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QUARTERLY REPORT

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

W. L. Pendergast, R. A. Clevenger, Edward C. Tuma



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• Office of Basic Instrumentation

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NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT

NBS REPORT

0903-21-4428

September 30, 1953

2832

QUARTERLY REPORT

ON

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

bу

W. L. Pendergast, R. A. Clevenger, Edward C. Tuma Refractories Section Mineral Products Division

Sponsored by
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Port Hueneme, California

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Approved:

R. A. Heindl, Chief, Refractories Section



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QUARTERLY REPORT

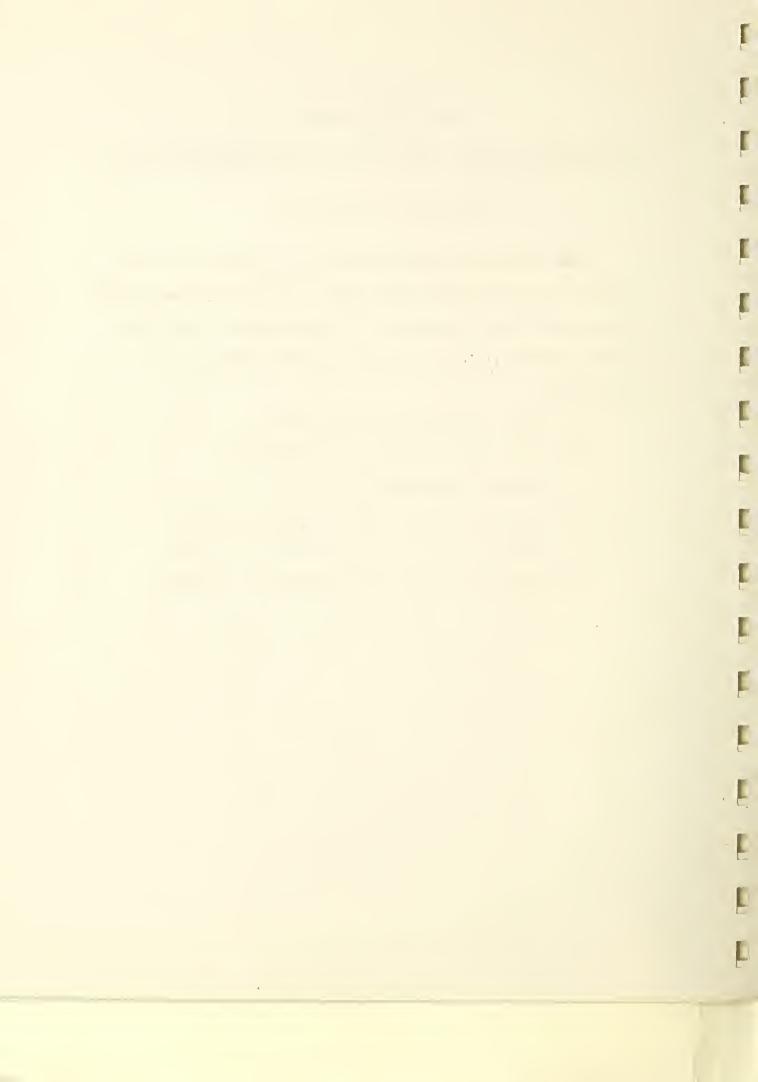
ON

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

Technical Requirements

The technical requirements are the same as those given in the NBS Report 2632 with a change in two of the five conditions of exposure of the concrete specimens before testing. The exposures before testing are as follows: 1/

- 1. Twenty eight days in fog-room
- 2. Seven days in fog-room, 21 days in ordinary laboratory air.
- 3. Cured as in No. 2 plus heating at 500°C
- 4. Cured as in No. 2 plus heating at 750°C
- 5. Cured as in No. 2 plus heating at 1000°C



