Report on Experimental Project in Kentucky

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● THE Kentucky Test Road was constructed during the summer of 1940, by the Kentucky Department of Highways in cooperation with the Bureau of Public Roads. The investigational pavement, a part of US 231 (formerly Ky. 71) is 6. 27 miles in length and is located approximately six miles southeast of Owensboro, in Daviess County.

This report presents a discussion of pavement performance and observations over a 10-year period, beginning in September, 1940. A complete discussion of the original scope, purpose, and early performance of this cooperative project has been given in previous reports (1, 2, 3).

GENERAL FEATURES

The general arrangement and design features of the pavement are given in Table 1. Essentially, there were seven sections with experimental variables which conformed to the general test program, and an added section designated as Standard. This section represented the design used by Kentucky at that time, and for the most part it was constructed over swampy land considered unsuitable for an experimental pavement.

Expansion joints were constructed to accommodate a 1-inch width of premolded bituminous fiber filler and contraction joints were of the weakened plane type with a premolded bituminous fiber filler.

Dowels for load transfer were ¾-inch plain round bars and secured in proper spacing and alignment by welded dowel spacers which remained in place. Spacing of expansion joints in the different sections varied from 60 feet to 5,040 feet in length and contraction joint spacing was 20 feet in all but two sections. In Section 6, the joint interval was 60 feet, alternating with contraction and expansion joints. In the Standard Section these joints were spaced at 30 foot intervals. Sections where wire mesh reinforcing was installed had the initial pour of concrete struck off 2 inches below grade for placing the mesh.

Soil Conditions

Soils throughout the project were predominantly H. R. B. A-4 or approximately A-4-6 materials. Generally speaking, they were uniformly of a fine sand or silty texture, with the clay content (-. 005mm) in all but a few cases lower than 20 percent. These characteristics reflected the derivation of the soil, which was associated with wind transportation.

Soils in the moderate upland usually consisted of windblown fine sands and silts, and only in a few spots did the underlying shale formation have an influence at subgrade elevation. In close association, but pertinent to a relatively small portion of the road, were the silty soils of the lowlands which originated through deposition in a lake created by glacial activity to the north about the same time that comparable windblown soils were deposited in the upland. So far as tests results were concerned, the soils from all parts of the road were quite similar. Fills through the lowlands kept the grade high enough to make internal drainage conditions relatively similar also.

Physical Properties of Concrete

A single brand of Type I Portland Cement was used throughout the project. Fine and coarse aggregates selected for use were Ohio River sand and gravel dredged from a well known bar approximately 8 miles upstream from Owensboro.

The average compressive strength for 68 specimens at 28 days of age, representing one cylinder for each 500 linear feet of pavement, was 4,910 psi. Maximum and minimum strength were 6,200 and 3,890 psi. respectively, and 71 percent of the strengths were within 10 percent of the average strength. The average modulus of rupture was 1,000 psi. at 28 days. Maximum and minimum values were 1,200 and 815 psi. respec-

TABLE 1

DESIGN OF EXPERIMENTAL JOINT SECTIONS

Section No.	Length	Design Section	Wire Mesh Reinf.	Expansion Joints		Contraction Joints	
				Spacing	Load Transfer	Spacing	Load Transfer
	ft.	in.		ft.		ft.	
7	1250	7-7-7	None	120	None	20	None
6	1500	9-7-9	70 lb.	60 alt.	Dowels	60 alt.	Dowels
5	1500	9-7-9	Nonc	120	Dowels	20	Dowels
4	1500	9-7-9	None	120	Dowels	20	None
3	2500	9-7-9	None	400	Dowels	20	None
2	3000	9-7-9	None	800	Dowels	20	None
1	5000	9-7-9	None	None	None	20	None
Std.[a]	7000	9-7-9	44 lb.	120	Dowels	30	Dowels
2-R	2500	9-7-9	None	800	Dowels	20	None
3-R	2500	9-7-9	None	400	Dowels	20	None
4-R	1500	9-7-9	None	120	Dowels	20	None
5-R	1500	9-7-9	None	120	Dowels	20	Dowels
6-R	1500	9-7-9	70 lb.	60 alt.	Dowels	60 alt.	Dowels
7-R	1200	7-7-7	None	120	None	20	None

R - Repeat Sections. Section No. 1 was not repeated.
[a] See Summary.

