 110 in-service P.C.C. and asphaltic concrete pavements. These consisted of 49 P.C.C. pavements and 61 H.M.A.C. pavements. Project information collected during the study included actual pavement typical section, soil support characteristics, and traffic load data, among other things. The project selection for the current research was based on these original AASHO pavements because of the background information available and because of the ages of the pavements. The average age to date of the original 110 projects is 18 years.

PHASE I

For the first phase of the evaluation a total of 18 pavements were selected, nine P.C.C. and nine H.M.A.C. pavements. The criteria for selection were:

(1) that the pavements had not been structurally overlaid,
(2) that the actual traffic load which the pavements had carried was not extremely different from the design traffic load,
(3) that all P.C.C. pavements have a slab length of 20 feet, and
(4) that a geographical distribution was achieved.

A tabulation of pavement typical sections, ages, and traffic load data may be found in Table 1.

Pavement construction reflecting the AASHO design method began in the mid-1960's in Louisiana. An evaluation of these pavements would probably not have facilitated a verification of 20-year design life since the oldest pavement was constructed only 13 years ago.

TABLE 1

GENERAL PROJECT INFORMATION

P.C.C. PROJECTS

Sect No.	Age Yrs	Typical Section	Design A.D.L.	Design Σ_6Load ($x10^6$)	Actual Σ_6Load ($x10^6$)	% Design Σ Load
2	18	9½"/3½"SD	547.9	4.000	2.500	63
5	19	9½"/5½"SC	547.9	4.000	4.530	113
21	18	$8\frac{3}{4}$"/6"SD	342.5	2.500	3.622	145
28	15	$9\frac{1}{3}$"/Sel	520.5	3.800	2.525	66
29	15	$8\frac{3}{4}$"/Sel	342.5	2.500	2.610	104
32	18	$7\frac{3}{5}$"/26"Sel	150.7	1.100	0.463	42
36	14	9"/$6\frac{5}{8}$"SD	383.6	2.800	1.320	47
37	14	9"/$4\frac{3}{8}$"SD	383.6	2.800	1.320	47
50	18	$8\frac{7}{8}$"/$11\frac{7}{8}$"Sel	342.5	2.500	1.191	48
Average	17		395.7			75

H.M.A.C. PROJECTS

Sect No.	Age Yrs	Typical Section	Design A.D.L.	Design Σ_6Load ($x10^6$)	Actual Σ_6Load ($x10^5$)	% Design Σ Load
86	15	2"/8-10"SdSH	9.6	0.070	0.026	37
89	20	3½"/8"SC/4"Sel	274.0	2.000	1.203	60
96	20	1"/7"SC	30.1	0.220	0.118	54
106	22	3½"/8"SC	164.0	1.200	0.507	42
109	14	5"/8½"SC	68.5	0.500	0.437	87
111	16	2"/8"SC	29.0	0.210	0.115	55
114	14	5"/8½"SC	205.5	1.500	1.015	68
121	15	2"/8½"SC/G	4.1	0.030	0.015	50
136	15	2"/8"StabSC/G	54.8	0.400	0.250	63
Average	17		93.3			57

SD = sand
SC = soil cement
Sel = selected soil
SdSH = sand shell
SC/G = sand-clay-gravel

The 18 pavements listed in Table 1 were not formally designed using the AASHTO design method, since the average age is 17 years. However each pavement was designed in the sense that its in-place section has a predicted design traffic life as determined by the AASHTO Design Guides. Design traffic data was obtained by entering the AASHTO design curves for rigid and flexible pavements with the as-built slab thickness or structural number and the appropriate soil support characteristics (obtained from the original Louisiana-AASHO research study).

One point which the reader should keep in mind regarding project selection is that of the nine P.C.C. projects evaluated only one was constructed with a cement stabilized base course. This project (No. 5), however, was apparently constructed without load transfer devices at the joints, as the researchers could not locate them with a metal detector. The inclusion of cement stabilized base courses, asphaltic concrete base courses, and an underdrain system in P.C.C. construction has, no doubt, increased pavement life beyond the level indicated in this report.

PHASE II

The second phase of the evaluation involved a traffic sampling of all the bituminous concrete projects from the LA. AASHO STUDY for which soils data was available (59 projects). It was felt that the larger sampling should be made in light of the results of PHASE I: that a majority of the bituminous concrete pavements surveyed appeared to not be carrying their designed Σ loads prior to end of life.

The HMAC projects sampled in PHASE II include some which have been structurally overlaid or reconstructed, some which have not been overlaid but which are structurally failed, and some which have not been overlaid but are exhibiting signs of initial fatigue cracking. The 9 HMAC projects discussed in PHASE I are included in PHASE II as it represents a total HMAC sampling.

