

Commonwealth of Kentucky
Department of Highways

Report

on

ROCKCASTLE (POTTSVILLE) CONGLOMERATE SAND
EVALUATION IN PORTLAND CEMENT CONCRETE

by

Milton Evans, Jr.
Research Engineer

Highway Materials Research Laboratory
Lexington, Kentucky

February, 1960



COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

August 14, 1959

Ward J. Oates
COMMISSIONER OF HIGHWAYS

ADDRESS REPLY TO
DEPARTMENT OF HIGHWAYS
MATERIALS RESEARCH LABORATORY
132 GRAHAM AVENUE
LEXINGTON 29, KENTUCKY
A. 1. 1.

MEMO TO: J. A. Bitterman
Director of Materials

ATTENTION: D. K. Arnold

SUBJECT: Rockcastle (Pottsville) Conglomerate Sand
Evaluation in Portland Cement Concrete

Some time ago, Dave Arnold requested assistance from our Concrete Section in an evaluation of the Rockcastle (Pottsville) Conglomerate sand. As an outgrowth of this, I am attaching hereto a memorandum report prepared by Milton Evans, Jr., covering the significant results from our work related to the problem.

I might point out that the greater water requirements to produce slump and workability, were anticipated because of the apparent angularity of the conglomerate sand; and, of course, that was one of the factors we wanted to investigate. As you know, this also has been one of the significant factors in the use of sand manufactured from limestone.

Aside from the test data, we have previously discussed, with Dave, some limitations in Article 7.3.2 and 7.3.5 and the interpretations of the terms "Natural" and "Crushed". Article 7.3.5 is very specific with respect to the requirements for the parent rock; whereas, 7.3.1 is specific in its definition of Natural Sand. Similar limitations also appear in Article 7.3.4.

We will await your response to the attached report before proceeding with any further work.

W. B. Drake
Associate Director of Research

JHH:d1



COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

August 14, 1959

Ward J. Oates
COMMISSIONER OF HIGHWAYS

ADDRESS REPLY TO
DEPARTMENT OF HIGHWAYS
MATERIALS RESEARCH LABORATORY
132 GRAHAM AVENUE
LEXINGTON 29, KENTUCKY

A. I. I.

MEMO TO: W. B. Drake
Associate Director of Research

SUBJECT: Pottsville Conglomerate Sand as Fine Aggregate
in Portland Cement Concrete

In order to analyze the concrete making properties of a processed Pottsville Conglomerate Sand from Rockcastle County, Kentucky, several batches of portland cement concrete were made. Standard mixing control, strength, and durability tests as well as a short cut test to detect excessive expansion during curing were performed on the concrete. Control specimens were made utilizing an Ohio River Sand, typical for this area, as the fine aggregate. This sand which was acceptable by Kentucky Highway Department Specifications was produced by the Nugent Sand Company of Louisville, Kentucky. The sand was submitted for evaluation in this manner by the State Geologist. The standard physical properties tests were made by his office prior to the submission, and the sand was found to be satisfactory in accordance with those tests.

Physical characteristics of the Rockcastle and the Ohio River sands are given in Table 1 along with gradation limits as set forth in

relevant specifications. The Rockcastle sand is considerably different from the Ohio River sand with respect to shape, gradation, and fineness modulus. Nevertheless, according to Kentucky Highway Department Specifications (Article 7.3.2) covering grading requirements of natural sands, both would be acceptable. If the Rockcastle sand were to be considered as a crushed sand, regardless of the parent rock, then it would not be acceptable by Kentucky Highway Department grading requirements without alteration of that specification (Article 7.3.5.).