TABLE 2

TEMPERATURE AND PRECIPITATION DATA
July 1940 to July 1950[a]

Month	Temperature					Precipitation	
	Average	Average of the Mixima	Absolute Maximum	Average of the Minimum	Absolute Minimum	Average	Snowfall Average
	deg. F	deg. F	deg. F	deg. F	deg. F	in.	in.
December	37	47	72	28	- 6	3.0	1.5
January	34	44	76	25	-15	4.6	3.2
February	36	46	72	25	0	3.7	2.6
Winter	36	46	76	26	-15	3.8	7.3
March	47	58	85	36	0	5.7	1.6
April	57	70	90	45	25	4.0	0
May	66	78	94	54	33	3.7	0
Spring	57	69	94	45	0	4.5	1.6
June	75	87	107	63	46	4.2	0
July	77	90	103	65	44	3.5	0
August	77	90	105	64	42	3.3	0
Summer	76	89	107	64	42	3.7	0
September	67	83	99	56	32	3.6	0
October	60	72	92	46	21	2.5	0
November	46	57	84	36	- 7	4.1	0
Fall	58	71	99	46	- 7	3.4	0
Annual	57	69	107	45	-15	45.9	8.9

[a] From Special Observer Station, U. S. Weather Bureau, ½ mi. west of Owensboro, Daviess County, Kentucky.

TABLE 3

AVERAGE DAILY TRAFFIC

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Passenger Cars	511	584	207	264	290	360	590	670	675	681	895
Light Trucks (under $1\frac{1}{2}$ tons)	150	237	413	300	325	333	363	300	282	194	255
Medium Trucks ($1\frac{1}{2}$ to 5 tons)	0	0	4	64	63	29	7	61	149	175	230
Tractor Semi-Trailers (over 5 tons)	6	8	8	11	12	16	28	22	18	2	3
Busses	8	11	17	9	10	12	15	15	16	14	18
Total Traffic	675	840	649	648	700	750	1003	1068	1140	1066	1400

tively, with 77 percent of the strengths falling within 10 percent of the average.

The 34 core specimens varied in age from 41 to 80 days, with an average compression strength of 4,855 psi. High and low strengths for the cores were 6,735 and 3,245 psi. respectively, with 47 percent of the strengths being within 10 percent of the average.

Climatological Data

Temperature and precipitation data from a station near the project are listed in Table 2. These data represent the period of pavement construction and the subsequent 10-year period of observation.

Mean annual rainfall at Owensboro for this period was 45.9 inches, with precipitation in this amount being generally representative of that for the entire state.

Severe changes in temperature were not frequent despite the excessive maximum and minimum values contained in Table 2. However, there are frequent reversals from freezing to thawing temperatures, and vice versa, within a normal winter. Past calculations (4) based on air temperatures, at a station in the central part of the state indicate that a total of about 55 such reversals occur in a representative year.

Traffic

The average daily traffic count by number and type using the projects is shown in Table 3. It should be pointed out that heavy traffic has been somewhat restricted throughout practically the entire life of the pavement because of reconstruction on other sections of the same highway and the recent completion of a bridge adequate for heavy traffic on a major river farther south within the state.

JOINT WIDTHS AND PAVEMENT ELEVATIONS

Measurements of daily, seasonal, and permanent changes in width were scheduled for a representative number of joints in each of the sections, and in addition there were five sets of precise measurements of elevation taken during the 10-year period. The number of joints represented in determinations of the average daily, seasonal, and permanent joint width measurements are noted in Table 4.

Elevation measurements were taken from points installed in a manner similar to that for the caliper inserts for width measurements, but were placed in the opposite lane. Elevation points, less frequent in number, were also installed at the midpoints of the slabs to detect warping.

Daily Measurements

With very few exceptions, the joint movement was quite uniform for all joints of a given type in a section for each date. This takes into account the fact that expansion joints and contraction joints were treated separately, in recognition of the fundamental

TABLE 4

NUMBER OF JOINTS SELECTED FOR WIDTH MEASUREMENTS

Section No.	Joint Width Measurements					
	Daily		Seasonal		Permanent	
	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.
7	2	5	4	10	2	5
6	3	2	6	5	4	3
5	2	5	4	10	2	5
4	0[a]	0[a]	4	10	0[a]	0[a]
3	2	5	3	10	0	7
2	2	8	2	20	2	14
1	0[b]	8	0[b]	21	0[b]	7
Standard	3	6	5	24	3	6

[a] No measurement scheduled.
[b] No expansion joints within the section.

differences between the two.

Daily movements of the expansion joints (Fig. 1) were somewhat erratic for the individual sections, and were even more at variance by comparison among different sections. The unit movement of expansion joints generally was greater than that of contraction joints in those sections with the 120-foot intervals between expansion joints. The opposite was true in those sections where this interval was 400 feet or greater. This inconsistency is probably due to permanent closure whereby expansion joints in those sections with the long joint interval reach a "permanent" condition early and retained that closure throughout the intervening years. In fact, these joint widths showed practically no change by seasons (Fig. 2 and 2A), whereas, joint widths in all sections with shorter intervals had considerable seasonal variation.

The unit change in widths of the contraction joints as shown in Figure 1A, was relatively uniform with respect to both dates measured and the different sections.

Some significance may be attached to the fact that Section 6, having the longest slab lengths, had the smallest unit change, and the next smallest average unit change occurred in the Standard Section, which was the only other section with a joint spacing greater than 20 feet. This does not, however, take into account the fact that Section 6 had by far the greatest frequency of crack development at the time of the 1950 inspection.

