

Florida Econocrete Test Road
A 10-year Progress Report

Torbjorn J. Larsen and Jamshid M. Armaghani

The Florida Econocrete Test Road was designed and constructed in response to the energy crisis of the 1970's. In addition to using econocrete bases with 3-in concrete pavements, several experimental features were included. Among those were the principle of elastic joints applied to the pavement-base interface, the CRCP, and to specially designed dowels. Thin unbonded reinforced pavements were also included. Common variables were joint spacings of 15-ft. and 20-ft., and skewed as well as transverse joints. The 10 year performance study was based on structural response in load-deflection tests and performance rating using the Mays Meter. All concrete sections were compared to a standard concrete pavement section as then built by the Florida Department of Transportation. The experimental sections generally performed equivalent or better than the concrete reference section. The study also included asphalt pavements placed on econocrete base structures. These sections were compared to an asphalt reference section as presently built by the Department. Again, the experimental sections fared well when compared to the reference section.

Materials Office, Florida Department of
Transportation, P. O. Box 1029, Gainesville,
Florida 32602

INTRODUCTION

During and following the energy crisis of the 1970's, means were sought to reduce the dependency on imported oil. One such effort was the development and use of a concrete paving material to become known as econocrete. The material was defined as:

"Econocrete is portland cement concrete designed for a specific application and environment and, in general, making use of locally, commercially produced aggregates. The aggregates need not necessarily meet gradation and quality requirements for conventional aggregates used in standard concrete mixtures."

The impetus leading to the concept of econocrete paralleled earlier concrete paving techniques where a concrete wearing course was placed monolithically on a less dense concrete base layer. Such was the early pavement in Bellefontain, Ohio. As early as 1944 an experimental road had been built in Florida using a crusher run limerock aggregate. It was later overlaid with a wearing course.

The econocrete energy saving envisioned in the 1970's was expected to come about by lesser crushing efforts, no need for aggregate separation, and locally available material with less hauling distance and associated wear on existing pavements. The American Concrete Pavement Association (ACPA) took the lead in promoting the idea and developed the necessary

support from industry as well as state and federal highway interests. A task force to pursue the framework for a research project was formed in 1974. Scope and objectives were established and in 1977 the Florida Econocrete Test Road was constructed. It was put under traffic in March of 1978. The road is located between the cities of Fort Myers to the South and Punta Gorda to the North on US highway 41 along the Florida South-West Coast. The road is in the subtropic region of the State with an annual rainfall exceeding 50-in. The information to be presented covers a 10-year time span. Some of the earlier test techniques for structural capacity measurement became obsolete during this period so that the data to be presented were not homogeneous throughout.

OBJECTIVE

The primary objective was to study the feasibility of construction and to evaluate the structural and performance characteristics of composite and composite monolithic pavements using an econocrete base with a relatively thin wearing course. It was reasoned that the information developed would also have application to overlays placed on a concrete base as when a concrete road is overlaid. Specific attention was given in the design to forces existing in the plane of the pavement structure due to volume changes by shrinkage, creep, as well as temperature and moisture variations. In this regard, the experimental designs using elastic joints and sections with fibrous concrete were practical attempts to control cracking. The effects of joint spacing and orientation on performance were also included.

SCOPE

Layout and designs for the 33 test sections were established by a task force consisting of members from the industry under the auspices of the ACPA,

by representatives from the Federal Highway Administration, and members of the Office of Materials and Research of the Florida Department Of Transportation. Specific features of each section are shown in the layout in Figure 1. The figure contain information for each subsection on: (1) its name, (2) total length in feet, (3) length of test section (The difference in lengths between the total length in feet in Item (2) and the length of the test section in Item (3) represents the half length of the transitions to the adjoining sections), (4) special pavement surface feature, (5) base structure, (6) sub-base structure, (7) pavement joints and (8) spacing, (9) interface treatment if any between surface and base, (10) joint spacing in base structure if any, (11) reinforcement and type if any, and (12) type of structure whether a composite overlay or monolithic composite. In the composite overlay construction the pavement or surface layer was placed on the hardened econocrete base without bond intended or provided between the two layers. For the composite monolithic construction the pavement or surface layer was placed on the econocrete base structure before the econocrete had attained its initial set. In this manner an affirmative bond was developed between the econocrete base and the pavement layer. Sections 1 and 2 were Florida standard designs for asphalt and portland cement concrete at the time of the test road design. All other sections contained a 9-in econocrete base with two exceptions where 8-in base structures were used. The econocrete was designed for three strength levels of 2000 (A), 1250 (B), and 750 (C) psi. The alpha notation was used in the section labels in Figure 1 to indicate design base strength levels. All experimental sections had a 3-in portland cement concrete wearing course with the exception of one subgroup of sections with 2-in wearing course using fibrous reinforced concrete. There were also two sections with asphalt pavements. The 33 sections were divided into seven major groups as indicated by the initial numerical in the section labels in Figure 1.

