NATIONAL BUREAU OF STANDARDS REPORT

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QUARTERLY REPORT

ON

EVALUATION OF REFRACTORY QUALITIES OF CONCRETES FOR JET AIRCRAFT WARM UP, POWER CHECK, AND MAINTENANCE APRONS

by

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Technical Requirements

The concretes must be of sufficient workability to give a 2-inch slump when tested in accordance with ASTM Method Designation C143-39 [1]. They also must develop a flexural strength of 650 psi. The strength requirement refers to the concretes after a twenty-eight day curing period. Resistance to destruction when exposed to rapidly increasing and fluctuating temperatures is necessary. Notification of the requirements for the limits of the slump test and flexural strength were received too late for application to the experimental work included in this report.

I. INTRODUCTION

The objective of the investigation is the evaluation of the physical properties and the determination of the suitability of concretes for jet aircraft warm up, power check, and maintenance aprons.

For this quarterly period the concretes were designed using portland cement with each of five aggregates.

II. MATERIALS

Cements. The three types of cement* selected for this investigation were North American Type II portland, Green Bay portland pozzolan, and Lumnite high alumina hydraulic. The quantity of portland and portland pozzolan cement already stored in waterproof drums was considered sufficient for current use. However, it was necessary to obtain an additional shipment of Lumnite cement because the stock of the previously stored material was practically depleted. This cement was subjected to the same physical and chemical tests** that the first shipment received. The results of these analyses indicated some slight differences, but such differences would not be considered significant.

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* The same brands of cement were used in an earlier investigation in which light-weight aggregates were studied [2].

** Made by the Mineral Products Division, Concreting Materials Section, National Bureau of Standards.

Aggregates. In the current work aggregates of a more dense type, namely, crushed building brick, raw flint clay, calcined flint clay, Bluestone, and olivine, are being used in designing the concretes.

A study of the properties of these aggregates indicated that such materials approach the properties of crushed stone and crushed sand. Since three of the dense aggregates are not marketed in the proper gradation that will produce a workable concrete, it was necessary to crush, grind, and screen them to the desired sizes.

The properties of the dense aggregates, previously reported [2] are again given in table 1. These properties of the aggregates are required in properly designing the concrete mixes.

Concretes. The data used in designing the various concrete mixes was obtained from publications by the Portland Cement Association [3] and the National Ready Mix Concrete Association [4].

Trial batches were calculated and mixed using each of the five aggregates with portland cement. The cement was varied from four and one-half to seven sacks per cubic yard. This variation in cement content was chosen in an effort to produce

Materials		›ight ‹t3		Bulk Specific Gravity	Water Absorption
Identification	Size		Jigged (b)	S.S. Dry (c)	Percent by weight
Bluestone	Coarse		98.0	2.74	0.24
	Fine		113.0	2.64	1.06
Building Brick	Coarse		71.9	2.26	8.93
	Medium		70.3	2.27	9.60
	Fine		91.9	2.37	6.10
Flint-clay Calcined	Coarse		101.7	2.65	0.90
	Fine		101.3	2.65	0.80
Flint-clay Raw	Coarse		101.5	2.52	4.76
	Fine		95.0	2.50	5.03
Olivine	Coarse		146.7	2.97	3.20
	Fine		130.5	3.09	1.00
White Marsh Gravel	Coarse		110.9	2.64	0.30
Sand	Fine		112.0	2.63	0.30