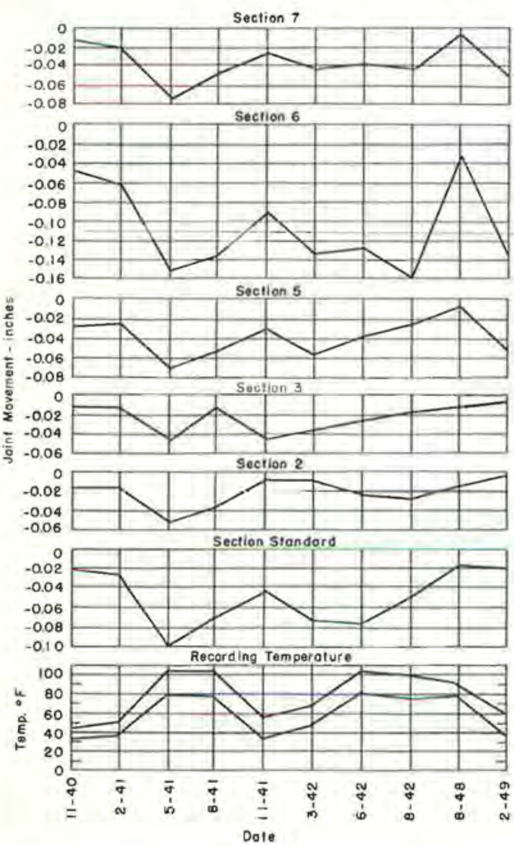

Figure 1. Average joint width change - daily. Expansion joints.

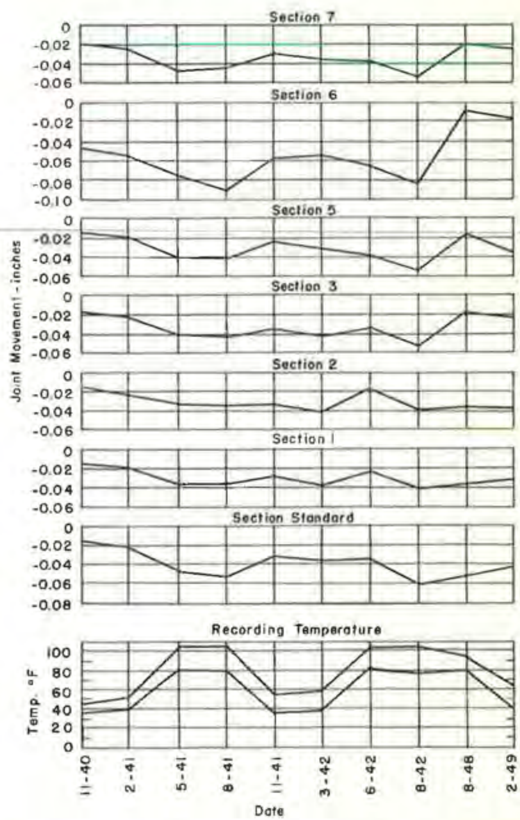

Figure 1A. Average joint width change - daily. Contraction joints.

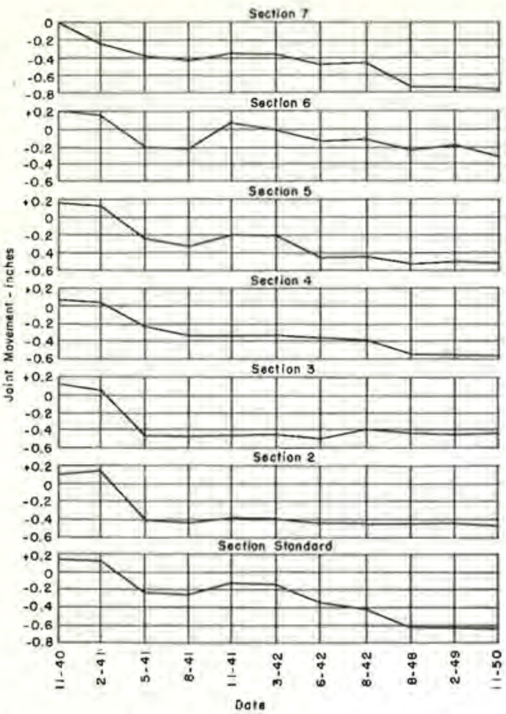

Figure 2. Average joint width change - seasonal. Expansion joints.