I. INTRODUCTION

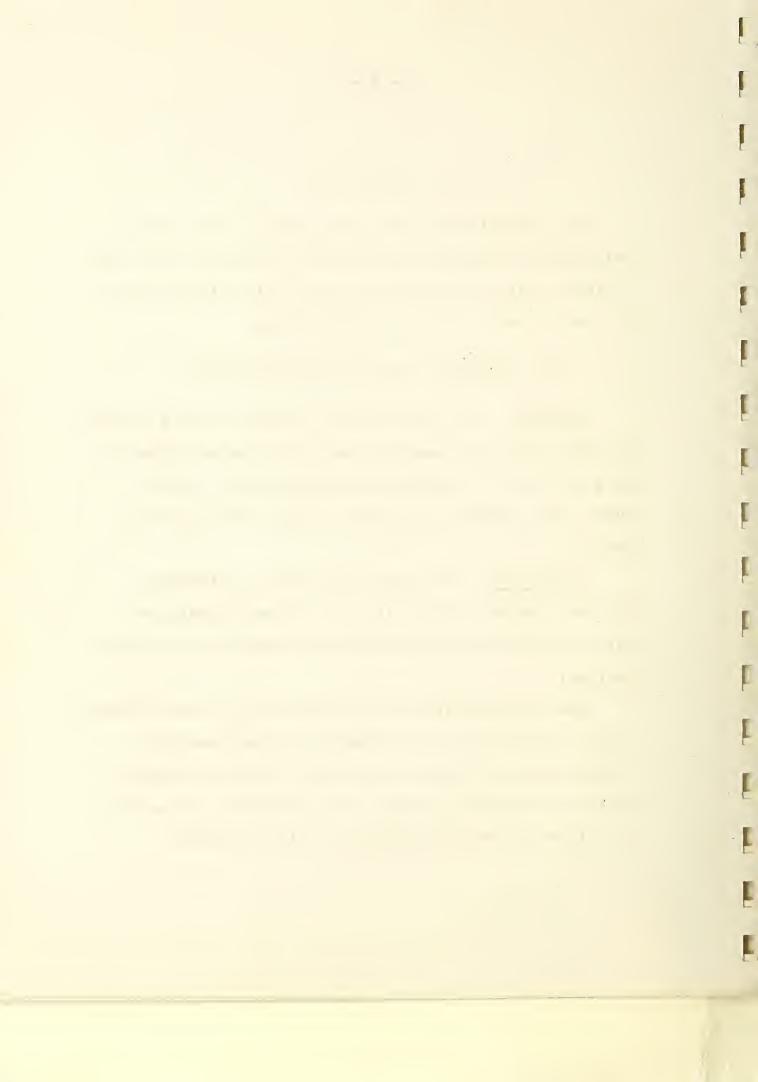
The objective of the investigation is the determination of the physical properties of concretes that will evaluate their suitability for use in jet aircraft warm up, power check, and maintenance aprons.

II. MATERIALS: PREPARATION AND TESTING

Cements. The three cements included in this project, portland, portland pozzolan, and high alumina hydraulic were used in the design of concretes mixed, placed, cured, heat treated, and tested during this reporting period.

Aggregates. Additional shipments of Bluestone, olivine, Kentucky flint clay (raw and calcined), and West Virginia hard burned face brick were received this quarter.

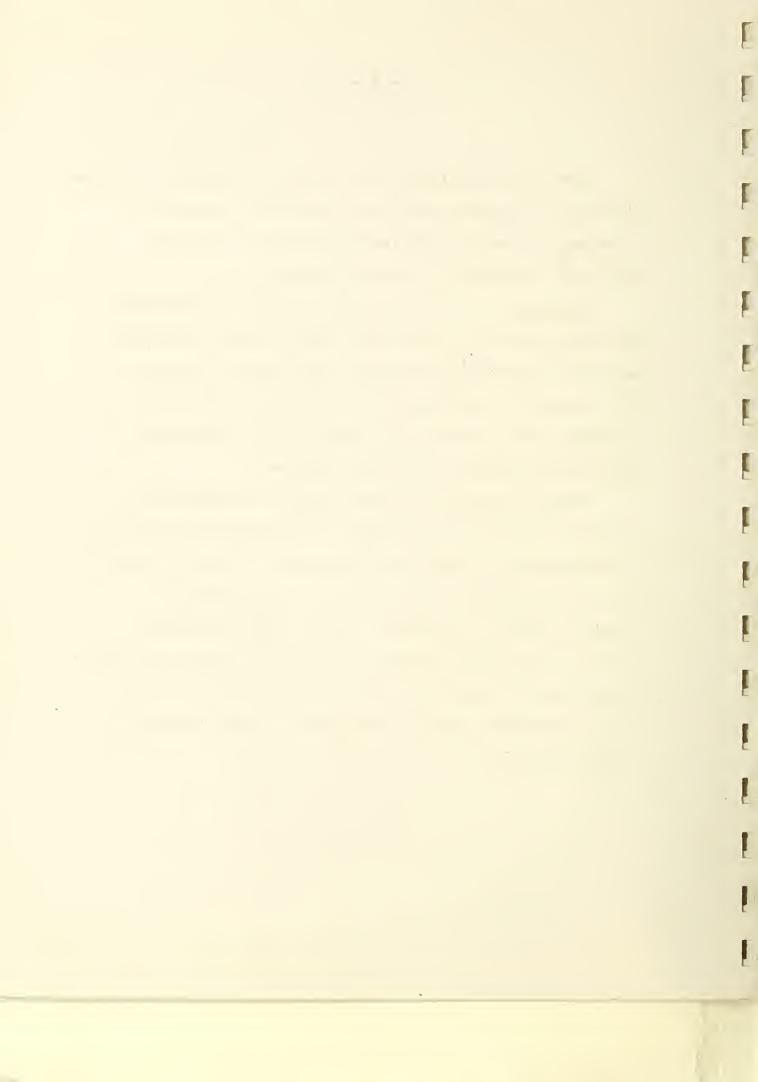
The Bluestone (dolomitic limestone) has been crushed, graded, recombined in accordance with the technical requirements, and used in the three concretes prepared during the reporting period. The correction factor for the air meter was determined for this aggregate.