The gradation shown (Table 1) for the Rockcastle sand is an average of several sieve analyses of samples taken from the sand submitted for test. The results of these analyses varied somewhat; and upon close examination it was found that the sand, as submitted, consisted of about 15% cemented particles. The attached photograph, Fig. 1, shows a sample of + No. 30-sieve material magnified ten times. This is a representative sample of the Rockcastle sand, and the particles which are made up of smaller grains and held together with cementing material can easily be seen. These particles are only weakly cemented and will break down into smaller sizes under the application of a small force. In fact, most of the cemented particles can be broken by pressing them against a hard surface with one's finger. However, these particles are strong enough that many of them do not break down when being subjected to a mechanical sieve analysis. Hence, the analyses vary considerably dependent on the number of particles which break down. If reasonably reliable gradations are to be obtained, these weakly cemented particles would have to be separated or else completely disaggregated.

Table 1: Gradations and Physical Characteristics of the Fine Aggregates

	Rockcastle	Ohio River
Fineness Modulus	3.10	2.74
Water Absorption	.4	1.1
Apparent Specific Gravity	2.65	2.69
S.S.D. Specific Gravity	2.63	2.64
Bulk Specific Gravity	2.62	2.62

Sieve Size	Rockcastle Sand		Ohio River Sand % Passing	Kentucky Spec.		ASTM Spec. % Passing
	Before Rubbing % Passing	After Rubbing % Passing		Natural Sand % Passing	Crushed Sand % Passing	
3/8 in.	100	100	100	100	100	100
No. 4	92.4	94.1	99.7	85-100	95-100	95-100
No. 8	79.5	81.7	90			80-100
No. 16	61.7	65.0	74	40-80	45-80	50-85
No. 30	45.2	49.4	54			25-60
No. 50	16.6	19.1	6.5	5-25	5-30	5-30
No. 100	4.5	5.8	.3	0-5	0-5	0-10