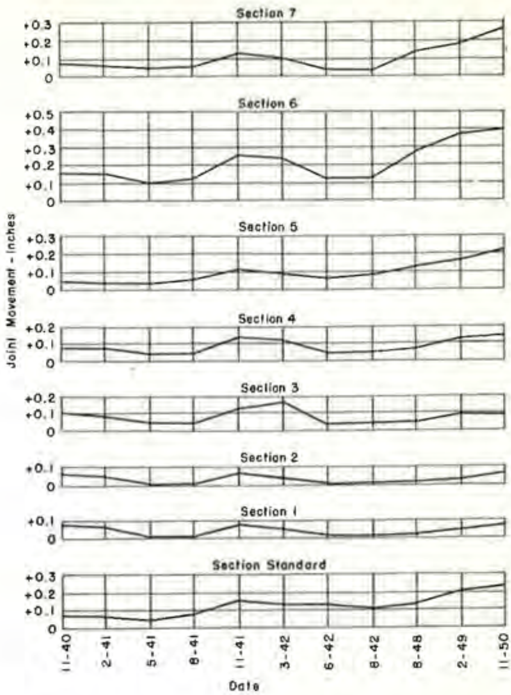

Figure 2A. Average joint width change - seasonal. Contraction joints.

Seasonal Measurements

Results of the seasonal measurements are shown in Figures 2 and 2A. The pavement showing the greatest average opening of contraction joints — and the greatest tendency on the part of those joints to remain open — was in Section 6. Contraction joints in Sections 1 and 2 almost invariably assumed their original widths at summer temperatures.

Section 6 was by far the most erratic of all from the standpoint of seasonal changes at expansion joints. For example, the expansion joints did not close and remain in "closed set" at an early age.

After the first year of service the joints were opened an average amount almost equal to the opening of the previous year. Even as late as $8\frac{1}{2}$ years after construction there was a tendency on the part of these expansion joints to show a response to seasonal conditions by opening and there were indications that this tendency would extend past the 10-year period. Actually, after the first year, contraction never approached the point of overcoming "closed set" and bringing the joints back to their original widths, but in contrast, none of the other sections showed any appreciable response to seasonal differences after 1942.

Permanent Measurements

The results of the permanent or progressive joint width measurements are shown in Figures 3 and 3A. No permanent measurements were scheduled for Section 4, and those taken for Section 6 are too erratic for evaluation. In Sections 5, 7 and Standard, the expansion joints showed a slight increase in the amount of closure each year. For the one expansion joint measured in Section 2, the closure was uniform throughout all measurements. Permanent expansion joint measurements were not included in Sections 1 and 3.

Contraction joints in Section 5 and the Standard Section in which dowel bars for load transfer were installed, remained open approximately 0. 15 inch on an average. This amount of opening was also representative of those joints in Section 7. In Sections 1, 2, and 3, the majority of contraction joints conformed to their original width measurements.

Changes in Elevation

Measurements and observations during this period intimate that changes in elevation of joints in concrete pavements do not particularly reflect or indicate structural failure in the concrete nor in its base. However, uneven settlement of these joints induces concrete deterioration which can ultimately produce failure in the pavement.

Original pavement elevations on this project were established in September, 1940. Subsequent and precise elevation measurements were made in March, 1942; July, 1944; August, 1948; and February, 1949. Table 5 shows the variations in pavement elevations from the original measurements and also the extent to which faulting has occurred in the different sections. Table 6 gives the percent of total joint faulting for all sections on specific dates. Elevations were read to the nearest 0. 005 foot by means of a standard engineer's level and leveling rod. The maximum variation in adjacent slab elevation was 0. 24 inches, which occurred at three joints, one each in Sections 1, 6, and 7.

The elevations for Section 5 taken in 1948 and 1949 were uniformly greater than those established in 1942 and 1944. This is believed to be apparent rather than actual, due to an inequality in leveling. The special bench mark for that section was destroyed between the years 1944 and 1948, and the elevations taken at later dates were established from a construction bench mark.

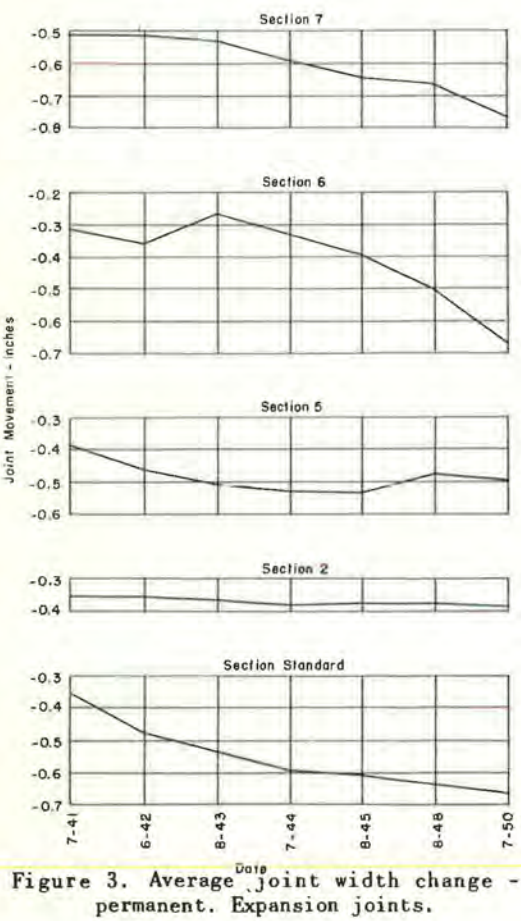

Figure 3. Average joint width change - permanent. Expansion joints.