(a) Indicates distrile and Concrete Aggregates," ASTM Standards on

(b) Indicates bulkin

(c) "S.S." Saturate

Table 1. Properties of Aggregates

Materials		Sieve Analysis: Amount passing U. S. Standard Sieve, percent by weight											Fineness Modulus (a)	Unit Weight lbs/ft^3		Bulk Specific Gravity S.S. Dry (c)	Water Absorption Percent by weight
						Nos.											
Identification	Size	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200		Loose	Jigged (b)		
Bluestone	Coarse	100.0	99.1	71.6	22.7	3.1	2.0	—	—	—	—	—	6.73	83.6	98.0	2.74	0.24
	Fine	—	—	—	100.0	99.3	79.6	50.7	26.7	11.5	3.7	11.3	3.28	99.8	113.0	2.64	1.06
Building Brick	Coarse	100.0	99.1	66.8	15.2	4.4	3.9	—	—	—	—	—	6.77	61.4	71.9	2.26	8.93
	Medium	—	—	100.0	98.3	16.5	5.4	4.3	—	—	—	—	5.75	60.5	70.3	2.27	9.60
	Fine	—	—		100.0	99.9	70.9	50.5	36.0	23.5	11.0	7.5	3.08	80.1	91.9	2.37	6.10
Flint-clay Calcined	Coarse	100.0	99.6	85.3	70.4	44.2	24.9	—	—	—	—	—	5.60	87.7	101.7	2.65	0.90
	Fine	—	—	—	100.0	75.1	38.0	20.2	10.6	5.2	1.8	0.9	4.49	89.4	101.3	2.65	0.80
Flint-clay Raw	Coarse	100.0	99.8	83.2	69.8	45.5	29.3	—	—	—	—	—	5.55	86.0	101.5	2.52	4.76
	Fine	—	—	—	100.0	76.3	37.3	20.1	10.2	4.6	1.5	1.9	4.50	80.9	95.0	2.50	5.03
Olivine	Coarse	—	100.0	85.3	70.9	54.3	45.6	—	—	—	—	—	5.29	124.8	146.7	2.97	3.20
	Fine	—	—	—	100.0	99.9	99.3	82.0	65.5	35.2	10.3	4.0	2.08	114.4	130.5	3.09	1.00
White Marsh Gravel	Coarse	89.9	76.2	54.1	31.9	3.3	—	—	—	—	—	—	6.88	100.1	110.9	2.64	0.30
Sand	Fine	—	—	—	100.0	97.9	8.00	64.9	49.5	22.0	4.1	1.2	2.82	100.4	112.0	2.63	0.30

(a) Indicatee distribution of sizes of aggregate as determined by ASTM method C125-43 "Standard Definitions of Terms Relating to Concrete and Concrete Aggregates," ASTM Standards on Mineral Aggregates, Concrete, and Nonbituminous Highway Materiale, Sept. 1948, page 70.

(b) Indicates bulking or fitting together of various sizes of aggregates.

(c) "S.S." Saturated aggregate - Surface Dry.

a concrete of satisfactory workability and of the specified strength. If a designed mix did not have good workability additional trial mixes were prepared changing the aggregate gradation by increasing or decreasing the fine- to coarse ratio of the aggregate. Eighteen batches of concrete were mixed and a set of specimens of each mix were fabricated. Each set of specimens consisted of: three 6x12 inch cylinders, two 3x4x16 inch prisms, and one 24x24x2 1/2 inch slab. The 24-inch slab, after a partial set, received an additional delayed finishing with a steel trowel. All specimens were covered with wet burlap until the end of a 24-hour period. They were then removed from the molds, cured for six days in a fog room, stored at laboratory temperature and humidity for twenty-one days, and tested. A detailed description of the method of testing was given in a previous report [2]. The compositions of the concretes are given in table II.

III. RESULTS

The results of tests of trial concrete batches are given in table II.

The slump results are not as accurate a measure of the workability when angular aggregates are used as they are in conventional concretes with rounded aggregates.

Laboratory Identification a/	gth t	Young's modulus of elasticity Dynamic Longitudinal	Linear shrinkage c/	Abrasion Loss
		Lbs/in² x 10⁶ c/	%	Gms.
P-O-1A		4.810	0.050	109
P-O-1B		4.471	0.167	210
P-O-1C		4.473	0.083	135
P-O-1D		5.199	0.070	62
P-B-1A b/		2.252	0.115	59
P-B-1B		1.736	0.335	—
P-B-1C		2.090	0.460	65
P-B-1D		2.480	0.115	64
P-B-1E		—	—	—
P-BS-1A		3.980	0.000	54
P-BS-1B		4.521	0.070	45
P-BS-1C		4.681	0.180	31
P-RC-1A		1.883	0.233	40
P-RC-1B		1.728	0.250	39
P-RC-1C		2.034	0.133	38
P-C-1A		2.649	0.000	71
P-C-1B		2.979	0.050	52
P-C-1C		4.379	0.016	43