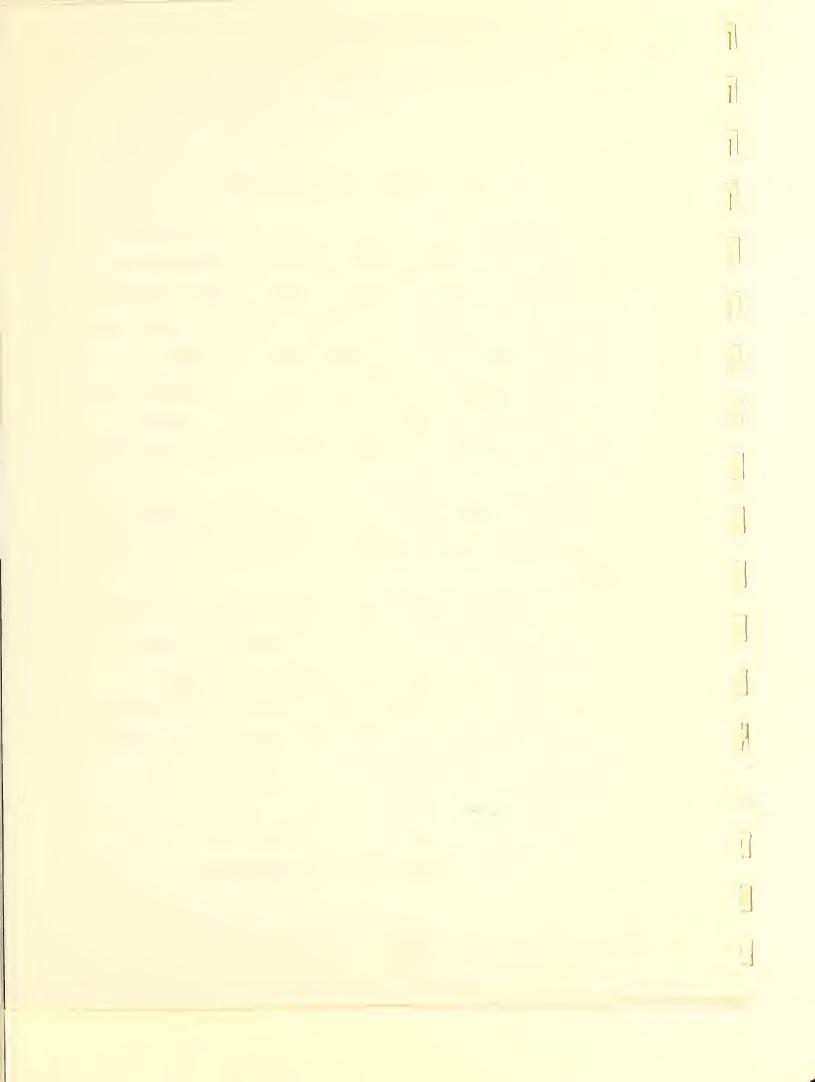


Four tons of olivine were screened using the 11 screens necessary in grading the coarse and fine fractions of aggregate. The -1 + 3/4 inch aggregate is the most difficult to obtain in grading olivine.