PHASE III

A determination of total miles of bituminous concrete pavement structurally overlaid each year in Louisiana was made for the period 1968-1978. This sampling included all HMAC projects which are state maintained totaling approximately 6000 miles. All plant mix seals, friction courses, etc. were eliminated from the survey.

METHODOLOGY

PHASE I

Field tests were conducted on a half mile test section in each of the 18 projects. The test sections were the same as those designated during the original Louisiana AASHO Study.

The Mays Ride Meter was used to measure the Present Serviceability Index (P.S.I.) of each test section. The P.S.I. value reflects the ability of a pavement to serve the motoring public. The rating is primarily a function of pavement rideability, i.e. pavement roughness. The numerical rating scale may be interpreted as follows:

4.1 - 5.0 Very Good
3.1 - 4.0 Good
2.1 - 3.0 Fair
1.1 - 2.0 Poor
0.0 - 1.0 Very Poor

Deflection tests were conducted with the Dynaflect device to quantify the structural needs of the pavements. For ease of interpretation the measured deflections have been translated into the inches of asphaltic concrete overlay currently required for 10 years of additional service.

The deflection test procedures and overlay design methods are described in the Louisiana research report "Asphaltic Concrete Overlays of Rigid and Flexible Pavements" (report no. FHWA-LA-109, September 1977).

A pavement condition survey is perhaps the most universally accepted means of determining if a pavement has reached end of life. An extensive condition evaluation was conducted on each of the test pavements to note all types and degrees of failure. Problems noted on the flexible pavements included alligator type cracking in the wheel paths (Class I, II, III), patching, rutting, pumping, reflection cracking from stabilized bases, crack faulting, and potholes or areas in need of patching. Problems noted on the P.C.C. pavements included slab faulting, slab cracking, pop outs, joint blow ups, patches, and slab curling.

PHASE II

A survey of overlay records was conducted to determine which projects had received structural overlays or had been reconstructed. The projects not overlaid were visually inspected to determine the existing structural condition of each pavement.

Designed Σ loads were calculated for each HMAC project using the method described in PHASE II of the project selection. Actual Σ loads were calculated from current traffic count data.

PHASE III

A survey of HMAC projects overlaid each year in Louisiana for the period 1968-1978 was accomplished by reviewing contracts for all state projects let for bids during that period.

STUDY FINDINGS

PHASE I

The pavements chosen for the field performance evaluation were selected according to the previously described criteria. Variation in pavement age, typical section, and traffic loading was the result of this means of selection. The following statistics represent the average P.C.C. pavement evaluated:

1) Project Age = 17 years
2) Design A.D.L. = 396
3) Percent of design load to date = 75%

The average H.M.A.C. pavement evaluated was as follows:

1) Project Age = 17 years
2) Design A.D.L. = 93
3) Percent of design load to date = 57%

Functional Pavement Condition

Average P.S.I. values for the P.C.C. and H.M.A.C. pavements are 2.1 and 2.4 respectively as indicated in Table 2. The total inches per mile of roughness was approximately equal for the two types of pavement. The average coefficient of variation figures, 0.06 for P.C.C. pavements and 0.27 for H.M.A.C. pavements, represent a measure of the variability in ride measured within each type of pavement. Lower coefficient values characterize pavements which have a less variable ride than pavements with higher coefficient values. Roughness of the concrete pavements was due almost entirely to joint faulting and slab curling. Roughness of the flexible pavements was a result of waves, patches, potholes, and other surface irregularities.

TABLE 2

PAVEMENT RIDEABILITY AND DEFLECTION

P.C.C. Pavements

Sect No.	PSI	Cv*	Dynaflect Deflection (in x 10^{-3})	Load Spreadability (%)	Selected Deflection (in x 10^{-3})	10 Year Overlay (inches)
2	2.0	0.07	0.73	82	0.89	0.0
5	0.7	0.11	0.83	83	0.92	0.0
21	1.9	0.06	0.86	86	0.92	0.0
28	2.2	----	0.93	84	1.08	1.0
29	1.9	0.00	1.34	81	1.58	3.7
32	1.9	0.00	1.00	79	1.20	0.0
36	3.3	0.05	0.62	85	0.67	0.0
37	3.2	0.08	0.64	83	0.73	0.0
50	2.0	0.12	0.80	80	0.95	0.0
Average	2.1	0.06				

H.M.A.C. Pavements

Sect No.	PSI	Cv*	Dynaflect Deflection** (in x 10^{-3})	Load Spreadability (%)	Selected Deflection (in x 10^{-3})	10 Year Overlay (inches)
86	0.5	0.00	2.79	70	3.28	2.0
89	2.7	0.29	0.89	75	1.00	1.4
96	0.5	0.64	1.90	49	2.28	1.5
106	3.1	0.05	0.89	72	1.01	1.7
109	3.5	0.21	0.66	61	0.83	0.5
111	3.0	0.10	0.38	62	0.43	0.0
114	3.7	0.16	0.49	67	0.57	1.0
121	2.6	0.56	1.15	50	1.30	0.0
136	1.8	0.39	0.48	64	0.58	0.0
Average	2.4	0.27				

*Coefficient of variation
**Corrected to 60°F base temperature.

