INVESTIGATIONAL CONCRETE PAVEMENT IN MISSOURI

By F V Reagel

Engineer of Materials and Tests, Missouri Highway Department

This report describes the experimental pavement constructed in Missouri and points out certain features wherein this project differed from the others included in the cooperative investigation

The project is located on U. S. Route 69, Gentry County, in Northwest Missouri This road carries relatively heavy traffic between St. Joseph and Des Moines, Iowa, and it is anticipated that the pavement will be subjected to weather conditions as severe as anywhere in the state.

SUBGRADE

The topography of the area traversed by the road ranged from gently rolling to moderately hilly, which necessitated a grade of alternate cut and fill sections. In some of the newly opened cuts, soft, wet subgrade sections were exposed. These were undergraded to a depth of 16 in and backfilled with suitable soil material. The subgrade throughout the length of the project was compacted with sheepsfoot rollers in 6-in layers at optimum moisture content.

A complete soil survey was made, all soil types and layers were described, and plotted on a profile map Samples of the different soils were taken and tested by A A S H.O. standard laboratory methods for mechanical and physical characteristics After fine grading and immediately ahead of the paving, density and moisture tests were made of the compacted subgrade to depths of 0-9 in and 0-18 in. at 300-ft intervals.

Three types of subgrade soils were encountered, two of which were derived from glacial deposits and one from an overlying loessial deposit According to the P R A. group classification, the soils conformed to three groups, namely, A-4, A-6, and A-6-7. The subgrade in general is far from uniform, but there is available for future study a complete record of the soil characteristics and subgrade condition.

CONSTRUCTION DETAILS

The pavement was scheduled to be constructed in 1940, but, due to unavoidable delay to the contractor, paving was not started until June, 1941. The pavement was approximately seven miles long and was completed early in August The progress of paving was hindered by frequent rains which also caused unusually high subgrade moisture content In general, temperature conditions during construction were normal for the time of year and location. The Missouri Highway Department standard specifications were followed in constructing the pavement. Asphalt saturated felt subgrade paper was used to insulate the pavement from the subgrade.

The concrete was mixed in a Rex 34-E dual drum paver and compacted by a Jaeger-Lakewood finisher equipped with a Jackson twintube vibrator. Portable vibrators were used for auxiliary vibration along the pavement edges and joints A Koehring mechanical longitudinal float followed immediately behind the finisher. After the usual straight-edging, floating, and belting a final broom-finish was given the surface. The transparent membrane method was used for curing the concrete. This was applied immediately after finishing by spraying the pavement with a liquid having a wax base.

It was specified in the contract that no changes would be permitted in the source of aggregates or cement, and the following materials were used

Coarse Aggregate—Bethany Falls Crushed Limestone (separated into two sizes).

Fine Aggregate—Missouri River sand.
Cement—a Type 1 portland cement from western Missouri
Water—local creek water supplied by tank trucks

The concrete mix was established at the start of the paving and held constant throughout the project. The proportions were 1 : 2.1 4 15 by weight measurements which gave an average cement factor of 1.3 bbls. per cu. yd. The mixing water used averaged slightly less than 6 gal per sack of cement.

EXPERIMENTAL VARIATIONS

Of the seven types of experimental sections suggested by the P R.A., one was deleted, but five additional sections were added to include features of particular interest to the Missouri State Highway Department This provided eleven variations in design eight of which were each repeated once so that in all, 19 test sections were built. Table 1 shows the layout of experimental sections as constructed. Sections 5 and 8 were added to investigate the effect of lighter weight mesh reinforcement Sections 7, 10 and 11 were included for studies of the effects of variations in the pavement cross-section

Within each test section a length of pavement not less than 600 ft was selected, designated as a subsection representing that particular design, and used as a specimen in making precise measurements of expansion, contraction, and deflection in the individual slabs. Table 2 shows the layout of the sub-test sections.

All of the transverse contraction joints were of the weakened plane type, consisting of a groove 2½ in. deep and ⅜ in wide cut by means of a Flex Plane joint cutter. Dowels were installed in prefabricated dowel bar assemblies of a single standard design.

Expansion joints were the 1-in premoulded bituminous type In thickened edge sections, provision for load transfer was made by means of steel angles of the type used in the Translode Base joint. In the sections of uniform thickness no dowels nor load transfer devices were installed in either the expansion or contraction joints.

As shown in Table 1, only two transverse joint intervals were specified 25-ft. and 60 ft Expansion joint spacings of 120, 125, 400, and 800 ft were used in the various test sections

The contraction joints were filled the day following construction with a plastic bituminous filler known as Tarvia XC, applied without heating by means of a pressure gun. The expansion joints were sealed with a bituminous rubber joint compound which was heated and poured into the upper portion of the joint A few joints were filled with asphalt-latex joint filling material for a special field trial of this filler.