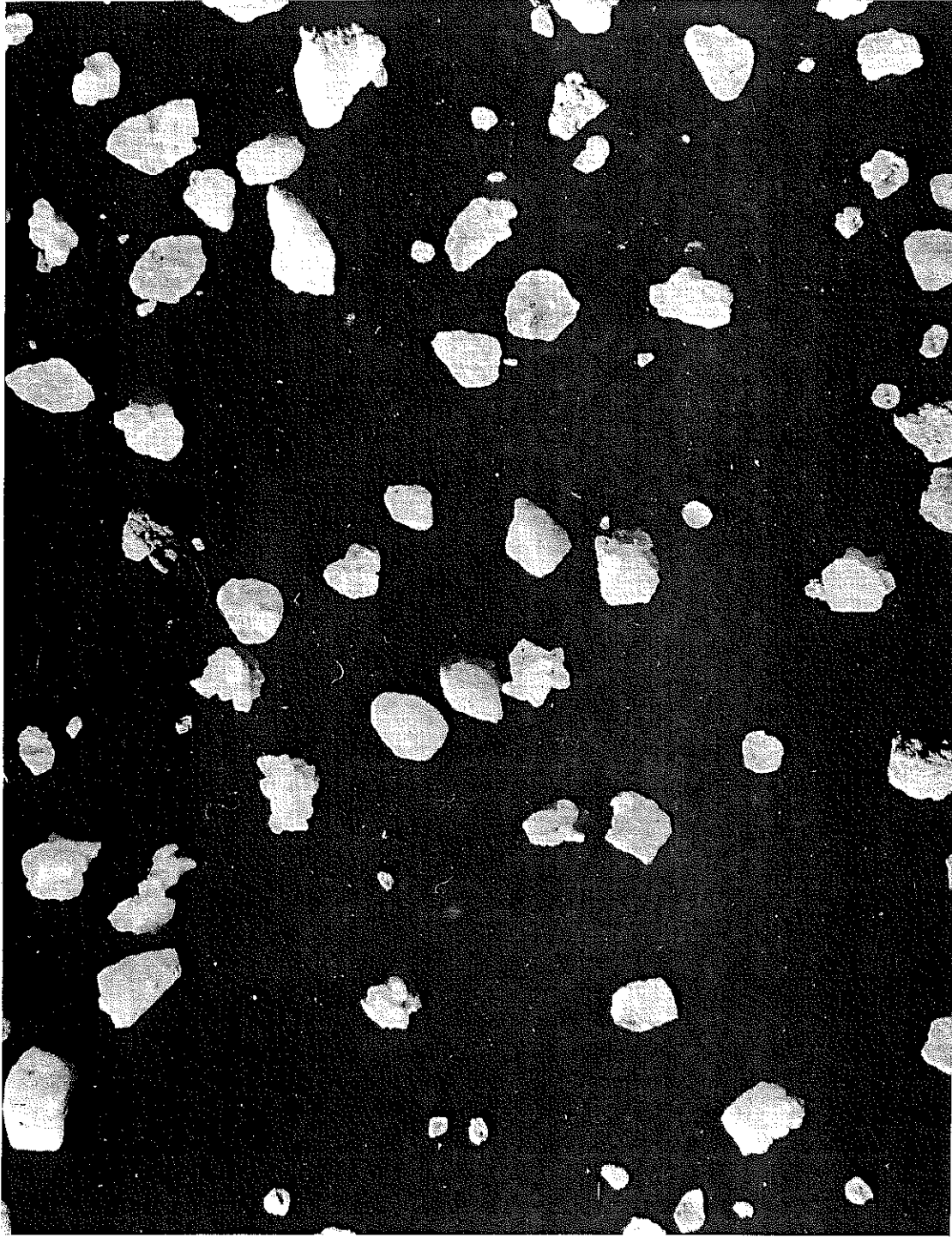


Fig. 1

To determine the variation which might occur as a result of particle breakdown, a sieve analysis was made of the sand as submitted. The same sample was then split into small portions which were rubbed vigorously between two oak boards. A second sieve analysis was made of the sand treated thusly. The two gradations are given in Table 1, where comparison shows an appreciable difference. The extremes of gradation caused by the breakdown of these particles would depend on the disruptive forces encountered in mixing, handling, and processing. Nevertheless, in either case, it appears that a satisfactory gradation can be produced.

Attention should also be given to the particle shapes shown in Fig. 1. It can readily be seen that the particles are generally angular and can be classified as sub-angular (edges distinct, but rounded). An exception to this is found in the larger sizes, mostly those retained on the No. 4 screen, where some pebbles, which are sub-rounded, occur. In comparison, river sand is generally rounded and can be classified as rounded to sub-rounded. The angularity of the Rockcastle sand affects workability adversely.

Further, an x-ray diffraction analysis was made which indicated that the Rockcastle sand is 99.7% quartz.

The same type of coarse aggregate and cement was used in each batch of concrete. The coarse aggregate was No. 6 crushed limestone produced from the Tyrone and Oregon formations by the Central Rock Co. of Lexington, Kentucky, and the cement was Type I Portland, manufactured by the Louisville Cement Company of Speed, Indiana.

In air entrained batches, the same type of neutralized vinsol resin entraining agent was used.

The mix proportions for the two types of fine aggregate were designed as nearly the same as possible. A cement factor of 1.5 bbls. per cu. yd. of concrete and a slump between 2 in. and 3 in. were selected as constants for all the mixes. However, a slightly different proportioning of the aggregates was necessary for the Rockcastle and the control batches, because of the difference in the fineness moduli of the two sands. The percent fines to total aggregate was about three percent more for the Rockcastle mixes than for the control mixes.

Mixing and test data are given in Table 2. A fairly constant cement factor and slump were maintained. In order to maintain the desired slump in the mixes containing Rockcastle sand, an excessive amount of water was required. Apparently, extra water was necessary for lubrication and to overcome the frictional effect of the angular particles as well as to coat the increased surface area of the angular sand. Of course, the additional water necessary for workability resulted in a corresponding strength reduction. The control specimens, which required approximately 1.5 gal. less water per bag of cement, showed much higher strengths in both compression and flexure for both plain and air entrained concrete (Note: see Research Laboratory Report on "Discussion of Manufactured Stone Sand," by James H. Havens, April, 1959).

