USE OF EXCESS FINE AGGREGATE IN CONCRETE PAVEMENTS

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The subject of this paper as the name implies concerns the usage of fine graded aggregates in relatively large proportions for concrete pavements.

The object is to briefly describe from available information, the materials, construction methods, costs and serviceability of this type of roadway surfacing

The scope of the information includes surfacing of this character as constructed in the states of Florida, Kansas, Kentucky and Iowa.

It is expected that subsequent discussions by Mr. Crum and others will more fully explain many of the details and principles not covered by the writer

GENERAL DESCRIPTION

In these localities where coarse aggregates are scarce and fine aggregates are plentiful, Portland Cement concrete pavements are being built with such local material as the aggregate.

The quantity of cement required according to the local engineers is greater for the concrete made with these aggregates The amount of cracking in the finished pavements is recognized as a condition which must be countenanced or controlled by joints Steel reinforcement is also used by some to assist in crack control

MATERIALS

The Portland cements used are standard brands which meet the requirements of the American Society of Testing Materials

IN FLORIDA

The aggregate consisted of local sand which passed the No. 30 sieve and an admixture of "Celite" The proportions for pavement were 1 part of Portland cement to 2 7 parts local sand. Celite was added in the amount of $1\frac{1}{2}$ per cent by weight of the cement content. When used as concrete base to be covered with a bituminous concrete the proportions were 1 of Portland Cement to 4 25 of local sand Celite was added at the same rate of $1\frac{1}{2}$ per cent by weight of total cement.

Concrete using local sand containing shells, has been used in this state

for base and one course pavements. Some of them are still in use but their history was not obtainable.

IN KANSAS

The aggregates for a one course pavement were required to meet the following gradations:

Sand-Gravel

Retained on No. 4 sieve	10 to 25 per cent
Retained on No. 8 sieve	35 to 60 per cent
Retained on No. 28 sieve	75 to 90 per cent

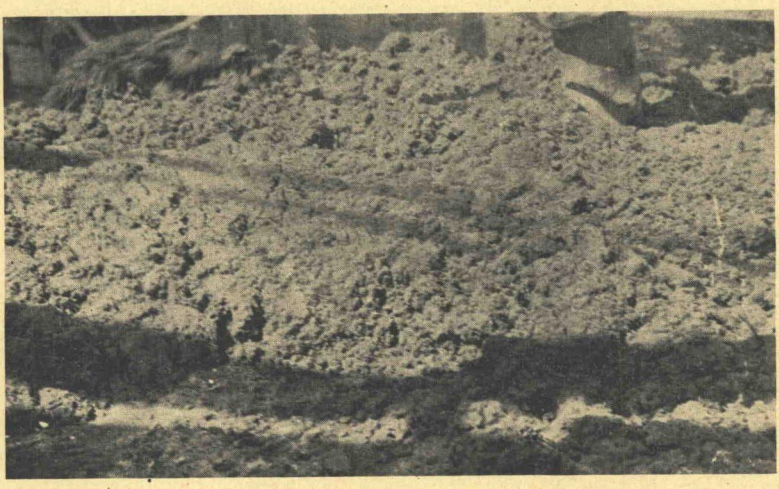

Figure 1. Showing a Batch of Fine Aggregate Concrete ("Densite") in Florida

The proportions of a dry rodded mix were 1 cement to 3.75 of sand-gravel. The minimum allowable cement content in the finished pavement was 1.8 barrels of cement per cubic yard of concrete. Two inch expansion joints were used at 150 foot intervals. The reinforcement consisted of two $\frac{3}{4}$-inch transverse bars at each expansion joint and 4-foot, $\frac{1}{2}$-inch bars through the longitudinal center joint.

IN KENTUCKY

On one project the State Highway Department approved the following gradation requirements:

Gravel: Not less than 20 per cent retained on a $\frac{3}{4}$-inch round screen and not more than 10 per cent passing a $\frac{1}{4}$-inch round screen.

Sand: At least 20 per cent to be retained on a number 20 sieve.

In all other respects both gravel and sand were required to pass the

standard specification Subsequent field analyses of materials being used showed grading as follows.

Per cent retained on	Gravel		Sand	
	First	Second	First	Second
1½-inch sieve	0	0	0	0
¾-inch	16 0	16 4	0	0
⅜-inch	66 6	48 6	0	0
No 4	96 4	97 0	0	0
No 8	97 6	99 6	2 3	3 5
No 14	98 0	99 7	14 1	17 5
No 28	100 0	100 0	37 5	39 0
No 48	100 0	100 0	93 8	88 0
No 100	100 0	100 0	100 0	100 0

The mix, on a dry rodded basis was 1 cement· 1 35 sand 3 25 gravel The field mix recommended was 1 cement· 1 6 sand 3 2 gravel The cement factor as shown by subsequent field reports was 1 79 to 1 83 barrels of cement per cubic yard of finished pavement

IN IOWA

The "Class 5 Aggregate" as used in this state consists in general of a mixture of fine and coarse aggregates of the following composition

Passing 1½-inch sieve	100 per cent
Passing No 4 sieve	80 to 87 per cent
Passing No 28 sieve	10 to 30 per cent
Passing No 100 sieve	0 to 4 per cent

The particular details for additional requirements for aggregate and proportions will be found in the Iowa Specifications

The materials were mixed in the ratio of one pound of cement to 4 00 pounds dry combined aggregate The amount of water used is specified to not exceed 5 00 gallons per bag of cement

The concrete is estimated to contain 1 90 barrels of cement for each cubic yard

CONSTRUCTION METHODS

1 Proportioning In Florida the sand and cement were proportioned by volume, and Celite by weight

In Kansas a weighing batcher was used for proportioning

In Kentucky bins and batch meters were used

In Iowa weight measurement of aggregates is standard practice

2 Mixing and Placing The proportioned aggregates are mixed in standard type pavers and the mixed concrete is deposited on the road usually from a bucket attached to the mixer

3 Finishing This operation commonly is done by finishing machine and belt and by other more or less standard methods The work in

Florida was finished by hand tamps and hand propelled rollers. Because of the unusually fine aggregate and workability of the mix, high and low spots in the Florida work are easily corrected during the finishing process.