[illegible]

	9" Econocrete "B"												8" Econocrete "C"						9" Econo "C"					
	6" TYPE "A" MODIFIED STABILIZATION																							
SECTION	5 BT	6B-2E1	6B-2E2	6B-2E3	6B-2E4	6B-2C2	6B-2C3	7B-1B1	7B-1B2	7B-1B3	7B-2E1	7B-2E2	7B-2E3	7B-3U1	7B-3U2	7B-3B								
TOTAL LENGTH	100	396	355	352	348	345	448	435	336	432	432	336	432	451	450	300								
TEST SECTION LENGTH	100	348	355	352	348	345	352	345	336	342	345	336	342	450	450	250								
SURFACE	3" ELASTIC DOWELLED						3" CRC						2" FRC											
BASE							9" Econocrete "B"						8" Econo "C"											
SUBGRADE	6" TYPE "A" MODIFIED STABILIZATION																							
SURFACE CNT-H	NONE																							
SURFACE V-SACING	NONE																							
INTERFACE	BONDED / UNBONDED																							
BASE V4 SACING	20'	12'	9'-4"	8'	12'	9'-4"	8'	15'	12'	9'	15'	12'	9'	NONE	UNBONDED	BONDED								
REINFORCEMENT	#4 BAR #4 BAR @ 12" C/C	#4 BAR #4 BAR @ 8" C/C	#4 BAR #4 BAR @ 8" C/C	#4 BAR #4 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C	#3 BAR @ 12" C/C								
TYPE OF CONSTRUCTION	MONOLITHIC COMPOSITE																							
	COMPOSITE OVERLAY																							

Figure 1 Sections Designs and Lay-Outs.

All sections in Group 1 had asphalt pavements. In Group 2 was the portland cement concrete reference section placed on 6-in cement-treated soil. This section did not meet present specifications and drainage requirements. Group 3 sections had skewed joints at 15-ft. The sections in Group 4 had transverse joints at 15-ft and the econocrete base was placed on a 6-in cement treated soil. Sections 5 had transverse joints with dowels at 20-ft. The subsections in Group 6 were elastic jointed and had dowels or continuous reinforcement. Group 7 had fibrous reinforced concrete pavements. The experimental layout permitted comparison of any of the experimental sections with the corresponding reference section for asphalt and concrete, respectively. Pavement groups which incorporated non-conventional features were those in Group 6 and Group 7. Subgroup 6B-1 contained CRC modeled after similar pavement used in Sweden.⁽³⁾ Subgroup 6B-2 incorporated the elastic jointed principle using dowels as well as CRCP. All pavements in Group 7 had fibrous reinforced concrete pavements which were either unbonded, bonded, or elastic jointed at the interface. Most sections were monolithic composite except for those in Group 1, Group 2, Subgroups 6B-1, and 7B-3. Design details for each section are given in Fig 1. The dimensions and spacings of the elastic joints were based on principles developed by the senior author.

Comments on Experimental Design

One purpose of the investigation was to demonstrate the various steps in designing an optimum econocrete mixture, its fabrication and application in pavement construction - in fact to field-test the econocrete pavement principle and system. These matters were presented and discussed in Reference 1.

A second goal of the study was to measure each section's structural and performance ratings over time in such a manner that the various sections could be given a relative rating. This matter will be dealt with in this presentation.

Justification for a thin concrete pavement layer was based on the assumption that concrete pavements, as built, were not compatible in stiffness with most subgrades over which they are placed. Thus, pavement deformation, which substantially mobilizes subgrade support throughout its entire interface area, is preferred.

Econocrete for base structures have low elastic modulus as compared to standard portland cement concrete and also a relatively high flexural strength - see strength properties in Table 4. This provides for a more flexible pavement to undergo larger pavement deformations to more effectively utilize subgrade support.

CONSTRUCTION DATA AND TEST RESULTS

The embankment was built in 8-in layers and compacted to 98 percent of the maximum density. The top 6-in of the embankment was stabilized with crushed shell to give a dense and uniform subgrade. For the sections in Group 2 and Group 4 a 6-in cement-modified soil layer and for Section 1 a 12-in limerock base were placed on top of the embankment. Plate bearing E-values for the stabilized subgrades using a 12-in diameter plate are shown in Table 1. This procedure utilizes Florida Method of Tests for Nonrepetitive Static Plate Load Tests and is a modification of AASHTO T-22-78 using Bunmister's theory.