Structural Condition - Deflection Measurements

For ease of interpretation, measured pavement deflections have been translated into the inches of bituminous resurfacing which would be required for ten years of additional pavement life as indicated in Table 2. The required thickness of overlay is a function of projected traffic loads as well as of measured deflections.

Two of the nine P.C.C. pavements evaluated exhibited deflections which would warrant an overlay. These two projects (Nos. 28, 29) are adjacent P.C.C. pavements. The reason for their relatively high deflections is principally due to the poor subgrade support measured on these pavements, $E_s < 3000$ psi. The pavement structural condition in both cases was classified as excellent since the pavement sections exhibited no signs of fatigue cracking. This finding was verified by the high load spreadability values measured with the Dynaflect, 84% and 81%. These values are an indication of the integrity or load spreading ability of the upper pavement layers.

Six of the nine HMAC pavements evaluated exhibited deflections which would require overlay. As previously stated overlay needs are as much a function of traffic load as they are a function of measured deflections. The overlay design guides may not prescribe an asphalt overlay for flexible pavements where the average daily loads are 15 or less even though other evaluations indicate that an overlay is needed. An example of one such pavement is test project No. 121 in Table 2.

Structural Condition - Condition Survey

A detailed condition survey of the nine P.C.C. pavements indicated no major structural failures as indicated in Table 3. Several projects exhibited small amounts of cracking and two projects contained several patches. Repair of joint "blow-ups" were counted as patches in this analysis.

TABLE 3

P.C.C. PAVEMENT CONDITION

Sect. No.	Percentage of Slabs									
	Pumping	Faulting	Long. Cracks	Transverse cracks	Diagonal Cracks	Corner Cracks	Pop Outs	Blow Ups	Patches	Slab Curling
2	0	32%	34%	0	0	0	0	0	0	60%
5	0	80%	0	0	0	0	0	0	0	80%
21	0	80%	1%	0	0	0	0	0	0	50%
28	0	58%	0	0	0	0	0	0	0	72%
29	0	64%	0	0	0	0	0	0	0	80%
32	0	70%	0	0	0	0	0	0	0	70%
36	0	14%	0	0	0	0	0	0	0	20%
37	0	74%	2%	1%	4%	7%	8%	0	2%	70%
50	0	75%	0	0	0	1%	1%	1%	1%	70%
AVG.%	0	61%	4%	0	0	1%	1%	0	0	64%

All of the P.C.C. pavements contained slab curling, ranging from 20% to 80% of the slabs in a given project. Additionally, all projects contained some degree of slab faulting, ranging from 14% to 80% of the slabs surveyed. This is thought to be principally due to the non-stabilized base course construction used on eight of the projects. Faulting measurements indicated 1/8-to 1/4-inch vertical slab displacement. Project No. 5, which was constructed with a 5 1/2-inch soil cement base, but with no load transfer devices, exhibited faulting in the range of 1/8 to 1/2 inch on 80% of the slabs surveyed.

A review of overlay records indicated that of the original 49 PCC AASHO projects 88% had not been structurally overlaid and were 18 years of age.

The results of the condition evaluation of the nine H.M.A.C. pavements are indicated in Table 4. All of the asphaltic concrete projects exhibited load-related, alligator-type cracking in the wheel paths. This type of fatigue cracking has been categorized as Class I, II, and III in the "AASHO ROAD TEST, REPORT #5" (Highway Research Board Special Report 61E). Class I cracking is the beginning of traffic load related failure of flexible pavements. It is characterized by short, unconnected, longitudinal cracks in the wheel paths. Class II cracking occurs when the Class I cracks connect forming small segmented, polygon-shaped islands. This condition was selected as the failure criterion in Louisiana's research report "Asphaltic Concrete Overlays of Rigid and Flexible Pavements". Additionally this type of failure criteria has replaced the Terminal Serviceability Index concept in many of the more recent rehabilitation studies utilizing the principles of layered theory. On six of the nine asphalt projects evaluated, the class II cracking exceeded 40% of the project length. Rutting greater than 1/2 inch was measured on five of the pavements.