Concretes. In the preceding report 2/ information was given relative to the properties of both the fresh and cured concretes containing White Marsh aggregate. The testing of specimens, fabricated from these three concretes, after curing and heating at 500, 750, and 1000°C respectively, has been completed.

During the current quarter twenty-five one-cubic foot trial batches of concrete with Bluestone aggregate were designed and specimens fabricated. Eight of these concretes contained portland cement, six portland pozzolan cement, and eleven high-alumina hydraulic cement. The cement content, the ratio of coarse to fine aggregate, the amount of mixing water, and the amount of air-entraining agent, were systematically varied in these concretes.





III. RESULTS AND DISCUSSION

Table I gives the results of the tests for the three concretes designed with White Marsh aggregate after six different exposures. These results indicate that two of the concretes definitely failed to meet the specified strength requirements (600 - 650 psi).

The precision of the method used in measuring the length changes is accurate to 0.02 inches. Values of a lower magnitude serve only as an indication of length change.

The decrease in strength as given or indicated by a decrease in elastic modulus is attended by a loss in weight.

The three concretes were designed using a 6-sack mixture. A redesigning of these concretes by which the cement content would be increased to a 6 1/2 or 7-sack mix, would probably have resulted in a concrete of the required strength after the 28-day curing period. However, the rapid decrease in strength after heat exposures at 500°C and above indicate that concretes containing natural siliceous aggregate of this type are possibly not suitable for such exposures.

| L - W II | Z - 191 191 191 191 191 191 191 191 191 1 | | Laboration | |
|---|---|------------------------------------|---|--|
| 1:3.58:1.93 | 1:3.58:1.94 | 1.3.57.1.95 | Weight: Count to Course and to Fine | |
| クペナシャ | 702702 | ひなたる ジト | Treatments Treceding Testsa' | |
| 3435 | 1.200 | 3080 | Compressive Strongth | |
| 25 25 25 25 25 26 27 | 260 | 177 177 1770 1770 1770 | Flexund Strength | |
| 43.5 269.0 593.0£/ | 12.6 22.0 | 4.7 | .brasion Loss | |
| 4.450 3.950 1.604 .254 .178 | 5.510 5.527 3.787 1.215 | 5,159 5.30 3.678 1.325 | Young's Modulus of Electicity Dynamic: Longitudinal lbs 'inch' x 10 | |
| +0.07 0.007 | +3.77 | +0.01 +0.01 -0.01 | Totalb Linear Thange | |
| -7.90 -7.90 | +0.84 +0.17 -4.67 | 6.20 | Trtile Weight Change | |

^{2&#}x27; The results of tests given in line 1 were obtained after 28 day fog-room curing: line 2 treatment (1) plus 7 days under oxilinary leboratory conditions; line 3 treatment (2) plus drying at 110°C; line 4 treatment (3) plus heating at 500°C for 5 hours; line 5 treatment (3) plus 750°C for 5 hours; line 6 treatment (3) plus 1000°C for 5 hours.