The econocrete aggregates were obtained from canal excavations in the test road vicinity. Gradation, absorption, specific gravity, and LA abrasion following AASHTO Methods of Sampling and Testing are listed in Table 2. Statistical analysis of econocrete mix characteristics and mechanical properties for the three strength levels are shown in Table 3 and Table 4 respectively. Compressive strength data for 24-hour accelerated, predicted, and actually measured strengths are compared in Table 5. This information was used as control during construction. Property values for the asphalt

mixture and the Portland cement concrete are not listed. Test data indicated these materials to be of good quality and of a uniform nature. These materials are discussed in details in Reference 1.

All those groups noted as monolithic in Figure 1 were constructed placing the econocrete base on the prepared subbase. Ideally, the surface concrete was placed at the time the sheen of the econocrete base disappeared, generally from 1/2 to 1 hour after the base had been placed. For those groups labelled as composite

there was a delay time of a day or more between construction of the base and placing of the pavement.

In 1977 and prior to traffic the sections were tested for structural load-deflection response using static loads and moving vehicle loads at various speeds. Deflections were measured using mechanical dial clock devices and electronic LVDT deflection sensors. The road was opened to traffic in March of 1978. The road was subject to heavy traffic for the first two years while the parallel I-75 was being constructed. Traffic data are shown in Table 6.

Table 1

Plate Bearing E-Values
(12" diam. plate test)

Section	E-Value psi x 10 ⁴
1	2.19
1B	2.20
1C	1.98
6B-1	2.27
2	3.97*
3A	1.87
3AH	1.72
3B	1.92
3C	1.82
4A	5.56*
4B	6.19*
4C	3.83*
5A	1.60
5B	2.27
6B-2	2.73
7B-1	2.76
7B-2	1.24
7B-3	1.66

* Sections with cement-treated soil bases.

Table 2

Econocrete Aggregate Properties

	Percent Passing													Absorption	Specific Grav	LA Abrasion
	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200			
Laboratory																
n	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
x	100	99	93	86	77	70	57	48	41	35	24	11	8	3.3	2.50	36
s	0	0.8	2.8	4.8	7.1	8.7	11.3	11.4	10.2	6.8	3.0	0.7	1.6	0.3	0.01	0.9
cv	0	0.8	3.0	5.5	9.3	12.5	19.8	23.9	24.5	19.5	12.4	6.6	19.4	10.2	0.5	2.4
range	0	97-	88-	78-	66-	59-	47-	39-	34-	29-	22-	10-	7-13	2.8-	2.47	35-37
		100	97	95	92	89	85	76	67	52	32	12		3.7	-	
															2.51	
Field																
n	36	36	36	36	36	36	36	36	36	36	36	36	36	--	--	--
x	100	100	90	84	75	70	57	50	45	41	31	16	10	--	--	--
s	0	0	5.3	6.1	6.8	7.2	7.8	7.9	7.6	8.1	6.0	2.3	1.7	--	--	--
cv	0	0	5.8	7.3	9.1	10.3	13.5	15.6	17.0	19.9	19.6	14.1	17.6	--	--	--
range	0	0	76-	75-	64-	58-	48-	41-	36-	28-	21-	11-	7-14	--	--	--
			100	95	92	89	85	80	74	71	49	21				

-- No data was obtained.

Table 3

Statistical Analysis of Econocrete Mix Characteristics

	Quality Assurance Results					Project Results				
	n	x	s	c.v.	range	n	x	s	c.v.	range
<u>Air Content, percent</u>										
Mix A	3	4.1	0.81	19.8	3.5 - 5.0	0.5	4.5	0.73	16.2	3.5 - 5.4
Mix B	8	3.2	0.43	11.3	3.2 - 4.5	14	4.1	1.41	34.4	1.0 - 5.8
Mix C	5	4.1	0.54	13.2	3.25 - 4.60	7	4.7	0.81	17.2	3.0 - 5.5
<u>Slump, inches</u>										
Mix A	3	1.8	0.14	7.8	1.8 - 2.0	4	1.3	0.31	23.8	1.0 - 1.5
Mix B	8	1.9	0.46	24.2	1.2 - 2.8	11	1.7	0.59	34.7	0.5 - 2.5
Mix C	5	1.7	0.32	18.8	1.2 - 2.0	6	2.2	0.58	23.4	1.4 - 2.8
<u>Unit Weight, pcf</u>										
Mix A	3	132.2	0.72	0.54	131.7 - 133.0					
Mix B	8	132.7	1.28	0.96	130.8 - 134.4					
Mix C	4	131.7	1.75	1.33	129.8 - 133.9					