CONSTRUCTION AND WEATHER RECORDS

The suggestions of the P R A outline were followed in detail for the record of preliminary and daily observations during construction, although the soils and subgrade data obtained were more complete than originally outlined. In addition to the daily weather observations, humidity determinations were made at 2 to 3 hr intervals by means of a sling psychrometer. Concrete temperatures were taken with an armored thermometer from time of dumping the batch until final set of the concrete Temperatures after that time were obtained by electrical resistance temperature detectors imbedded in the concrete

A time-stationing record of the principal construction operations was obtained so that the progress of the work and time intervals between the various operations could be plotted for the entire length of pavement Descriptive notes of all details of construction and variations in procedure were recorded in detail Copies of

TABLE 1

LOG OF EXPERIMENTAL SECTIONS

Test sect No	P R A sec No	Station at start	Station at end	Length	Spacing of trans joints	Spacing of Expans joints	Dowels at contr joint	Mesh reinforcement	Cross-sect of pavement
				ft	ft	ft			in
1	2	175+50	199+50	2400	25	800	No	None	9–7–9
2	3	199+50	227+50	2800	25	400	No	None	9–7–9
3	5	227+50	242+50	1500	25	125	Yes	None	9–7–9
4	6	242+50	257+50	1500	60	120	Yes	70-lb	9–7–9
5	Extra	257+50	272+50	1500	60	120	Yes	43-lb	9–7–9
6	7	272+50	287+50	1500	25	125[a]	No	None	7″ uniform
7	Extra	287+50	302+50	1500	25	125	Yes	None	9 8–7 8–9 8
8	Extra	302+50	317+97 7	1547 7	60	None	Yes	43-lb	9–7–9
9	1	337+00 6	399+49	6248 4	25	None	No	None	9–7–9
1R	2	399+49	423+50	2401	Test Sections 1R to 8R, inclusive, are repetitions of, and have same design features as, Sections 1 to 8, respectively				
2R	3	423+50	451+50	2800					
3R	5	451+50	466+50	1500					
4R	6	466+50	481+50	1500					
5R	Extra	481+50	496+50	1500					
6R	7	496+50	511+50	1500					
7R	Extra	511+50	526+50	1500					
8R	Extra	526+50	541+50	1500					
10	Extra	541+50	553+25	1175	25	125[a]	No	None	8″ uniform
11	Extra	553+25	564+87 4	1162 4	25	125[a]	No	None	9″ uniform

[a] Expansion joints in these sections will not have dowels or other means of load transfer

inspection and test reports of all materials were assembled for future reference.

TESTS AND MEASUREMENTS

The recommendations of the Public Roads Administration for test procedure were followed in general. Three 6 by 6 by 36-in. beams for standard third-point loading tests were made at noon each day. For volume change and elasticity studies, two 6 by 6 by 20-in. beams were molded of concrete taken from the middle of each sub-test section. One from each pair of these was sent to the P.R A. laboratory and the other sent to the state highway laboratory. In the latter, stainless steel plugs were set in the top and bottom surfaces for extensometer measurements in connection with volume change determinations.

At a point near the middle of each sub-test section and about four feet from the edge of the pavement three electrical resistance coils were imbedded in the fresh concrete. By means of these a record of the concrete temperatures at the top, mid-depth and bottom of the pavement was obtained at times of pouring and whenever measurements were taken of slab movements.

Three additional temperature detectors were installed at one of these temperature stations in the subgrade at depths of 10, 20 and 30 in. These, together with the

TABLE 2

Log of Sub-Test Sections

Test Sect No	Sub-Sect No	From station	To station	Length Subr S	Joint spacing	No 1st joint	No last joint
				ft	ft		
1	1a	183+50	186+00	250	25	E33	43
1	1	191+50	199+50	800	25	E65	E97
2	2	207+50	215+50	800	25	E33	E65
3	3	227+50	233+75	625	25	E6[a]	E21[a]
4	4	251+50	257+50	600	60	C16	C26
5	5	266+50	272+50	600	60	E16	E26
6	6	277+50	283+75	625	25	E26[a]	E41[a]
7	7	290+00	296+25	625	25	E16[a]	E31[a]
8	8	308+50	314+50	600	60	C11	C21
	8b	314+50	317+97 7	347 7	60	C21	C27
9	9a	337+00 6	339+00	199 4	25	C1	C9
9	9	367+00	375+00	800	25	C121	C153
9	9b	397+50	399+49	199	25	C243	E250
1R	1R	407+50	415+50	800	25	E33	E65
1R	1Rb	421+50	423+50	200	25	89	E97
2R	2R	431+50	439+50	800	25	E33	E65
3R	3R	454+00	460+25	625	25	E16[a]	E31[a]
4R	4R	474+90	481+50	660	60	E15	C26
5R	5R	488+10	494+10	600	60	E12	E22
6R	6R	499+00	505+25	625	25	E16[a]	E31[a]
7R	7R	517+75	524+00	625	25	E31[a]	E46[a]
8R	8R	529+50	535+50	600	60	C6	C16
10	10	545+25	551+50	625	25	E21[a]	E36[a]
11	11	554+00	560+25	625	25	E9[a]	E24[a]