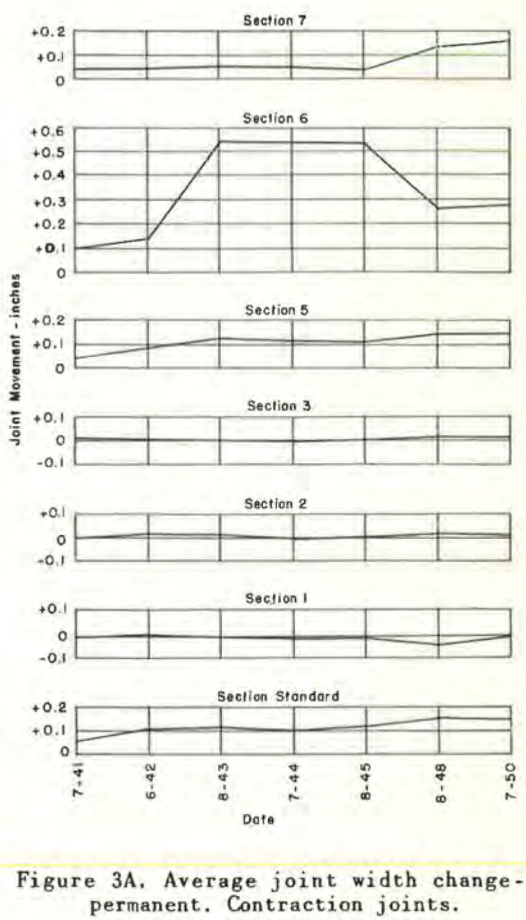

Figure 3A. Average joint width change - permanent. Contraction joints.

TABLE 5

DIFFERENCE IN ELEVATION FROM ORIGINAL ELEVATIONS

Section No. (Joints)	Measurement Date	Change in Elevation - in.		No. Joints Faulting	
		Maximum	Average	0. 12 in.	0. 24 in.
	March, 1942	0. 36	0. 17	1	0
7	July, 1944	0. 36	0. 17	4	0
(31)	August, 1948	0. 66	0. 33	6	0
	February, 1949	0. 72	0. 25	7	1
	March, 1942	0. 40	0. 23	0	0
6	July, 1944	0. 48	0. 25	0	0
(11)	August, 1948	0. 60	0. 34	1	0
	February, 1949	0. 72	0. 29	2	1
	March, 1942	0. 48	0. 27	0	0
5	July, 1944	0. 42	0. 22	2	0
(31)	August, 1948	1. 14	0. 90	3	0
	February, 1949	1. 26	1. 01	5	0
	March, 1942	0. 54	0. 30	1	0
4	July, 1944	0. 84	0. 23	2	0
(31)	August, 1948	1. 08	0. 41	1	0
	February, 1949	0. 96	0. 32	3	0
	March, 1942	0. 66	0. 40	5	0
3	July, 1944	0. 48	0. 25	2	0
(41)	August, 1948	0. 90	0. 46	5	0
	February, 1949	0. 66	0. 31	7	0
	March, 1942	0. 84	0. 38	2	0
2	July, 1944	0. 72	0. 25	4	0
(41)	August, 1948	1. 14	0. 48	6	0
	February, 1949	0. 66	0. 16	8	0
	March, 1942	0. 90	0. 53	2	0
1	July, 1944	0. 60	0. 40	3	0
(31)	August, 1948	0. 96	0. 70	0	1
	February, 1949	0. 78	0. 48	3	0
	March, 1942	0. 60	0. 30	4	0
Std.	July, 1944	0. 60	0. 24	0	0
(41)	August, 1948	1. 02	0. 43	3	0
	February, 1949	0. 78	0. 32	5	0
	March, 1942	0. 90	0. 32	15	0
Total	July, 1944	0. 84	0. 25	17	0
(258)	August, 1948	1. 14	0. 45	25	1
	February, 1949	1. 26	0. 39	40	2

Note: 0. 24 in. maximum difference observed.