Table 4

Statistic Analysis of Econocrete Strength Properties

	Quality Assurance Results					Project Results				
	n	x	s	c.v.	range	n	x	s	c.v.	range
<u>Compressive Strength, psi</u>										
Mix A	9	1955	87	4.5	1873 - 2085	9	1788	268	15.0	1340 - 2210
Mix B	24	1278	220	17.2	927 - 1731	30	1259	297	23.6	960 - 1820
Mix C	15	976	190	28.1	445 - 968	21	633	224	35.4	370 - 990
<u>Modulus of Rupture, psi</u>										
Mix A	9	380	27	7.1	347 - 434					
Mix B	26	279	33	11.8	213 - 343					
Mix C	15	158	43	27.2	103 - 210					
<u>Splitting Tensile Strength, psi</u>										
Mix A	6	247	14	5.7	230 - 270					
Mix B	16	176	31	17.6	128 - 227					
Mix C	11	93	29	31.2	58 - 142					
<u>Modulus of Elasticity, psi x 10⁶</u>										
Mix A	9	2.21	0.13	5.9	2.06 - 2.44					
Mix B	23	1.73	0.26	15.0	1.32 - 2.15					
Mix C	15	1.29	0.26	20.2	1.01 - 1.69					

Note: All tests were made according to AASHTO Test Procedures.

Table 5
Econocrete Accelerated Cure Tests

Mix Designation	Laboratory Results			Field Results		
	Design Strength, psi	24-hr Strength, psi	28-day Strength, psi	24-hr Strength, psi	Predicted Strength, psi	Actual 28-day Strength, psi
A	2000	656	2224	532	1803	1752
B	1350	432	1464	413	1399	1288
C	750	279	764	281	770	700

All values are Compressive strength.

Table 6
Traffic - One Direction

<u>Year</u>	<u>AADT</u>	<u>ESAL (1000)</u>	<u>Accum (1000)</u>
1979	11810	224.6	224.6
1978	12600	239.6	464.2
1980	12205	232.1	696.3
1981	8187	122.3	818.6
1982	7310	109.2	927.8
1983	8300	124.0	1051.8
1984	8500	127.0	1178.8
1985	8528	142.3	1321.1
1986	9772	122.3	1443.4
1987	10200	126.9	1569.3

Note: The parallel I-75 was opened to traffic in 1981.

All traffic data were obtained from weight in motion installation.

Early Pavement Failures

All section in subgroup 6B-1 with CRCP developed a crack pattern which often reflected the reinforcement. During construction problems had developed with the wire mesh reinforcement. Its undulations exceeded the 3-in pavement thickness. It was therefore nailed to the subbase. Where reinforcing bars were used, the transverse steel provided the "chairs" for the longitudinal reinforcing steel. It is believed that the reinforcement in these sections acted as crack initiators causing the pavement failures. The 2-in fibrous concrete pavements of subgroup 7B-2 and the 3-in fibrous pavement of Section 7B-3 likewise experienced early failure. All of these sections with exception of 7B-3 were removed in September of 1978 and replaced with a 3-in asphalt pavement. This eliminated all concrete composite overlay sections with the exception noted. It was concluded that for thin pavements on a rigid base affirmative bond must be established between the layers.

Test Data

The structural performance of the sections was based on deflection data. From 1977 Through 1984 such data were obtained using the Benkelman Beam (BB) and two load levels of 18-kip and 27-kip axle loads. From 1985 and on the Falling Weight Deflectometer (FWD) was used employing load levels of 550 and 930 kPa corresponding to the above axle loads. The joint efficiency until 1985 was measured using the Dynaflect. Later, the joint efficiency was estimated based on data from the FWD.

Rideability of the sections was based on present serviceability index (PSI), from data obtained using the Mays Ride Meter.

Traditionally deflection data are obtained during daylight hours. Such is the case for all data collected in this study. Because of variations in ambient conditions, the compatibility of the data varied. Further, to

observe the influence of seasons on the test results, data were obtained during the warm and wet season with high water table and during the cooler, dry season. However, all data reflected some average condition and defined a trend over the 10-year observation period.