Indications of distress noted include transverse cracks, potholes, mud pumping, patching, crack faulting, and surface deformations in the form of waves and bumps. All H.M.A.C. projects contained transverse cracks reflecting from their base courses. Seven of the base courses were cement stabilized.

TABLE 4

H.M.A.C. PAVEMENT CONDITION

	Percentage of Project										
Sect. No.	Type I Cracking	Type II Cracking	Type III Cracking	Pot Holes	Rutting		Mud Pumping	Patching	Reflection Cracks	Wavy Surface	Crack Faulting
					<½"	>½"					
86	80%	90%	72%	54%	38%	36%	45%	87%	91%	90%	76%
89	40%	24%	1%	0	1%	0	0	0	24%	1%	0
96	74%	11%	5%	5%	18%	15%	4%	4%	19%	21%	4%
106	76%	44%	11%	2%	24%	14%	0	0	84%	0	0
109	62%	52%	1%	0	22%	5%	0	0	77%	0	0
111	66%	56%	0	0	2%	0	0	0	76%	4%	0
114	32%	0	0	0	5%	0	0	0	32%	0	0
121	58%	42%	18%	0	8%	17%	0	28%	76%	5%	2%
136	56%	64%	0	0	5%	0	0	0	74%	0	0
AVG.%	60%	43%	12%	7%	14%	10%	5%	13%	61%	13%	9%

PHASE II

The population of 59 HMAC projects was divided into three categories following a review of overlay maintenance records. These are: those projects overlaid or reconstructed, those projects not overlaid but structurally failed (heavy maintenance), and those projects not overlaid but containing early stages of fatigue cracking. The projects are listed in Tables 5 and 6.

Seventy percent (41/59) of the HMAC projects were structurally overlaid or reconstructed at an average service life of 13 years. Sixty-six percent (27/41) of these projects had not carried their designed Σ loads prior to overlay.

Twelve percent (7/59) of the HMAC projects had not been overlaid but exhibited advanced failures and had received heavy maintenance. Eighty-six percent (6/7) of the projects in this group had not carried their designed Σ loads prior to failure. Their mean age is 16 years.

Eighteen percent (11/59) of the HMAC projects had not been overlaid and exhibited signs of initial fatigue cracking. Sixty-four percent (7/11) of these projects have not carried their designed Σ loads to date. Their mean age is 16 years.

Figure 1 is a log-log plot of design Σ load versus % design Σ load actually carried for the projects overlaid or reconstructed and for the projects not overlaid but structurally failed. Extreme flyers can be observed for the projects with very high and very low design Σ loads. These flyers may be due, in part, to the varying terminal serviceability indices assigned to low volume and high volume roads. Dotted lines have been superimposed on Figure 1 to separate the extreme flyers from the other data points.

TABLE 5

PROJECTS OVERLAID AND RECONSTRUCTED

Section No.	Design $\Sigma L \times 10^6$	Actual $\Sigma L \times 10^6$	% Design Load	Years of Service
52	2.200	0.064	3	8
54	2.400	0.800	33	15
55	0.700	0.739	106	13
60	0.002	0.174	8700	14
67	0.280	0.031	11	6
70	0.060	0.079	132	11
79	0.030	0.036	120	15
82	10.000	1.043	10	13
85	0.270	0.097	36	8
89	2.000	1.203	60	17
91	0.100	0.109	109	13
95	0.400	0.175	44	15
97	0.030	0.073	243	11
98	0.150	0.427	285	14
104	0.140	0.272	194	16
105	0.003	0.013	433	12
106	2.000	0.507	25	10
110	0.090	0.083	92	14
111	0.210	0.115	55	16
118	1.000	0.826	83	11
122	0.490	0.122	25	9
123	2.100	1.183	56	15
126	20.000	0.082	1	15
133	1.000	0.470	47	17
140	0.100	0.193	193	11
152	0.700	0.452	65	13
156	19.000	0.583	4	15
157	2.000	0.225	11	15
158	0.020	0.042	210	16
160	0.006	0.032	533	11
162	1.800	0.077	4	23
167	0.020	0.014	70	7
172	20.000	2.526	13	12
173	20.000	2.526	13	12
175	0.140	0.017	12	13
178	0.030	0.012	40	8
183	0.028	0.027	96	9
185	1.300	0.124	10	8
96	0.220	0.118	54	25
134	0.330	0.375	114	17
139	0.050	1.126	2252	19
				Average 13 Years

TABLE 6

PROJECTS NOT OVERLAID - STRUCTURALLY FAILED (HEAVY MAINTENANCE)