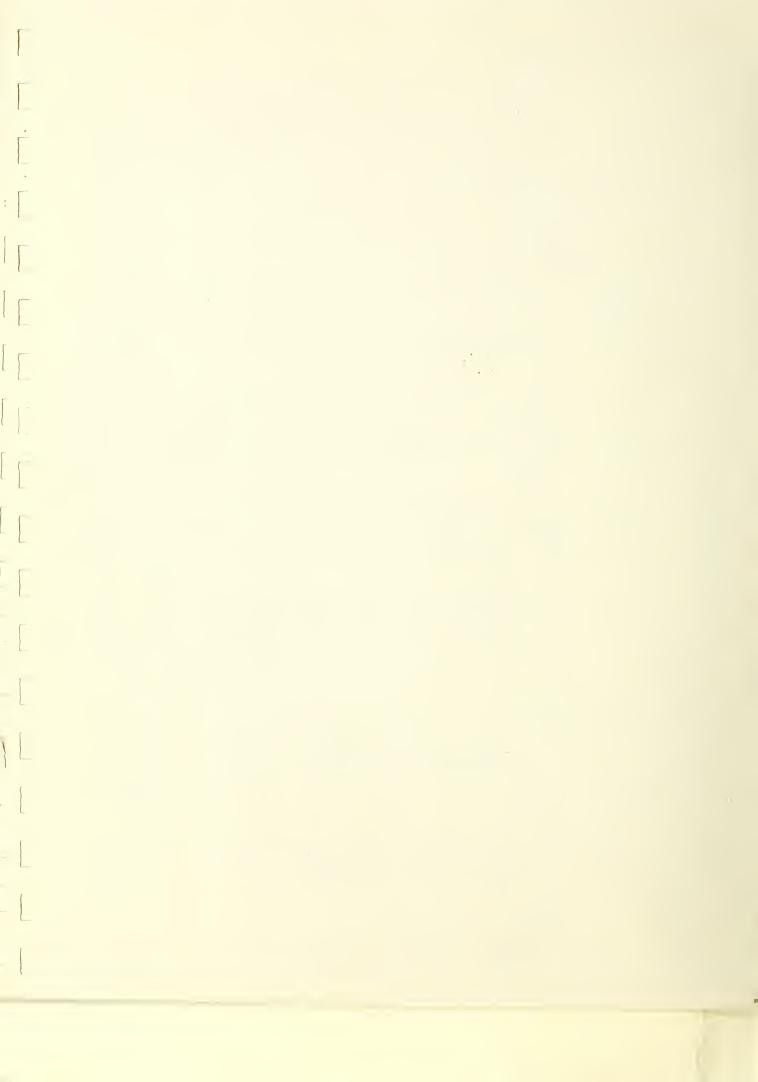
b' Based on length after 24 hours in mould.

c/ Based on weight after 24 hours in mould.

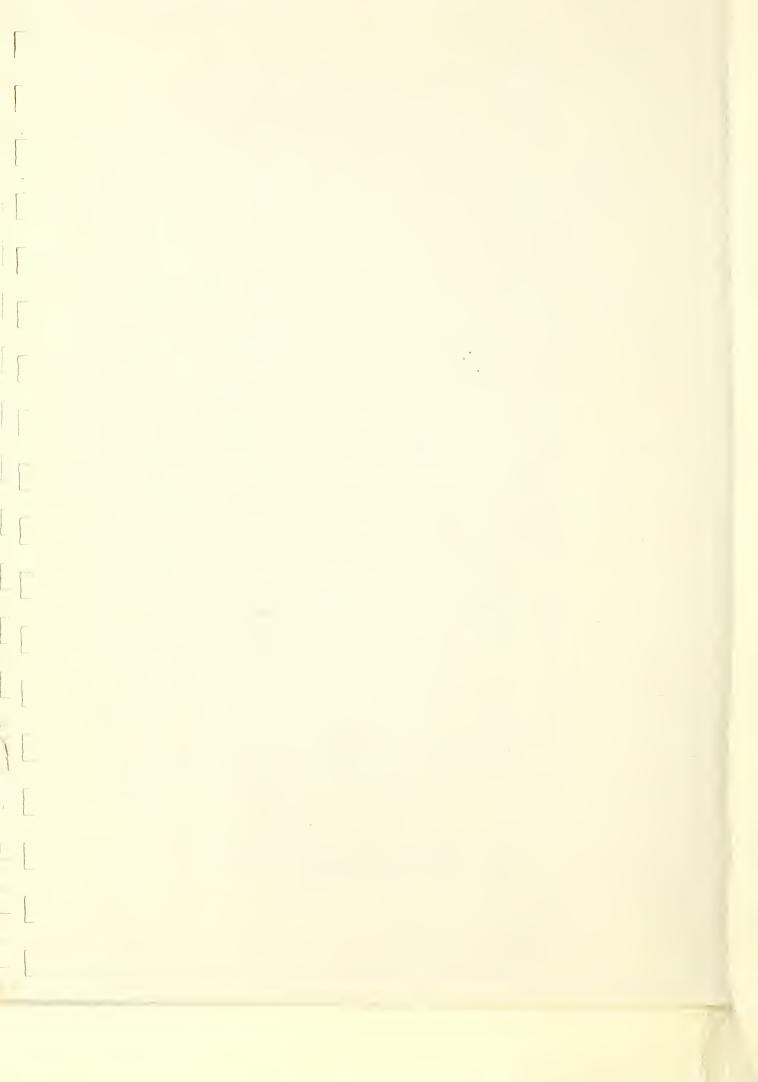
d/ Based on length after 28 days in fog-room.

e/ Based on weight after 28 days in fog-room.