DATA ANALYSIS AND DISCUSSION

The averages for each of the four variables and for each section and test period were determined and plotted versus time. It was reasoned that the slope of the curve signified the time effect. For instance, a negative slope for deflection would indicate improved strength while a negative slope for joint efficiency would suggest a decrease in the ability to transfer load across the joint. However, it was realized that with equal performance for two sections as expressed by two parallel lines, the one with the smaller deflection or higher joint efficiency would be the one with least wear and also likely to continue to perform better. Hence, the basis for comparison became the slope of the time vs. performance curve as well as the integrated area under it. For each variable these two indicators were used to express section performance. In total eight indicators were established for each of the concrete pavement sections. Each section was ranked according to each of its indicator using 10 as the maximum value. The indicator values for slope and area of the performance expressions were summed into a single factor for each section giving a final numerical value. These values were used to rank the sections and are listed in Table 7. In Table 7 and for Section 2 the four indicators for slope summed to a value of 12. It means that each indicator had an average value of 3 which ranked the section as number three from the low end. By the area concept the section rated low and in sum was ranked as the third lowest section.

It is reemphasized that the two indicators are visualized to represent the influence of time on the performance characteristics as expressed

Table 7
Ranking of Test Sections

Section	Slope		Area		Sum	
	Total Points	Rank	Total Points	Rank	Total Points	Rank
2	12	9	2	12	14	11
3A	27	3	10	7	37	3
3Alt.	30	1	9	8	39	2
3B	28	2	11	6	39	2
3C	23	4	17	3	40	1
4A	13	8	7	9	20	9
4B	10	10	17	3	27	7
4C	8	11	18	2	26	7
5A	6	13	9	8	15	10
5B	15	6	5	11	20	9
5BT	7	13	20	1	27	7
6B-2E1	17	5	20	1	37	3
6B-2E2	13	8	12	5	25	8
6B-2E3	14	7	18	2	32	4
6B-2C1	15	5	16	4	31	5
6B-2C2	13	8	17	3	30	6
6B-2C3	27	3	10	7	37	3
7B-1B1	4	14	5	11	9	12
7B-1B2	1	15	6	10	7	13

Performance	Superior	Good	Medium	Low	Lowest
Points	37-40	30-32	25-27	14-20	7-9
Sections	3C 3Alt 3B 3A 6B-2E1 6B-2C3	6B-2E3 6B-2C1 6B-2C2	4B 4C 5BT 6B-2E2	4A 5B 5A 2	7B-1 7B-2

by the slope of the performance coefficient in the performance - time equation while its capacity to perform is expressed by the area term. Even when it is assumed that the ranking is perfect, the performance difference between two adjoining sections in the ranking list can not be quantitatively established in this type of analysis.

The rating ranked the sections in Group 3 as best performing. Sections A and B in Group 3 are structurally equivalent to those in Group 5 except for joint spacing. The sections in Group 3 had 15-ft skewed joints and those in Group 5, which were given a lower rating, had 20-ft transverse joints with one-inch dowels spaced at 12-in. center to center. The second group in

performance were those with elastic joints in Group 6 with one exception for Section 6B2E2 which showed a distinctly lower performance. This group was followed by the sections in Group 4 rated medium in performance where the econocrete was placed on six inches of cement treated soil with 15-ft transverse joint spacing. Of the sections in Group 5 the elastic dowelled transition, Section 5BT showed a distinctly better performance than the remaining sections in this group. The concrete reference section, Section 2, demonstrated the lowest performance in this rating with the exception of the fibrous reinforced concrete sections in Group 7. It is noted that the econocrete base strength was not a significant factor in the rating at this time. The better performance of the sections in Group 3 suggests a monolithic composite pavement consisting of a 9-in. econocrete base of average strength, say 1000/1500psi at 28 days, and with a 3-in. concrete wearing course will provide a durable pavement when the joints are skewed and spaced at about 15-ft. Elastic jointing, using dowels or CRC, will also provide a durable pavement and may provide the more economical solution because of savings for cutting and sealing of joints. None of the monolithic composite pavements developed pumping while the concrete reference section - Section 2 - developed pumping shortly after construction indicated by fines on the shoulder pavement.

Theoretical Stress Evaluation

In Reference 2 a theoretical analysis was made of stresses using the FEACONS IV finite element programs. Stresses were determined for live loads and for combinations of live loads at various points on a slab incorporating temperature differentials. It was established that the most critical condition occurred when the pavement was subjected to a combination of a positive temperature differential with a load at the center of the slab. The result of the calculations is shown in Table 8. It is realized

that a pavement slab is seldom loaded at its center.