[a]These joints are each 125 ft within their respective sub-test sections.

detectors imbedded in the concrete and a similar detector installed in a standard housing of the type commonly used to shelter weather bureau thermometers, were attached to an automatic recorder which prints the respective temperatures on a continuous scroll at 6-min intervals. This will provide a continuous record of the air temperatures and temperatures at the top, mid-depth and bottom of the pavement as well as temperatures in the subgrade to a depth of 30 in.

For the measurement of joint opening and closing a special extensometer with a 1-in. travel and reading to 0.001 in. was designed. After the pavement had been given its final broom finish, non-corrosive metal plugs ½ in. in diameter and 1 in. long were set in the concrete on each side of the joints selected for measurements of changes in width. Gage points for use with the extensometer were provided by drilling 1/16-in. holes in the surface of these plugs prior to setting them. A procedure was developed which permitted obtaining readings 6 to 8 hr. after the joint was installed. To protect the gage points a few drops of rubber latex emulsion were injected into the holes by means of a hypodermic needle. This emulsion breaks in a short time and leaves a rubber cap and plug which effectively protects the surface of the metal, keeps silt and sand grains out of the holes, and yet is easily removed with a thumb nail when readings are taken. To date this method has proven quite satisfactory and permits obtaining readings earlier and more rapidly than other methods suggested for joint width measurements.

The vertical movements of the pavement were measured by means of a reversible precision level. Bench marks were established at convenient locations by driving 1-in. solid steel rods 10 to 12 ft. into the ground. To prevent frost heaving and protect the bench marks, a 3-in. pipe was placed to form an air well around the rod for the top 3 ft. and encased in a concrete cap about 5 in. deep and 2 ft. in diameter.

Reference points for level readings were distributed as suggested in the P.R.A. plans with the addition of intermediate points in the 60-ft. slabs. At these points the surface of the pavement was ground smooth with a small carborundrum grinding burr in a portable electric drill and a spot about ½ in. in diameter painted with a special lacquer paint. This spot is the size of a hardened steel bullet-shaped point which is affixed to the base of the level rod. Several years experience have proved that these painted spots satisfactorily identify the reference points for successive precise level readings.

The schedule suggested by the P.R.A. has been followed in measuring the daily, seasonal and permanent changes in joint width. The first set of level observations has been made to provide a base profile of the normal elevations of the different points on the pavement. A second set of elevation measurements is planned for this winter.

A strip map of the entire project was made showing to scale the pavement surface and the location by stationing of all joints. Two condition surveys have been made and all visible cracks and surface defects plotted on this strip map. The same strip map will be used for future surveys so that the progression of deterioration can be followed.

DISCUSSION ON INVESTIGATIONAL CONCRETE PAVEMENT IN OREGON

Mr. A. T. Goldbeck, *National Crushed Stone Association:*

Mr. Paxson has described a series of concrete road test sections built to study several points in connection with concrete road design as outlined by E. F. Kelley in his Highway Research Board report on "History and Scope of Cooperative

Studies of Joint Spacing in Concrete Pavements" In general, the present test as well as those of a similar nature reported by other State highway departments including Kentucky, Michigan and Minnesota has as its ultimate objective the determination of those design features, (1) which are necessary to prevent overstress in the concrete road slab and, (2) which will best preserve its smooth riding qualities

In outlining and executing such investigations as Mr Paxson has described, it is too easy to omit the gathering of data which are needed to explain completely what has taken place in the test sections Cracking of the concrete resulting from overstress will be one of the principal phenomena observed Consequently, it is highly important that all auxiliary information be obtained which will help to explain cracking Without attempting to be complete, let me illustrate what I have in mind by asking the following questions

1 Will the coefficient of subgrade friction be determined for different amounts of slab movement? This value will be necessary in later calculations for stress

2 Will attempts be made to study the elastic and also the plastic qualities of the concrete?

3 Have concrete specimens been made for testing at later periods extending over the life of the experiment so that the strength, especially beam strength, may be known at the time the cracks begin to form?

4 What is the coefficient of thermal expansion of the concrete and also the effect of moisture on the unrestrained concrete?

The above are merely sample questions There are many more I call attention also to the fact that there is a vast difference in the resistance of different concrete pavements to cracking depending on a great many factors and unless all of the influencing factors are taken into account when each particular investigation is made, the field results become difficult or even impossible to analyze in a manner which will satisfactorily explain the observed phenomena

It has been my experience that it pays to get very complete auxiliary information, for it probably will be needed in the final analysis of the field observations and tests