Loss after 3 minutes in abrasion test (usual test is of 5 minute duration).



5 | 1



| | Proportions | | Vinsol Reein | | Air C | ntent | | | Water | | 1 | |
|----------|---|-----------------------|---------------------|----------------------------------|-----------------------|---------------------|--|-----------------------------|-----------------|--|----------------------|---|
| cation b | by Weight; Cement to Coarse and to Fine Aggregate | Cement Content | by Weight of Cement | Water Content | Gravimetric Method | Air Meter Method | Slump | Weight of Fresh Concrete | Coment Ratio | Remarks Fresh Concrete | Flexural Strength | Remarks Cured Concrete |
| | | Sacks 'yd of Concrete | % | Gale yd ³ of Concrete | A | ₹, | Lnches | Lbs 'ft ³ | | | psi. | |
| P-BS-A | 1:2.50:2.44 | 6.26 | .015 | 39.0 | 5.95 | 7.30 | 3.00 | цз.07 | 0.55 | Over sanded: alightly high in air content and slump. | 630 | 50 percent pull outs; small aggregate fractured. |
| F-BS-B | 1:3.30:1.70 | 6.66 | .015 | 32.6 | 2.70 | 3.45 | 150 | 151.08 | 0.43 | Good workability for this type appregate: Slightly low in air content and slump. | 81,5 | |
| P-BS-C | 1:3.30:1.70 | c.52 | .025 | 31.8 | 5,(Y) | (.50 | 2.00 | 147.19 | 0.43 | Good (Lacability | 710 | Large aggregate pulled out about 60% fracture. |
| P-3S-F | 1:3.40:1.60 | 6.53 | .020 | 33.: | 3.8 | 4.60 | 1.50 | 148.40 | 0.45 | do | 705 | ರೆಂ |
| P-BS-D | 1:3.07:1.55 | 6.92 | .025 | 32.7 | 3.10 | C. | 1.75 | 146.75 | 0,42 | Fair workability: harsh | 720 | 50 percent pull outs. |
| F-BS-G | 1:3.16:1.45 | 7.11 | .320 | 32.9 | 4.00 | 3.05 | 1.87 | 1501.32 | 0.41 | Harsh but placed well | 700 | do |
| P-BS-E | 1: 2.97: 1.33 | 7. 58 | .025 | 33.6 | 2,20 | 3.17 | 0.75 | 151.95 | 0.39 | Harsh: hard to place | 690 | All below 3/4, inch: aggregate fractured |
| P-BS-H | 1:2.97:1.33 | 7.37 | .020 | 32.7 | 4.80 | 4.18 | 1.75 | 147.62 | 0.39 | Very good | 820 | Most aggregate fractured |
| P-BS-1 | 1:1.33:1.57 | 6.47 | .020 | 31.1 | 5.40 | 5.30 | 2,00 | 143.72 | 0.43 | Good workability; slightly sticky | | Large aggregate |
| P-BS-2 | do | 6.49 | .020 | 31.4 | 5.00 | 4.75 | 2.25 | 14.70 | 0.43 | đo | | ' |
| P-BS-3 | do | 6.53 | .020 | 30.7 | 4.70 | 5.40 | 1.75 | 146.75 | 0.42 | do | | |
| Z-BS-A | 1:3.40:1.60 | 6.70 | none | 34.8 | 1.55 | 1.70 | 1.00 | 151.75 | 0.45 | Good workability for this type mortar; harsh | 685 | 90 percent aggregate fractured |
| Z-BS-D | 1:3.40:1.60 | 6,66 | .010 | 34.6 | 2.00 | 2.40 | 1.00 | 151.08 | 0.46 | . do | 630 | Large aggregate pulled out |
| Z-BS-B | 1:3.16:1.45 | 7.12 | none | 33.8 | 2.50 | 2.10 | 2.50 | 151.08 | 0.42 | do | 675 | do |
| Z-BS-B | 1:3.16:1.45 | 7.13 | .015 . | 33.8 | 2.50 | 2.90 | 2.1.25 | 151.08 | 0.42 | Fair workability: harsh | 810 | Very few pull oute; nearly all aggregate fractured. |
