

November 13, 1962

A.I.I.

MEMORANDUM

TO: W. B. Drake  
Director of Research

FROM: Ronald D. Hughes *R.D.H.*  
Research Engineer Associate

SUBJECT: Laboratory Test Results on Natural Sand  
Produced by the Kapco Construction Company  
in Logan County

On September 19, 1962, a sample of sand produced by the Kapco Construction Company was received by the Research Division. This material was sampled at the quarry in Logan County and forwarded to the Research Division by personnel from District No. 3 of the Bowling Green Office. The sample was submitted for laboratory evaluation in regard to possible use of the material as fine aggregate in Class A concrete.

In order to evaluate the water requirement of concrete using this Logan County sand as the fine aggregate, two laboratory mixes were made:

1. Type A, concrete made with normal portland cement, and
2. Type D, concrete made with normal portland cement to which has been added at the mixer, an approved air-entraining agent.

Control mixes were made using Ohio River sand obtained at Louisville, Kentucky, and meeting the physical requirements of the Department's Standard Specifications, Article 7.3.2. All mixes were made using No. 6 stone obtained from the Central Rock Company, Lexington, Kentucky, and meeting the physical requirements of Article 7.4.2-D. This aggregate was graded in the laboratory so as to meet the mid-point of requirements for gradation of No. 6 stone. Type I, Speed Portland cement was used in all mixes and the air-entraining agent NVX was used in both the control and evaluation Type D mixes. Both the cement and air-entraining agent are approved materials.

Both Class A, Type A mixes were designed on the assumption of 1.5 percent air being entrained at the mixer without the use of an air-entraining agent. For mix design purposes, a total free water content of 34 gallons per cubic yard of concrete produced was assumed for the mix in which Logan County sand was used and 31 gallons per cubic yard was assumed for the mix with river sand. This assumption was made on basis of previous mix results and was used in order that a uniform slump and cement factor might be obtained for each of the Type A mixes. The Class A, Type D mixes were designed for an air-content of 4.5 percent with the design free water content of each being the same as those mixes produced without the use of an air-entraining agent.

All mixes were designed for 40 percent fine aggregate by weight of the total aggregate combination. A specific gravity of 3.10 was assumed for the cement used, and the following saturated surface dry specific gravities were found from laboratory tests on the aggregates:

Coarse aggregate	2.72
River sand	2.66
Logan County sand	2.64

The design mix weights (SSD Basis) used are contained in Table I.

TABLE I - Mix Design Weight (SSD Basis) for One Yard<sup>3</sup> Each

	Type A		Type D	
	River Sand	Logan Co. Sand	River Sand	Logan Co. Sand
Cement	564	564	564	564
Free Water	258.6	283.6	258.6	283.6
SSD Fine Aggregate	1314.6	1283.8	1260.0	1229.4
SSD Coarse Aggr.	1971.8	1925.7	1890.1	1844.2

The weights contained in Table I were adjusted for weights to produce a 2-cubic foot mix (capacity of the laboratory mixer). Design weights used for each of the four mixes are contained in Table II. In all cases a slump near that desired was obtained using less free (mix) water than that anticipated or assumed in Table II. Results of tests performed on the fresh concrete and the calculated values therefrom are contained in Table III.

TABLE II - Mix Design Weights for Two Feet<sup>3</sup> Each

	Type A		Type D	
	Ohio River Sand	Kapco Logan Co. Sand	Ohio River Sand	Kapco Logan Co. Sand
Cement	41.8	41.8	41.8	41.8
Free Water	19.2	21.0	19.2	21.0
SSD Fine Aggr.	97.4	95.1	93.3	91.1
SSD Coarse Aggr.	146.1	142.6	140.0	136.6

TABLE III - Test Results on Fresh Concrete and Calculated Values

	Type A		Type D	
	Ohio River Sand	Kapco Logan Co. Sand	Ohio River Sand	Kapco Logan Co. Sand
Slump - (in.)	3.5	3.25	3.5	3.25
Unit Wt. (pcf)	150.4	150.0	144.6	145.4
Air Content (%)	1.5	1.3	4.8	5.0
Water Underrun (lb.)	0.20	0.40	0.35	1.00
Actual Gals. Water /yd <sup>3</sup> . Produced	30.72	33.46	30.52	32.64
Cement Factor	1.50	1.50	1.50	1.51
W/C Ratio-Gals. Water/Sack of Cement	5.11	5.56	5.07	5.40

The maximum allowable free moisture content for Class A concrete is 36.0 gallons per cubic yard of concrete produced. All of the laboratory mixes thereby meet this requirement.

Cylinders and beams were molded from the fresh concrete and cured for compressive and flexural strength tests. Nine cylinders were made from each mix for triplicate compressive tests at 7, 14 and 28 days. Nine beams were made from each mix for triplicate flexural tests at 7 and 28 days. The remaining three beams from each mix were subjected to freeze-thaw testing beginning at 14 days after mixing. The results of compressive and flexural tests on cylinders and beams are contained in Table IV.

TABLE IV - Compressive and Flexural Test Results-psi.