Composite Asphalt - Econocrete Section

The asphalt reference pavement, Section 1, had a 4-in conventional asphalt pavement with 10-in of primed limerock placed on 12-in crushed shell stabilized subgrade. The remaining sections in Group 1 were experimental with 9-in of econocrete placed on the subbase and with 3-in of asphalt pavement. The sections were ranked in the same manner as for the concrete sections except that load transfer at joints was not applicable. Section B with the medium econocrete strength was rated best followed by Sections 1 and 1C. All sections were judged to perform quite well. The sections with econocrete base have hairline cracks spaced at about 40-ft. Section 1 had no transverse cracks. It is concluded that the econocrete base sections, having compressive strengths in the range of 800 to 1500 psi and with a 3-in. asphalt pavement, are equivalent in performance to the standard Florida asphalt section.

Validity of Ranking

Although the indicators used may rate the sections in the proper sequence, it is realized that the procedure had many shortcomings. The season when tested, whether wet or dry, had little influence on the measured deflections. Likely, the materials themselves were influenced by the moisture conditions but in such a manner to compensate the influences.

The ambient conditions of temperature and moisture at the time the data were obtained did influence the test results. The change in test technique from Benkelman Beam and Mays Meter and to the Falling Weight Deflectometer represent another source of potential influence on the test data.

Perhaps, the method of analysis and its rational may have had a substantial influence on section ranking.

Table 8
Maximum Computed Stresses

TEST SECTION		MAXIMUM COMPUTED STRESSES (psi) DUE TO:					
		ESTIMATED FLEXURAL STRENGTH (psi)**	9-KIP LOAD AT SLAB CENTER	9-KIP LOAD AT JOINT CENTER	9-KIP LOAD AT EDGE CENTER	T = +20 F 22-KIP AXLE LOAD AT SLAB CENTER	T = -10 F 22-KIP AXEL LOAD AT SLAB CENTER
3A	CONC.	755	- 88 (12%)*	-148 (20%)	-142 (19%)	-334 (44%)	+142 (19%)
	ECONO.	385	+ 64 (17%)	+108 (28%)	+104 (27%)	+244 (63%)	-103 (27%)
4B	CONC.	623	- 79 (13%)	- 95 (15%)	-135 (21%)	-319 (51%)	+118 (19%)
	ECONO.	322	+ 55 (17%)	+ 66 (20%)	+ 94 (29%)	+222 (69%)	- 82 (25%)
5B	CONC.	524	- 94 (18%)	-143 (27%)	-156 (30%)	-343 (65%)	+144 (27%)
	ECONO.	419	+ 58 (14%)	+ 89 (21%)	+ 97 (23%)	+213 (51%)	- 89 (21%)
6B-2E1	CONC.	751	- 98 (13%)	-130 (17%)	-156 (21%)	-328 (44%)	+137 (18%)
	ECONO.	401	+ 63 (16%)	+ 83 (21%)	+100 (25%)	+211 (53%)	- 88 (22%)
6B-2C1	CONC.	657	-107 (16%)	-134 (20%)	-160 (24%)	-348 (53%)	+141 (21%)
	ECONO.	316	+ 59 (19%)	+ 73 (23%)	+ 88 (28%)	+190 (60%)	- 77 (24%)
7B-1B	CONC.	751	-128 (17%)	-	-216 (29%)	-454 (60%)	-
	ECONO.	312	+ 67 (21%)	-	+113 (36%)	+239 (77%)	-

NOTE: * Percent of estimated flexural strength of concrete.

** Estimated flexural strength were obtained by multiplying the split tensile strength by a factor of 1.5.

- no data obtained

However, in viewing all of these possible sources of influences it is felt that the rating provided is reasonable and a good estimate.

Recommendations

For the specific circumstances of this investigation it is concluded that the standard concrete pavement design for rural areas used in prior years and without edge drainage placing 9-in. of concrete on a stabilized subbase such as cement-treated soil produced the least desirable of the 19 concrete pavement sections which have remained in test. This pavement developed faulting and pavement pumping at an early age.

The sections in Group 3 placing a 3-in. monolithic concrete wearing course on 9-in. of econocrete and with skewed joints placed at

15-ft. proved superior to all other designs. The experimental elastic jointed pavements in subgroup 6-2 proved also to perform very well. It is considered a viable design option and may prove an economical solution to overlay pavements where the effects of joints in the existing pavement may be a problem. Details of the elastic jointed systems are described in Ref.(1).

The sections in Group 4 had a soil-treated subbase below the econocrete base and joints at right angle to the edge, but was otherwise equal in construction to the sections in Group 3. The addition of the cement-treated subbase did not prove an advantage.