Section No.	Design $\Sigma L \times 10^6$	Actual $\Sigma L \times 10^6$	% Design Σ Load	Age (Years)
65	8.000	0.047	1	16
69	0.270	0.365	135	14
72	0.100	0.073	73	15
86	0.070	0.026	37	15
121	0.030	0.015	50	15
103	2.500	0.239	10	20
135	0.300	0.142	47	17

TABLE 7

PROJECTS NOT OVERLAID - FAILURES BEGINNING

Section No.	Design $\Sigma L \times 10^6$	Actual $\Sigma L \times 10^6$	% Design Σ Load	Age (Years)	Pavement Condition
68	0.030	0.071	237	16	Type I - Alligator Cracks
76	0.400	0.364	91	18	Type I, II, III, Minor Patching
101	0.017	0.034	200	15	Type I, II, Minor Patching
109	0.500	0.437	87	14	Type I, II, Rutting, Refl. Cracks
114	1.500	1.015	68	14	Type I, Refl. Cracks
131	0.020	0.054	270	19	Type I, II, III, Refl. Cracks
136	0.400	0.250	63	16	Type I, II, Refl. Cracks
138	4.000	0.376	9	15	Type I, II, III, Refl. Cracks
142	0.550	0.016	3	14	Type I, II, Minor Patching
165	0.100	0.014	14	15	Type I, Refl. Cracks
166	0.030	0.133	377	19	Type I, II

"DESIGN ≡ LOAD vs %DESIGN LOAD"