4. Curing. Wet burlap is usually applied as soon as possible after the finishing. No burlap was used in Florida but the surface was sprinkled with water. Ponding, wet earth and calcium chloride are permitted methods of curing.

COSTS AND SERVICE

In Florida the estimated price of one course pavement was given as about $22,000 per mile for a 7-inch uniform section, 18 feet wide.

Figure 2. A Florida Fine Aggregate Concrete Base Showing Sheet Asphalt Top

In Kansas the contract price was $21,126 per mile for a 9-6-9 section 18 feet wide.

In Kentucky a saving of $1600 to about $2200 per mile was anticipated when using local sand-gravel aggregates in the place of shipped-in gravel or stone.

In Iowa contract prices on nine projects ranged from $1.82 to $2.39 per square yard, with an average of $2.15. The cross section area of the thickened edge pavement section was 11,544 square feet for an 18-foot width.

The modulus of rupture of test beams broken at age of 10 days on 10 projects ranged from 492 to 1063 with an average of *684*. The crushing strength in compression for these 10 projects at age of 28 days, ranged from 3600 to 5190 pounds per square, with an average of *4657*.

The average of all projects for the entire state of Iowa for the year

1928 up to October 15, was, modulus of rupture (age 10 days, 15-inch span, mid-point loading) 599, the average crushing strength at age of 28 days was 4486 pounds per square inch.

Experience with this type of surface indicates considerable cracking in Florida and Iowa In Iowa where center joints are used the transverse cracks occurred at intervals of 15 to 20 feet

Longitudinal cracking is satisfactorily controlled by center joints, transverse cracking if regular is controlled or countenanced by transverse planes of weakness, by joints, by reinforcements, or by both methods

DISCUSSION

ON

USE OF EXCESS FINE AGGREGATE IN CONCRETE PAVEMENTS

R. W CRUM, *Director Highway Research Board*· The use of natural gravels and sand and gravel mixtures in which the sand portion of the total aggregate ranges from 34 to 60 per cent for both pavements and bridges, has been standard practice in Iowa for some ten years Continuing experience has shown this concrete proportioned as described in Bulletin No 60, Engineering Experiment Station, Iowa State College and in a paper on "The Use of Excess Sand and Pit-Run Gravel in Concrete Pavements" in Volume No 22, page 375, Proceedings, American Society for Testing Materials, to equal in strength and durability the more conventional mixtures The use of these mixtures has been a successful engineering solution to a difficult material situation

An interesting variation of the problem was presented when it became necessary to make concrete pavements from the material referred to in Mr Conner's paper. As produced for this purpose, this material is mostly coarse sand with about 15% of pebbles retained on the No 4 sieve, but which are mostly smaller than ½ inch About 50% of the aggregates pass the No. 10 sieve The source of the material is in the Platte River valley in Nebraska. It has also been used in Nebraska, Missouri and Kansas

The mortar-void characteristics of the aggregate were studied by the methods described by Dr Talbot and mixtures designed This particular study was described last year in the report of the Committee on Character and Use of Road Materials, Seventh Annual Proceedings, Highway Research Board, page 205. The mixture described therein was used upon one contract On the other contracts the mixture was designed somewhat leaner, in as much as the original design appeared to call for a somewhat higher quality of concrete than was necessary.

The experience with the use of this material on 43 miles of pavement gave some interesting information concerning the design of mixtures Two differences between the laboratory concrete, upon which the design was based, and the pavement concrete became apparent (1) The proper workability was secured in the field with a lower water cement ratio than was expected and (2) the crushing strength of the concrete was greater than expected

The results secured on four projects are as shown in Table I

TABLE I

PROPORTION 1 4 BY WEIGHT

Water not to exceed 5 gallons per bag of cement

Project	Length of project, miles	Per cent of estimated cement used	Average strength of field specimens	
			Transverse 10 day	Crushing 28 day
F 16	13 50	102 10	631	4,666
P 27	17 10	100 34	574	4,641
226	8 10	99 08	711	5,080
F 15	4 25	99 12	—	5,110
	42 95			

On three projects careful measurements were made of the amount of concrete placed in several hundred feet of pavement The comparison of actual with the estimated quantities is shown in Table II.

TABLE II

	Estimated quantities	Actual quantities average for three jobs
Proportion	1 4	1 4
Cement, bbl per cubic yard	1 90	1 87
Water, gallons per bag	5 00	4 34
Solidity ratio	0 763	0 772
Voids, cu ft per bag of cement	0 856	0 829
Crushing strength	3,500	4,806

As shown in Table I, taking the jobs as a whole, the amount of cement used as compared to the estimated amount is greater than that determined by the measurements of the sections shown in Table II This means that the average thickness of the slab was slightly greater than the designed thickness