The two main sections in Group 5 had dowels at mid-depth and 20-ft right angle joint spacing. The sections showed lesser performance than those

in Group 3 and Group 4. The interface jointed sections in Group 7 with 2-in. fiber reinforced concrete failed to perform as expected. However, the sub-sections are still under test.

Descriptive Condition Survey

Each year the test road was subject to a detailed inspection. The result for each section is condensed in a short summary statement. The terms used are not defined and are the raters own. Thus, the ratings should be seen in a relative perspective. It should also be noted that the comments made in 1988 are similar to those made in 1984. The subjective ratings in the following may differ from those based on the indicators used in this report. The term "Stabilization" used in the following refers to crushed shell used to stabilize the subgrade soil.

Section I - Asphalt Reference Section, 4" Asphalt Overlay, 10" Limerock Base, 12" Stabilization - Section appears to be in good condition. No transverse cracking noted. Moderate wheel path rutting was measured from 0.1 - 0.2 inches.

Section 1B - 3" Asphalt Overlay, 9" Type B Econocrete Base, 6" Stabilization - Transverse hairline cracking at 30 to 40 feet intervals possibly corresponding to the Econocrete base shrinkage cracks.

Section 1C - 3" Asphalt Overlay, 9" Type C Econocrete Base, 6" Stabilization - Transverse cracking similar to that of 1B is noted throughout the section.

Section 2 - Concrete Reference Section (Standard), 9" Concrete, 6" Cement Treated Subgrade - Pumping and moderate shoulder depressions are evident throughout this section at transverse contraction joints between the shoulder/and the pavement. Asphalt sealant

has been applied in an attempt to reduce the infiltration of water in these areas. In addition, minor faulting on the order of 0.05-0.10 inches is typical throughout this section.

Section 3A - 3" Concrete, 9" Type A Econocrete Base, 6" Stabilization, Skewed Joints at 15' Spacing - Pavement remains in excellent condition. 90-95% of the defects noted can be attributed to poor finishing techniques at construction. The neoprene joint sealant is beginning to deteriorate through tear and excessive depression.

Section ALT - 3" Concrete, 9" Type B Econocrete Base, 6" Stabilization, Skewed Joints at 15' spacing - Pavement continues to appear in very good condition. Overall visual inspection indicates little or no defects. In addition, longitudinal edge joints remain comparable to section 3A. Minor spalling was observed at the edge joint and believed to have been caused during construction of the asphalt shoulder.

Section 3B-1S - 3" Concrete, 9" Type B Econocrete Base, 6" Stabilization, Econocrete Shoulder with Rumble Strips, Skewed Joints at 15' Spacing - Pavement appears to be in good condition with minor faulting at transverse joints. Sporadic corner cracks are evident at the outside edge of the econocrete shoulder. These cracks are believed to have occurred due to the lack of maintenance in preventing runoff erosion at the shoulder joints.

Section 3B-2S - 3" Concrete, 9" Type B Econocrete Base, 6" Stabilization, Econocrete Shoulders without Rumble Strips Skewed Joints at 15' Spacing - Pavement appears in relatively good condition with the exception of an area where the slabs show extensive scaling which has now been patched. Construction error, not design failure, is believed to be the cause of these defective slabs. Although the specific content

patches appear to be adhering to the residual pavement quite well. Shoulder conditions indicate some spalling and minor corner breaks which could be attributed to the lack of maintenance.

Section 3C - 3" Concrete, 9" Type C Econocrete Base, 6" Stabilization, Skewed Joints at 15' Spacing

- General pavement condition seems quite good with the exception of some shoulder spalls and minor faulting. Approximately 90% of the surface defects noted may be accredited to poor finishing techniques.

Section 4A - 3" Concrete, 9" Type A Econocrete Base, 6" Cement Treated Subgrade, Transverse Joints 15' Spacing - Marked longitudinal cracking is evident on the inside wheel path which is believed to be caused by settlement of the pavement near its center line. Some minor spalling is located at the edge joint. This could be caused by construction procedures in paving the adjacent asphalt shoulder.

Section 4B - 3" Concrete, 9" Type B Econocrete Base, 6" Cement Treated Subgrade, Transverse joints at 15' Spacing - Pavement appears to be in good condition. Longitudinal shoulder cracks appear sporadically with isolated spalls at shoulder/pavement interface near the end of the section.