Specimen No.	Type A				Type D			
	Ohio River Sand		Kapco Logan Co. Sand		Ohio River Sand		Kapco Logan Co. Sand	
	Comp.	Flex.	Comp.	Flex.	Comp.	Flex.	Comp.	Flex.
7-Day Strengths								
7-1	3866	919	3698	825	4061	731	3822	675
7-2	4185	863	3981	863	4282	750	3723	713
7-3	3937	825	3742	863	4170	788	3627	713
Avg.	3996	869	3807	850	4171	756	3724	700
14-Day Strengths								
14-1	4778	--	4397	--	4565	--	4229	--
14-2	4813	--	4601	--	3946	--	4034	--
14-3	4654	--	4795	--	3822	--	4300	--
Avg.	4748	--	4598	--	4111	--	4188	--
28-Day Strengths								
28-1	5291	1050	5768	1313	5149	1125	4671	1013
28-2	5291	1163	5096	1163	4495	825	4883	938
28-3	5132	1200	5415	1200	5591	937	4742	1088
Avg.	5238	1137	5255	1225	5078	962	4765	1013

The gradation and all physical tests were performed on the Logan County sand in accordance with the methods outlined under Article 7.3.2. The following are results of these tests. Results from gradation tests on two samples of the sand are contained in Table V.

TABLE V - Sieve Analysis (Kapco)

Sieve Size	Wt. Retained	% Retained	% Passing	Spec.
Test No. 1				
No. 4	23	3.01	96.99	85-100
No. 8	179	23.40	73.59	--
No. 16	156	20.39	53.20	40-80
No. 30	155	20.26	32.94	--
No. 50	145	18.95	13.99	5-25
No. 100	85	11.11	2.88	0-5
Pan	22	2.88	0.00	0
Test No. 2				
No. 4	27	3.25	96.75	85-100
No. 8	210	25.30	71.45	--
No. 16	169	20.36	51.09	40-80
No. 30	168	20.24	30.85	--
No. 50	148	17.83	13.02	5-25
No. 100	86	10.36	2.66	0-5
Pan	22	2.66	0.00	0

TABLE VI - Deleterious Substances (Kapco)

Materials	Percent by Weight in Sample	Maximum Allowable Percent by Weight Ky. Specification
Clay	0.0	1.0
Coal and Lignite	0.0	1.0
Other deleterious substances	0.0	1.0

TABLE VII- Soundness Test (Kapco)

Sieve		Grading of Original Sample (%)	Test Fractions				Weighed Average % Loss
Passing	Retained		Initial Wt. (gms)	Final Wt. (gms)	Loss (gms)	Loss (%)	
No. 100	--	2.7	--	--	--	--	--
No. 50	No. 100	10.4	--	--	--	--	--
No. 30	No. 50	17.8	100.0	96.5	3.5	3.5	0.62
No. 16	No. 30	20.2	100.0	100.0	0.0	0.0	0.20
No. 8	No. 16	20.4	100.0	1.5	1.5	1.5	0.31
No. 4	No. 8	25.3	100.0	1.5	1.5	1.5	0.38
3/8 in.	No. 4	3.3	--	--	--	--	0.45
Totals							1.76

When subjected to the colorimetric test for organic impurities, a color lighter than the standard resulted. The sample thereby passes this test requirement.

Mortar-strength tests for tensile and compressive strengths were made using graded Ottawa sand as the control sand as specified. The proportions of Type I portland cement, sand, and water used for molding mortar specimens are contained in Table VIII. The results of the strength tests thereon are found in Table IX. The required weights of water for each of the mortar-cube specimens were determined from flow tests; and flows thus obtained with the Ottawa and Logan County sands were 100.0% and 107.0% respectively. The water requirement for tensile strength

specimens (briquetts) was determined as the amount required to produce a normal consistency in the cement paste.

TABLE VIII - Mortar Proportions for Tensile and Compressive Specimens

Materials	Ottawa Sand		Kapco Logan Co. Sand	
	Tensile	Comp.	Tensile	Comp.
Cement -gms.	250	500	250	500
Water - gms.	105	238	105	230
Sand - gms.	750	1375	750	1375

TABLE IX - Tensile and Compressive Strength Test Results - 7-Day Strengths (psi.)

Spec. No.	Ottawa Sand		Kapco Logan Co. Sand	
	Tensile	Comp.	Tensile	Comp.
1	330	2838	475	6325
2	340	2950	475	5750
3	335	2888	440	6650
Avg.	335	2892	463	6241

Your attention is directed to the Research Division's memorandum report of August 14, 1959, to J. A. Bitterman, on "Pottsville Conglomerate Sand as Fine Aggregate in Portland Cement Concrete," and to a related report on "Limestone Fine Aggregate in Portland Cement Concrete," dated February 24, 1960 (See bound Reports of the Highway Materials



Research Laboratory, Vol. XV, 1960, pages 159-169 and 11-52, respectively).

More specifically, attention is directed to Table 6, page 31 which gives the bulking value of various sands in relationship to particle shape. There natural sand gave a value of 45.4 (percent voids); whereas, crushed but un-milled sands gave values of 50 or greater. It was of interest to compare the Kapco sand on this basis also. Ohio River sand yielded a value of 44.87, whereas the Logan County sand yielded 47.86. On this basis, the Logan County sand is adjudged to be slightly inferior to the river sand, but is adjudged to be superior to un-improved crushed sands in roundness and in concrete-making characteristics. Likewise, but on the basis of water-requirements, this sand is superior to the Rockcastle conglomerate sand.

The following are findings from a mineralogic analysis on samples from various sizes of the sand produced by the Kapco Construction Company:

- +No. 4 - Quartz grains and some quartzite grains, well rounded with surfaces well worn and pitted.
- No. 4 and +No. 8 - Quartz grains and some quartzite grains, rounded to well rounded, traces of iron oxide concentrations, surfaces worn and pitted.
- No. 8 and +No. 16 - Quartz grains, rounded to well rounded, traces of iron oxide concentrations
- No. 16 and +No. 50 - Quartz grains, sub-rounded to rounded, surfaces slightly pitted, traces of iron oxide concentrations and muscovite.
- No. 50 and +No. 100 - Quartz grains, sub-rounded, traces of iron oxide concentrations, biotite and muscovite.