As might have been predicted, neither the Rockcastle nor the control specimens showed good durability without air entrainment. The critical factor in the durability of these specimens was their air content, and it was not possible to evaluate their durability on any other basis. The plain concretes showed very poor durability, but the air entrained concretes were very good.

Table 2: Summary of Test Data

Type	Cement Factor (bbl/yd)	W/C Ratio (g/bg)	% Air	Unit Weight Fresh Conc. (lbs.)	Slump (in.)	% Fines to Total Agg.	Avg. 7 Day Comp. Str. (psi)	Flex. Str. (psi)	Avg. 28 Day Comp. Str. (psi)	Flex. Str. (psi)	No. F & T Cycles to Failure	Excess. Expan.
------	------------------------------	------------------------	----------	--	----------------	-----------------------------------	--------------------------------------	------------------------	---------------------------------------	------------------------	---	-------------------

Air Entrained Specimens

Ohio River	1.50	4.84	4.7	146.4	3	39.0	4380	845	5434	995	355*	None
Rock- castle	1.43	6.51	5.2	142.4	2.5	41.8	2678	627	3686	840	355*	None

Plain Specimens

Ohio River	1.47	5.49	2.0	148.4	2.5	39.9	4677	900	5878	1060	28	None
Rock- castle	1.44	6.73	1.4	146.4	2.25	43.0	3657	767	4810	1013	28	None

Note: Strengths are the average of three test specimens.

* Test terminated at 355 cycles.

The concretes were tested for alkali-aggregate reaction by placing samples of each mix in glass fruit jars and keeping them immersed in water for observation. After several months a few small cracks appeared, indicating a slight amount of expansion. However, there was as much expansion in the control specimens as in the Rockcastle-sand specimens, and it can be assumed that the sands were about equal in this respect.

CONCLUSIONS

The Pottsville Conglomerate sand appears to have satisfactory physical characteristics and composition for use in portland cement concrete except that the amount of water required for workability is excessive from the standpoint of strengths obtainable and good established practice. Table 3 sets forth the requirements for various classes of concrete as given in Kentucky Highway Department Specifications.

The concretes tested, utilizing Rockcastle sand, did not meet the requirements set forth here for Class "A" concrete because of excessive water contents even though the 28-day compressive strengths are permissible.

The sand appears to have some potential use as a concrete sand but not without some changes to attain satisfactory workability at lower water contents. Possibilities for improving its performance in concrete include varying the ratio of the percent of fines to total aggregates, increasing the cement factor, altering the gradation, or blending with a rounded sand. The results from these sands indicate

Table 3 : Specifications for Various Classes of Concrete (Non-Air-Entrained)

Class of Concrete	Minimum Cement Factor (bbl/yd)	Maximum Free Water (gals/bag)	Slump (in)	Approx. % Fine to Total Aggregates (gravel)	Minimum Compressive Strength (28-Day, psi)
A	1.50	6.00	2-4	36	3500
B	1.20	7.50	3-5	40	2500
D	1.70	6.00	3-5	35	3500
D Mod.	1.95	5.75	3-5	35	4000*

When entrained air is incorporated in concrete mixtures the Engineer shall readjust the aggregate proportions to compensate for the increased volume due to the entrained air, as necessary to maintain the specified cement factor.

* Minimum expected compressive strength at 7 days when cured at a temperature of 70 degrees.

W. B. Drake

- 9 -

August 14, 1959

that further consideration along these lines might be profitable. While the limitations described herein apply to the use of this sand in portland cement concrete, they are not limiting in its use in bituminous concrete; in fact, there, the angularity of the sand might be considered advantageous.

Milton Evans, Jr.
Milton Evans, Jr.
Research Engineer

ME:dl