Section 4C - 3" Concrete, 9" Type C Econocrete Base, 6" Cement Treated Subgrade, Transverse Joints at 15' Spacing - Pavement is in fair condition with light to moderate longitudinal cracking located on the inside wheel path. Some slight spalling at roadway shoulder interface along with isolated hairline map cracking or crazing is noted. Some joint seal deterioration noted.

Section 5A, 3" Concrete, 9" Type A Econocrete Base, 6" Stabilized, Doweled Transverse Joints at 20' Spacing - Pavement is in excellent condition with the exception of some intermittent poor finishing and a few small pop outs. Faulting at transverse contraction joints is negligible.

Section 5B - 3" Concrete, 9" Type B Econocrete Base, 6", Stabilization, Doweled Transverse Joints at 20' Spacing - Pavement appears in very good condition. A few minor defects are noted, such as small pop outs, but could be attributed to construction finishing. Longitudinal edge joints show no signs of distress. In addition, some transverse contraction joints were found unsealed. This condition may be due to defective seal installation or contractor oversight. It is interesting to note these areas show no distress due to water intrusion.

5BT 3" Elastic Doweled, 9" Type B Econocrete Base, 6" Stabilization, Doweled Transverse Joints at 20' Spacing - Transverse cracks with intermittent spalling are noted. These cracks are believed to be induced by the dowel configuration.

6B2E1 - 3" Elastic Doweled Concrete, 9" Type B Econocrete Base with Crack Initiators at 12' c/c, 6" Stabilization - Pavement is in good condition. Observations made are: Transverse elastic joints formed approximately normal to the edge. In some cases these joints have been filled with a sealant. Frequently, longitudinal hairline cracks (1-3ft) have formed normal to the elastic joint. Slight spalling is evident at the joints. The joint/cracks described are found throughout the section.

6B2E2 - 3" Elastic doweled Concrete, 9" Type B Econocrete Base with Crack Initiators at 9'-4" c/c, 6" Stabilization - Pavement is in fair condition. Elastic joints and longitudinal hairline cracks have formed as described for Section 6B2E1.

6B2E3 - Elastic doweled Concrete, 9" Type B Econocrete Base with Crack Initiators at 8' c/c, 6" Stabilization - Pavement is in fair condition. Elastic joints and hairlines cracks have formed similar to those in section 6B2E2. Thus cracks have been watched closely over the last four years without further deterioration observed.

6B2C1 - 3" continuously Reinforced Concrete, 9" Type B Econocrete Base with Crack Initiators

at 12' c/c, 6" Stabilization - Pavement is in fair condition. Minor spalling is frequent at transverse elastic joints. Cell type cracks are noted at a number of isolated locations.

6B2C2 - 3" Continuously Reinforced Concrete 9" Type B Econocrete Base with Crack Initiators at 9'-4" c/c, 6" Stabilization - Pavement is in fair condition. Moderate to heavy spalling has occurred along transverse elastic joints. Cell type cracks are observed in the test section and have been closely monitored over the last four years with only minor development.

6B2C3 - 3" Continuously Reinforced Concrete, 9" Type B Econocrete Base with Crack Initiators at 8' c/c, 6" Stabilization - Pavement is in poor condition. Moderate to heavy spalling has occurred along transverse elastic joints. Some cell type cracking is apparent.

7B1B1 - 2" Fiber Reinforced Concrete, 9" Type B Econocrete Base with Crack Initiators at 15' c/c, 6" Stabilization - Pavement is in fair condition. Longitudinal cracking near or at center line extends roughly the entire section. Some faulting has occurred on these breaks. Pop outs are frequent and assumed to be caused by small concentrations of metal fibers near the surface which have become dislodged.

7B1B2 - 2" Fiber Reinforced, 9" Type B Econocrete Base with Crack Initiators at 12' c/c, 6" Stabilization - Pavement is in poor condition. A variety of defects are noted: Pop outs, cell type cracks and spalls. The most probable cause of these problems are believed to be small to large collections of metal fibers which have created stress concentration in the pavement system. Approximately 100 feet of this section length has been overlaid.

REFERENCES

1. Page, G.C., and Harper, L.W., Econocrete Test Road - Post Construction and Materials Report, Research Report 80/221, Florida Department of Transportation, Gainesville, Florida, February, 1980
2. Wu, Chung-Lung, Field Evaluation and Comprehensive Structural Analysis of Concrete Pavement for the Development of Rational Thickness Design Methods, Ph.D. Dissertation, University of Florida, Gainesville, Florida, 1988
3. Losberg, A, "Continuously Reinforced Pavements with a very Thin Surface Layer", European Road Conference Proceedings, Paris, France: July 1969.