Bituminous Concrete Projects Overlaid or Structurally Failed

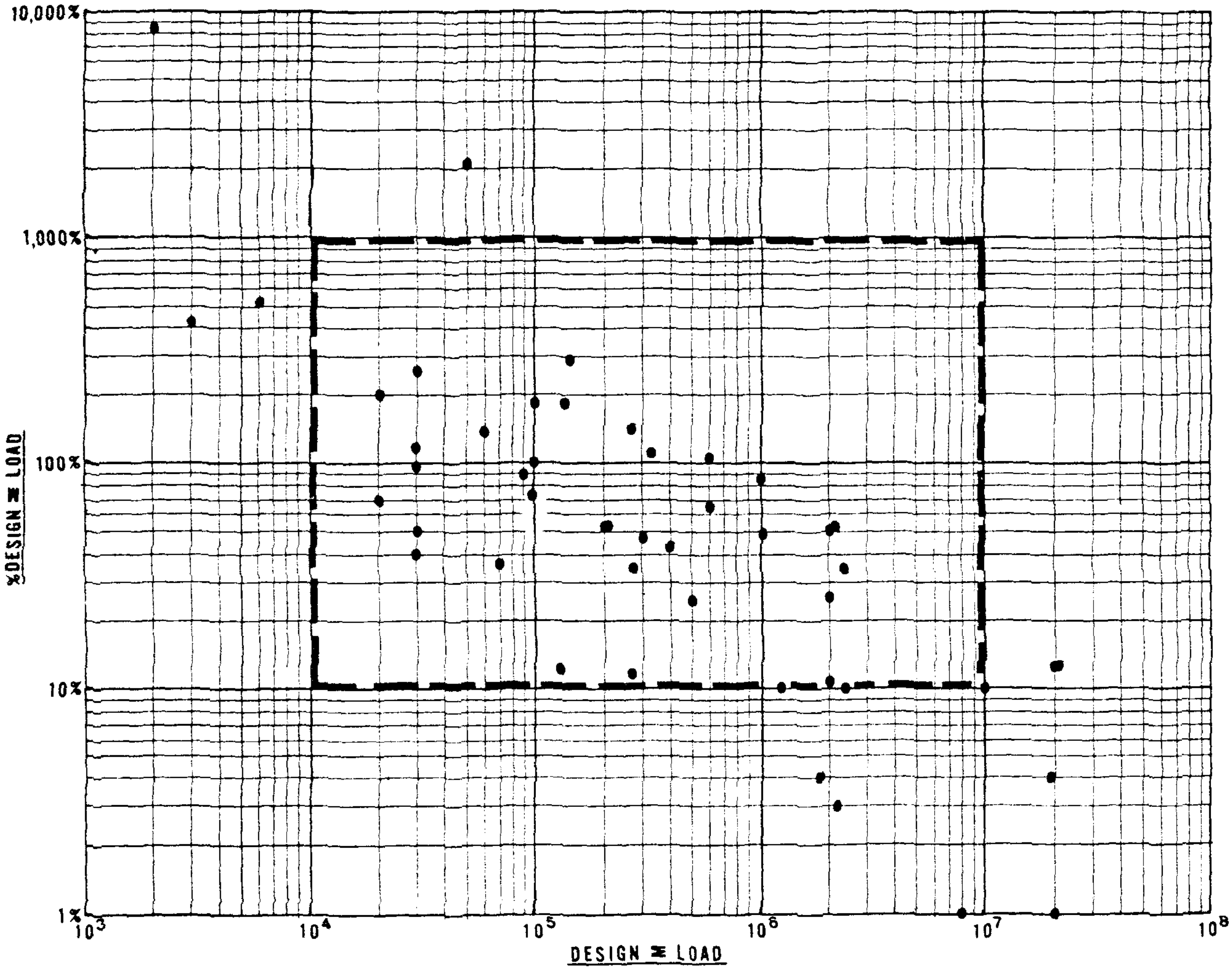

Figure 1

Figure 2 is a log-log plot of design Σ load versus actual Σ load using all the data points from Figure 1 except for the extreme flyers. The 45^{o} line in Figure 2 indicates 100% design Σ load carried. Projects plotted to the right of this line have carried less than their design Σ loads prior to failure. Projects plotted to the left of the line have carried greater than their design Σ loads.

Sixty-eight percent (23/34) of the projects have carried less than their design Σ loads prior to structural failure. The mean service life of these projects is 13 years. The mean service life of the projects which carried greater than the design Σ load is 14 years.

PHASE III

A determination of total miles of bituminous concrete pavements structurally overlaid each year was made for the period 1968-1978. Plant mix seals, friction courses, etc. were not included in the survey.

It was found that an average of 7% of the total miles of bituminous concrete in Louisiana is overlaid each year. This figure may be translated into a 14 year time span between construction and overlay. A more detailed presentation of the survey may be found in Table 8.

A similar analysis for overlays of PCC pavements is confounded by the fact that a majority of the pavements of this age which have been overlaid were done so as part of a pavement widening program in the early 1970's.

"DESIGN ≡ LOAD vs ACTUAL ≡ LOAD"

Bituminous Concrete Projects Overlaid or Structurally Failed
(Flyers Omitted)

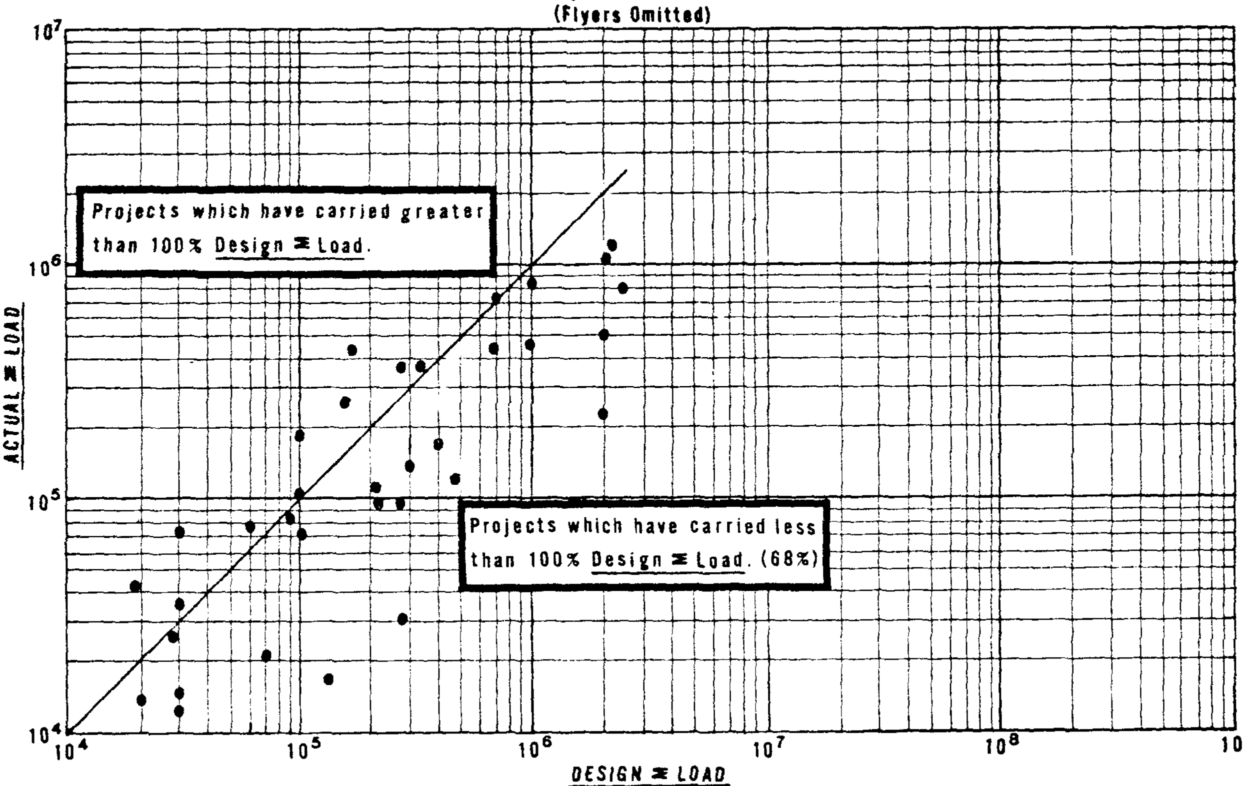

Figure 2

TABLE 8

HMAC STRUCTURAL OVERLAYS
(STATE SYSTEM)