TABLE 6

PERCENT OF TOTAL JOINTS FAULTING

Measurement Date	Amount of Faulting				
	0 in.	0. 06 in.	0. 12 in.	0. 18 in.	0. 24 in.
	%	%	%	%	%
March, 1942	53. 10	41. 09	5. 81	0	0
July, 1944	49. 22	44. 19	6. 59	0	0
August, 1948	47. 67	40. 31	9. 69	1. 94	0. 39
February, 1949	40. 70	41. 86	15. 50	1. 16	0. 78

PAVEMENT CONDITION

Condition surveys were conducted and reported twice yearly through 1945 and resumed again in the summer of 1948 with the latest survey being made in November, 1950. Service characteristics of the pavement at that time were generally considered satisfactory from the standpoint of

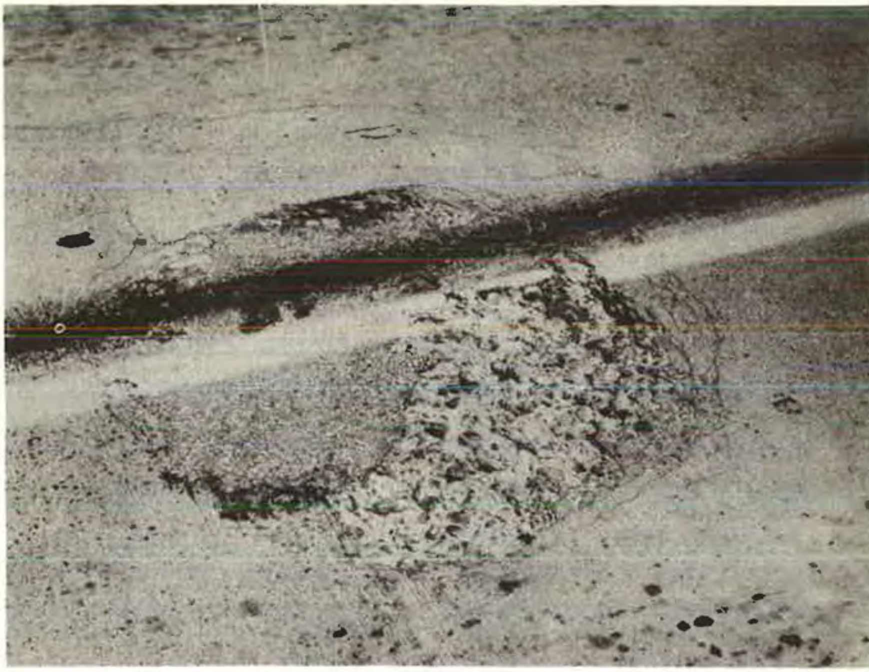

Figure 4. One of the more serious examples of spalling, Section 1 in May 1949.

Figure 5. View to north of Section 2-R through Section 1 in May 1949. Pavement in foreground contains expansion joints at 800 foot intervals with dowel bars and contraction joints are at 200 foot intervals without dowel bars. Wire mesh reinforcement was not used in this section.

Figure 6. Typical of cracking where drop inlet is constructed near joint installation, Section 4-R in May 1949.

Figure 7. Faulted joint in foreground, Section 4-R. Pavement contained expansion joints at 120 foot spacing with dowel bars and contraction joints at 20 feet without dowel bars. Wire mesh reinforcement was not installed in this section.

TABLE 7

CRACK SUMMARY BY TYPE PER SECTION

Section No.	Length (feet)	No. of Transverse Cracks		No. of Longitudinal Cracks		No. of Outside Corner Breaks		No. of Inside Corner Breaks		No. Spalling Joints
		Per Station	Per Mile	Per Station	Per Mile	Per Station	Per Mile	Per Station	Per Mile	
7	1250	10	42.4	10	42.4	7	29.1	9	38.0	1
6	1500	30	105.6	0	0.0	3	10.6	0	0.0	1
5	1500	6	21.4	1	3.6	1	3.6	0	0.0	0
4	1500	19	67.0	12	42.3	1	3.5	4	14.1	0
3	2500	5	10.6	4	8.5	0[a]	0.0	1	2.1	0
2	3000	1	1.8	11	19.4	0	0.0	0	0.0	0
1	5000	12	12.7	2	2.1	0	0.0	2	2.1	1[b]
Std.	7000	31	23.4	4	3.0	1	0.8	6	4.5	5[c]
2-R	2500	3	6.3	14	29.6	0	0.0	0	0.0	1
3-R	2500	2	4.2	8	16.9	0	0.0	0	0.0	1
4-R	1500	6	21.1	14	49.3	0	0.0	1	3.5	2
5-R	1500	7	24.6	3	10.6	0	0.0	1	3.5	0
6-R	1500	14	49.3	1	3.5	0	0.0	0	0.0	0
7-R	1200	4	17.6	3	13.2	1	4.4	2	8.8	0

[a] 1 diagonal crack.
[b] Spalling along centerline, 2 locations.
[c] Spalling in slab.

existing traffic and particularly so with respect to initial design expectations.

Faulting and Pumping

Faulting, though not infrequent, exists in such magnitude as to defer any particular emphasis on relative merits of design or imply definite association with particular construction features. Additionally, neither the presence of expansion joints nor their spacing as compared with contraction joints, had any measurable effect on faulting or differentials in pavement elevations in adjacent slabs. Little or no significant evidence of pumping was observed to have occurred in any of the sections during the 10-year period.

Figure 8. Irregular transverse cracking in east lane of Section 5-R in May 1949. Section does not contain wire mesh reinforcement.