a/ The firng Brick, BS=Bluestone, RC=Raw Flint Clay,
C=Calci

b/ Cement

c/ Determi

Table II. Properties of Trial Concrete Mixes

Laboratory Identification [a]	Proportions by weight cement to fine to coarse aggregate	Cement content	Vinsol resin by weight of cement	Water content	Air content	Slump of fresh concrete	Weight of fresh concrete	Weight of concrete after 7-day fog and 21-day R.T.	Compressive strength 6x12 in. cylinder	Strength weight ratio	Young's modulus of elasticity Dynamic Longitudinal	Linear shrinkage [c]	Abrasion Loss
		Bags/yd^3 of concrete	%	Gals/yd^3 of concrete	%	Inches	Lb/ft^3	Lbs/ft^3	Lbs/in^2 [c]		Lbs/in^2 x 10^6 [c]	%	Gms.
P-O-1A	1 : 1.1 : 4.6	6.3	0.02	46.7	1.7	3.75	163	162	3145	19.5	4.810	0.050	109
P-O-1B	1 : 0.9 : 5.4	5.9	do	39.3	3.8	4.00	164	162	2825	17.4	4.471	0.167	210
P-O-1C	1 : 0.8 : 4.4	6.2	do	39.0	3.9	3.25	164	162	3330	20.5	4.473	0.083	135
P-O-1D	1 : 0.6 : 3.4	6.7	do	37.2	3.8	3.50	164	163	4155	25.6	5.199	0.070	62
P-B-1A [b]	1 : 3.6 : 0.9 : 0.8	4.6	0.02	60.7	9.4	1.00	119	110	1900	17.3	2.252	0.115	59
P-B-1B	1 : 1.7 : 1.3 : 2.0	5.1	do	55.7	8.1	0.00	124	114	1480	15.0	1.736	0.335	—
P-B-1C	1 : 1.5 : 1.1 : 1.7	5.9	do	55.7	7.9	0.25	124	117	2470	21.1	2.090	0.460	65
P-B-1D	1 : 1.2 : 0.9 : 1.4	6.7	do	60.0	7.9	1.50	123	121	3125	25.8	2.480	0.115	64
P-B-1E	1 : 1.7 : 1.0 : 1.5	5.8	0.015	54.5	6.5	0.00	127	—	—	—	—	—	—
P-BS-1A	1 : 2.8 : 3.4	5.1	0.02	37.3	7.1	3.75	140	137	2340	17.0	3.980	0.000	54
P-BS-1B	1 : 2.2 : 2.5	6.5	do	39.2	5.7	3.50	142	140	3130	22.4	4.521	0.070	45
P-BS-1C	1 : 2.0 : 2.3	7.0	do	40.0	5.2	3.00	143	142	3330	23.5	4.681	0.180	31
P-RC-1A	1 : 2.8 : 3.0	4.7	0.02	47.0	12.5	0.75	125	121	1665	13.8	1.883	0.233	40
P-RC-1B	1 : 2.3 : 2.5	5.5	do	46.8	12.7	1.00	128	120	1690	14.0	1.728	0.250	39
P-RC-1C	1 : 1.9 : 2.1	6.2	do	49.8	15.1	2.50	125	123	1980	16.1	2.034	0.133	38
P-C-1A	1 : 2.9 : 3.2	4.5	0.02	36.7	15.3	—	126	123	960	7.4	2.649	0.000	71
P-C-1B	1 : 2.4 : 2.6	5.8	do	35.4	11.5	—	133	124	1775	14.3	2.979	0.050	52
P-C-1C	1 : 2.0 : 2.2	7.0	0.01	37.8	8.1	0.50	138	134	2975	24.2	4.379	0.016	43

a/ The first letter indicates the type of cement, namely, P=Portland; the second letter, or letters, indicate the type of aggregate, O=olivine, B=Building Brick, BS=Bluestone, RC=Raw Flint Clay, C=Calcined clay; the numerical, 1, indicates cured for 28 days; the letters A, B, C, D,E, indicate different cement contents.

b/ Cement : Fine : Medium : Coarse

c/ Determined after 28-day curing period.

With an increase of cement content and the ratio of fine- to coarse aggregate remaining unchanged [a] an increase in compressive strength was developed. The concretes that failed to develop the expected compressive strength have higher air contents than are normally desirable. The air content can be decreased by lowering the amount of the air-entraining agent (Vinsol resin). This, however, may effect the placement of a mix.

The resistance to abrasion of concretes designed with olivine as an aggregate was less than it was when any other of the five aggregates were used. The data thus far indicates that concretes designed with the raw or the calcined flint clay aggregates, although comparatively low in compressive strength, have a somewhat higher resistance to abrasion.

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[a] Does not apply to P-O-1A, P-B-1A and P-B-1E. The figures denoting the ratio were rounded off to the nearest one-tenth.

[1] ASTM Standards on Mineral Aggregates, Concrete, and Nonbituminous Highway Materials, September, 1948. Slump Test for Consistency of Portland Cement Concrete, page 115.

[2] National Bureau of Standards Report 1817.

[3] Design and Control of Concrete Mixes, Ninth Edition.

[4] The Proportioning of Concrete, A. T. Goldbeck and J. E. Gray, revised edition June, 1949.

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