Year	Miles HMAC Overlaid	% Total Miles
1969	387	6
1970	Not Available	-
1971	456	8
1972	107	2
1973	505	8
1974	161	3
1975	474	8
1976	415	7
1977	477	8
1978	511	9
		Average 7%/Year

$\frac{100\%}{7\%/\text{Yr.}}$ = 14 Year Service Life

SUMMARY OF FINDINGS

PHASE I

The following findings represent the 9 P.C.C. pavements and the 9 HMAC pavements measured for performance:

1) A population of 18 projects was selected so that both the PCC and HMAC pavement groups would have reasonable ratios of actual Σ load to design Σ load. The average ratios are 0.75 for the PCC pavements and 0.57 for the HMAC pavements. The average age of 17 years is common to both groups.

2) Average pavement roughness measurements were approximately equal for both pavement types. Average Present Serviceability Indicies were 2.4 for the HMAC pavements and 2.1 for the PCC pavements.

3) A structural field evaluation of the P.C.C. pavements indicated no major structural failures. Slab faulting at joints and slab curling were common. The faulting and curling accounted for a majority of the roughness measured on these pavements.

4) A structural field evaluation of the HMAC pavements indicated that six out of the nine projects contained Class II fatigue cracking in excess of 40% of the project length. Rutting greater than 1/2 inch was measured on five of the projects. All projects surveyed contained transverse cracks reflecting from their respective base courses.

PHASE II

The results of PHASE I of this study prompted a closer look at the HMAC projects used for Louisiana's AASHO Satellite study. The entire population of 59 projects was evaluated by reviewing overlay records and traffic history data, and by a visual field inspection. The results follow:

1) 70% (41/59) of the pavements were overlaid or reconstructed at an average service life of 13 years. 66% (27/41) of the projects had not carried their design Σ loads prior to overlay.

2) 12% (7/59) of the pavements had not been overlaid but exhibited advanced failures and had received heavy maintenance. 86% (6/7) of the projects had not carried their design Σ loads prior to failure. (Average age = 16 years).

3) 18% (11/59) of the pavements had not been overlaid and exhibited signs of initial fatigue cracking. 64% (7/11) of the projects had not carried their design Σ loads to date. (Average age = 16 years).

A review of overlay records for the 49 PCC pavements in the Louisiana AASHO study was also conducted. The records survey indicated that of the 49 PCC pavements 88% (43/49) of the projects had not been structurally overlaid and were 18 years of age.

PHASE III

A tabulation of the total miles of bituminous concrete structurally overlaid each year in Louisiana for the past 10 years indicated the following:

1) An average of 7% of the total miles of HMAC is overlaid each year.

2) This figure may be translated into a 14 year time span between construction and overlay.

A similar analysis for overlays of PCC pavements is confounded by the fact that a majority of the pavements of this age which have been overlaid were done so as part of a pavement widening program in the early 1970's.

CONCLUSIONS

1. A majority of the P.C.C. pavements (constructed from the mid-1950's to the early 1960's) in Louisiana will meet or exceed their design traffic lives.

   A statistical sampling indicates that 12% of the P.C.C. pavements have required structural overlay. The remaining 88% are in good to excellent condition at an average age of 18 years. It is reasonable to expect that these pavements will not require structural rehabilitation either before they have reached a 20 year service life or before they have carried their design traffic loads.

   A majority of the P.C.C. pavements sampled did not contain stabilized base courses. Several significant improvements in P.C.C. construction since 1960 will, no doubt, improve pavement performance beyond the level indicated in this report. The design improvements include addition of cement stabilized and asphaltic concrete base courses as well as provisions for a pavement underdrain system.

2. A majority of the HMAC pavements (constructed from the mid-1950's to the early 1960's) in Louisiana have not reached their design traffic lives prior to structural end of life.

   A statistical sampling indicates that 82% of the HMAC pavements have required structural overlay or have failed in fatigue after an average of 13 years of service. A comparison of actual Σ load and designed Σ load indicates that 68% of the sample carried less than the designed Σ load prior to structural end of life.