Cracking, Corner Breaks, and Joint Deterioration

Observations throughout the test project, as disclosed in Table 7, indicate that cracking has occurred with greater frequency in the test sections than in their corresponding "repeat" sections, with the exception of the majority of longitudinal cracks.

In Sections 7 and 7-R, cracks of all types were somewhat equally represented. In Sections 6 and 6-R there was a predominance of transverse cracks which may be a consequence of greater slab lengths. However, the transverse crack interval for this section which is considerably lower than that of any of the other sections was about 50 feet. Transverse cracks also occurred rather frequently in Section 4, while in Section 4-R the number was comparable with a general average condition. The frequency of longitudinal cracks in Section 4-R was considerably greater than for the other sections.

Corner breaks, both inside and outside, were outstanding in Section 7. Sections 4 and 7-R were next in order with the number of inside corner breaks, and Section 6 with outside corner breaks. This type of cracking occurred quite infrequently in the remaining sections.

From the standpoint of all cracks appearing over the 10-year period, Section 1 had the best overall record. Performance of Sections 2, 3, and 3-R was very nearly the same, with Section 5 and Standard next in order. The rate of crack development generally increased in the last 4 years or following the survey in December, 1946. Some sections ran contrary to this trend, outstanding examples being Sections 5, 6, Standard and 2-R. Some of the spalling at joints reported from time to time has become obliterated by the application of joint sealer in maintenance operations.

Riding Qualities

A measure or comparison of riding qualities during this period could not be undertaken since this state does not maintain appropriate equipment for this evaluation. Nevertheless, the data indicate that warping and faulting offers no discernible variation in the riding qualities of slabs of different lengths.

SUMMARY

This experimental pavement, as viewed from the original scope and design, has brought to light several interesting and perhaps significant facts concerning slab behavior under varying conditions. Unfortunately, traffic conditions during the test period were somewhat inadequate for evaluation of design features under critical or maximum loads.

Despite these limitations, several differences among the sections have developed, and the effect of different variables can be analyzed to a considerable degree. More particularly, these observations may be listed as follows:

1. All expansion joints tended to close and retain a certain amount of closed set within 6 months after construction. Only Section 6, with the longest slab lengths, showed any reversal of this tendency.

2. Section 7 was unique with respect to progressive change toward closure of expansion joints. Expansion joints in that section started closing almost immediately, whereas expansion joints in all other sections opened a considerable amount during the first period of two to six months before beginning the progressive change to closed set.

3. With very few exceptions, changes in widths across joints were quite uniform for all joints of a given type measured within each section individually on each date. There were, however, great differences in the change for the different sections and for expansion joints as compared with contraction joints.

Spacing of Expansion Joints

4. Expansion joint spacing had no appreciable effect on the tendency of these joints to assume and retain a closed set, although the data pertaining to this were very meager.

5. The influence of temperature variation on changes in width of expansion joints was much greater when the spacing was relatively short — 120 feet or shorter — than when it was 400 feet or greater. After six months of service, the joints in sections with the larger intervals were hardly affected by temperature changes.

6. The unit movement of expansion joints with changes in temperature generally was greater than that of contraction joints on those sections with the 120 foot intervals between expansion joints. The reverse was true in those sections where this interval was 400 feet or greater.

7. In the sections with the 120 foot or shorter spacing of expansion joints, openings in contraction joints were greater and the tendency for them to remain open was greater than in sections where the expansion joint interval was at least 400 feet.

8. Expansion joint spacing or even the existence of expansion joints as compared with contraction joints had no measurable effect on faulting or differentials in pavement elevations in adjacent slabs.

9. The longer spacing of expansion joints – or omission of expansion joints – was conducive to fewer cracks of all types developing in slabs of equal length after construction.

10. Fewer transverse cracks, and on the whole fewer cracks of all types, developed in the sections with the lengthy expansion joint spacing than in sections having shorter expansion joint spacing and equal slab lengths. This applies to progressive crack development as well as the pavement condition at the end of the 10 years.

Spacing of Contraction Joints

Spacing of contraction joints can not be viewed as an entirely separate variable since load transfer and particularly mesh reinforcement were unique in the two sections having greater than normal spacing.

11. In the two sections where the contraction joint spacing was greater than 20 feet, the expansion joints showed the greatest tendency to return to their original widths with reductions in temperature. This was more pronounced in Section 5 with a 60 foot contraction joint interval than in the Standard Section with a 30-foot interval.

12. The extent of opening of contraction joints increased in approximate proportion with the increase in slab length. Joints in sections with the greatest interval (or greatest slab length) assumed and retained the largest opening regardless of changes in temperature. However, the computed unit change was smallest in Section 6, which had the greatest slab length.

13. Pavement elevations showed that the greater the slab length the greater the difference in elevation between the ends and centers of slabs where warping occurred. However, the average difference in elevation per foot of slab was about the same regardless of slab lengths. All sections had some warped slabs according to the measurements that were made. In most cases neither the amount nor the direction of warping remained constant year after year, and in many instances the warping reversed from a concave to convex shape. No general increase in tendency toward warping with increase in the years of service was recorded.

14. All sections had tilted slabs, but in Section 6 (60-foot slab lengths) the tendency was less pronounced and there were fewer instances of tilting in relation to the number of slabs than in the other sections with shorter slab lengths.

15. The data show no definite effect of contraction joint spacing on the development of cracks in the pavement. Not only were there variations among sections having equal joint spacing, but one of the two sections with an extraordinarily long interval had by far the greatest number of transverse cracks, and in contrast the other had no more than an average number of cracks of any type at the end of 10 years.

Load Transfer and Reinforcement

As in the case of slab lengths the presence or absence of mesh reinforcement can not be considered entirely as a separate variable, however, load transfer by dowels at the joints were varied enough to provide a limited basis for separate evaluation.

16. The data show no evidence of resistance on the part of dowels to the closure of contraction joints.

17. The prevalence of transverse cracks within about five feet of contraction joints in Section 4, as opposed to the almost complete absence of this condition in Section 5, indicates that dowel bars were beneficial in transferring load across contraction joints, even though the joints were open considerably. Similarly, corner breaks were more pronounced where the dowels were omitted. The same contrast does not exist between Section 4-R and Section 5-R.

18. No load transfer in either contraction or expansion joints in pavement with nor-

mal joint spacing resulted in exceptional deterioration of all types, if the influence of pavement thickness in Section 7 can be discounted.

19. In the absence of load transfer, closure of contraction joints and accompanying aggregate interlock tends to prevent development of cracks and corner breaks, as shown by the performance of Sections 1, 2, and 3 in contrast with Sections 4 and 7.

20. Aside from pronounced faulting at expansion joint No. 19 in Section 7 and contraction joint No. 23 in Section 4 (both having no dowels for load transfer), there was no noticeable effect of dowels on the tendency for displacement of adjacent slabs at expansion and contraction joints.

21. Lack of opportunities for comparison obscure the influence of mesh reinforcement on pavement performance. However, the high rate of transverse crack formation in both Section 6 and Section 6-R is strong evidence that the 70-lb. mesh failed to counteract the tendency toward cracking in slabs of 60 foot length. In contrast, the combination of 44-lb. mesh and 30-foot slab length resulted in a transverse crack interval that was about average for all sections.

Pavement Section

22. On the whole, the pavement of uniform 7-inch section had the poorest performance record of all pavement in the project. Much of this could possibly be attributed to the absence of load transfer bars at both contraction and expansion joints, for the contrast between Section 7 and Sections 4, 4-R and 7-R in pavement performance was not extreme despite the fact that Sections 4 and 4-R had a 9-7-9 section and dowels at expansion joints.

CONCLUSIONS

The observations and results accumulated from this experimental pavement, together with that from other states participating in the project, should contribute substantially toward a better understanding of future performance of concrete pavements and slab behavior under specific conditions. To what extent any of the results or trends established thus far might indicate future performance of this pavement, is of course a situation wholly dependent upon pavement age and service.

Nevertheless, the results obtained from this project, representing specific aggregate and specific construction methods, permit the following important conclusions: Expansion joints are of little benefit and are probably detrimental unless installed in at least 400-foot intervals; close intervals (at the most 30 feet) for contraction joints are preferable; dowel bars for load transference at contraction joints are of questionable value except in the case of joints that open considerably and remain open thus being deprived of any advantage that might be gained through interfacial pressure and aggregate interlock; the thickened edge pavement section is superior to that of uniform 7-inch thickness; and mesh reinforcement alone will not prevent cracking particularly in slabs greater than 30 feet in length.

With due regard to the very narrow margin for differentiation in some cases, overall performance characteristics by sections were from best to poorest in the following order: 1, 2, 3, 5, Standard, 6, 4, and 7.

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During the course of this experimental project, several progress reports have been written under different authorship by men of the Kentucky Department of Highways, the latest being a 9-year report by S. T. Collier, Senior Research Engineer. Inasmuch as the tenth year data and observations have continued to substantiate the conclusion previously drawn by Collier, the bulk of this report, along with most observations, were stated previously in his report.

References

1. Kelley, E. F., "History and Scope of Cooperative Studies of Joint Spacing in Concrete," Proceedings, H. R. B., Vol. 20, December 1940.

2. Thomas, T. R., "Investigational Concrete Pavement in Kentucky," H. R. B. Re-

port No. 3B, November 1945.

3. Collier, S. T., "Cooperative Investigation of Joint Spacing in Concrete Pavements," Kentucky Department of Highways, Progress Report No. 4, Proj. FA 125 F (2)S, July 1949, (Unpublished).

4. Gregg, L. E., "Experiments with Air Entrainment in Cement Concrete," Univ. of Kentucky Engr. Exp. Sta. Bull. No. 5, September 1947.