A sampling of the HMAC pavements not overlaid indicated that a majority of the survivors were structurally failed in fatigue. (Average age = 17 years).

A survey of all HMAC overlays of bituminous concrete pavements (excluding surface treatments) for the past 10 years in Louisiana, indicated a 14 year time span between construction and structural overlay.

RECOMMENDATIONS

1. Significant modifications of Louisiana's AASHTO Rigid Pavement Design procedure have been implemented within the past 20 years. The inclusion of cement stabilized bases, asphaltic concrete bases, and a provision for pavement underdrains have practically eliminated faulting of concrete slabs such as that noted in this study. The current P.C.C. design practices would appear to be adequate and therefore no further modifications are recommended at this time.

2. Pavement performance has indicated that a majority of the flexible pavements sampled in this research study did not carry their designed summation of loads before structural rehabilitation was needed. Accordingly it is recommended that Louisiana's AASHTO Flexible Pavement Design method be modified in an attempt to correct this problem. Based on data immediately available to this report, the author has included suggested modifications of the design procedure as an Appendix to this report.

   Additional research is needed to evaluate the structural design coefficients for base course and subbase course materials used in Louisiana.

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APPENDIX

SUGGESTED MODIFICATIONS OF LOUISIANA'S FLEXIBLE PAVEMENT DESIGN PROCEDURE

SUGGESTED MODIFICATIONS OF LOUISIANA'S FLEXIBLE PAVEMENT DESIGN PROCEDURE

The author feels that modifications in at least two areas of the flexible pavement design procedure would increase the service life of asphaltic concrete pavements. These are materials properties and soil support. The suggestions do not represent a restructuring of the existing design procedures, but instead represent a refinement of the current procedures.

AREA I - MATERIALS PROPERTIES (Structural Design Coefficients)

A structural design coefficient of 0.44 for high type asphaltic concrete was related to a Marshall Stability of 2000 pounds from the AASHO Road Test experiment. In a related publication (NCHRP 128, Evaluation of AASHO Interim Guides for Design of Pavement Structures), an expanded relationship between stabilities and coefficients indicates the following coefficients for Louisiana's specified stabilities for asphaltic concrete:

MIX TYPE	STABILITY SPECIFIED (POUNDS)	DESIGN COEFFICIENT
Types 1, 2, and 4		
Wearing Course	1200	0.33
Binder Course	1200	0.33
Type 3		
Wearing Course	1700	0.40
Binder Course	1400	0.36
Type 5A		
Base Course	1200	0.33
Type 5B		
Base Course	800	0.28

The author recommends that this listing of structural design coefficients be used to provide design thicknesses which are more compatable with the stability values specified in this state.

A recent sampling of Louisiana stability values extracted from a MATTS system print out of 218 construction projects indicated the following: (1) 27% of the stabilities measured on Type III wearing course material were below the specified minimum stability, and (2) 22% of the Type 5A base course stabilities were below the specified value. The possibility of materials problems such as these lends credence to the stated need for more design conservatism.

AREA II - SELECTION OF SOIL SUPPORT VALUES

The AASHO Guides do not specify a designed level of soil support to be selected from the range of support values determined within a given project. The author feels that the level selected should vary with the designed traffic volume.

Specific suggestions regarding the minimum soil support levels selected for various highway facilities are as follows:

Designed Facility	Minimum Selected Level of Soil Support
Interstate Highway	100th percentile (i.e., the lowest value measured)
Primary Highway	90th percentile (i.e., 10% are lower than the selected value)
Secondary Highway	80th percentile (i.e., 20% are lower than the selected value)
Farm to Market Road	60th percentile (i.e., 40% are lower than the selected value)

The selected support levels indicated may be slightly more conservative than those currently specified. A more conservative level of soil support will help delay load related cracking of flexible pavements and thereby extend pavement service life.

According to Louisiana's AASHTO Design Curves for flexible pavement, an inch of additional asphaltic concrete will in most instances significantly increase allowable cumulative traffic loads. The following data was extracted from the design curves for a hypothetical flexible pavement with a six inch soil cement base:

Soil Support Value	Existing Designed H.M.A.C. Thickness Inches	Increase in Allowable 18 kip Load Due to a One Inch Increase in Designed H.M.A.C. Thickness
2.4	5	1.5×10^5
	6	2.9×10^5
	7	4.1×10^5
	8	8.5×10^5
	9	1.2×10^6
	10	2.5×10^6
4.5	5	8.0×10^5
	6	1.5×10^6
	7	3.0×10^6
	8	6.5×10^6
	9	8.0×10^6
	10	9.0×10^6