| Z-BS-C | 1:2.97:1.33 | 7.54 | none | 35.4 | 1.80 | 1.99 | 2.00 | 151.51 | 0.41 | Good workability: harsh | 790 | 50 percent pull outs |
| Z-BS-Y | 1:2.97:1.33 | 7.46 | .020 | 34.2 | 3.20 | 2.85 | 1.50 | 1749.78 | 0.40 | Fair workability | 780 | 50 percent pull outs |
| Z-BS-1 | 1:3.16:1.45 | 7.08 | .020 | 31.3 | 4.20 | 3.10 | 1.675 | υ, ° . 35 | 0.40 | Fair workability: slightly stiff to place easily | r · | |
| Z-BS-2 | do | 6.99 | .020 | 31.5 | 4.90 | 4.00 | 1.75 | 147.62 | 0.40 | do | | |
| Z-BS-3 | do | 7.03 | .020 | 31.9 | 4.50 | 3.57 | ു.ന | 11.8.1.8 | -0.40 | | | |
| L-BS-A | 1 : 3.40 : 1.60 | 6.38 | .025 | 30.9 | 7.10 | 3.70 d | 1.,0 | U.4.15 | 0.43 | Set too quickly to place well | 505 £ / | Numeroue voids; aggregate fractured |
| L-BS-B | đo | 6.52 | .020` | 35.5 | 3.10 | 2.80 | 1.50 | 148.49 | 0.48 | Thin: large aggregate may have settled out some | 625 9/ | |
| L-BS-C | do | 6.59 | .015 | 36.8 | 1.70 | 2.00 | 8.00 | 150.22 | 0.49 | Placod well | 640 9/ | 40 percent aggregate fractured |
| L-BS-D | 1:3.00:1.38 | 7.18 | .025 | 38.3 | - 2.90 | 2.60 | 1.50 | 147.62 | 0.47 | Fair; set up quickly | 675 € | Slightly honey-combed |
| L-BS-E | 1:2.70:1.20 | 7.89 | .025 | 39.9 | 2.10 | 2.50 | 1.25 | 148.49 | 0.45 | do | 675 ° | Badly honey-combed |
| L-BS-P | 1:3.33:1.57 | 6.70 | .020 | 35.4 | 2.50 | 2.40 | Not suf- ficiently plastic to remain as cone | 149.78 | 0.47 | Very good; placed well | 565 <u>e</u> / | Large aggregate pulled out |
| L-BS-G | 1:2.97:1.36 | 7.26 | .025 | 39.9 | 2.00 | 2.30 | do | 148.48 | 0.49 | do | 595 ₺ | do |
| L-BS-H | 1:2.71:1.20 | 7.78 | .030 | 43.7 | 1.40 | 2.10 | do | 147.62 | 0.50 | Started to set before specimens were complete | 490 5/ | |
| L-BS-I | 1: 2.60: 1.73 | 7.20 | .025 | 39.5 | 2.60 | 3.m | do | U,7.19 | 0.49 | do | 590 ₫/ | 50 percent pull outs |
| L-89-J | 1:2.70:1.20 | 7.67 | .030 | 41.1 | 4.00 | 3.95 | do | 145.02 | 0.48 | Tonwet: segregation of appropriate | 535 e/ | All large aggregate pulled out |
| L-BS-K | 1:2.82:1.25 | 7.28 | .030 | 32.0 | 8.00 | d | 1,,50 | 1.39 . 39 | 0.39 | Pinced well | 610 £ | Most of aggregate broken |
| L-BS-1 | 1:3.01:1.34 | 7.53 | .01.5 | 30.5 | 3.40 | 2.60- | 1.75 | 151.08 | 6.36 | Harah: poor : lacability | | |
| L-BS-2 | do | 7.44 | do | 33.7 | 3.00 | 2.65 | 3.50 | 150.32 | 0.39 | do | | |
| L-BS-3 | do | 7.42 | do | 35.3 | 2.60 | 2.65 | 2.40 | 150.21 | 0.41 | do | | |
| | | | | | | - | | | | | | |

a/ For convenience, the flexural etrength of specimens of the trial batches after 28-day fog-room curing are included.

b/ P = Portland Cement; Z = Portland Pozzolan Cement; L = Lumnite Cement; BS = Bluestone aggregate.

The last letters "A" to "K" inclusive, indicate trial mixes made in a 1-cubic foot mixor.

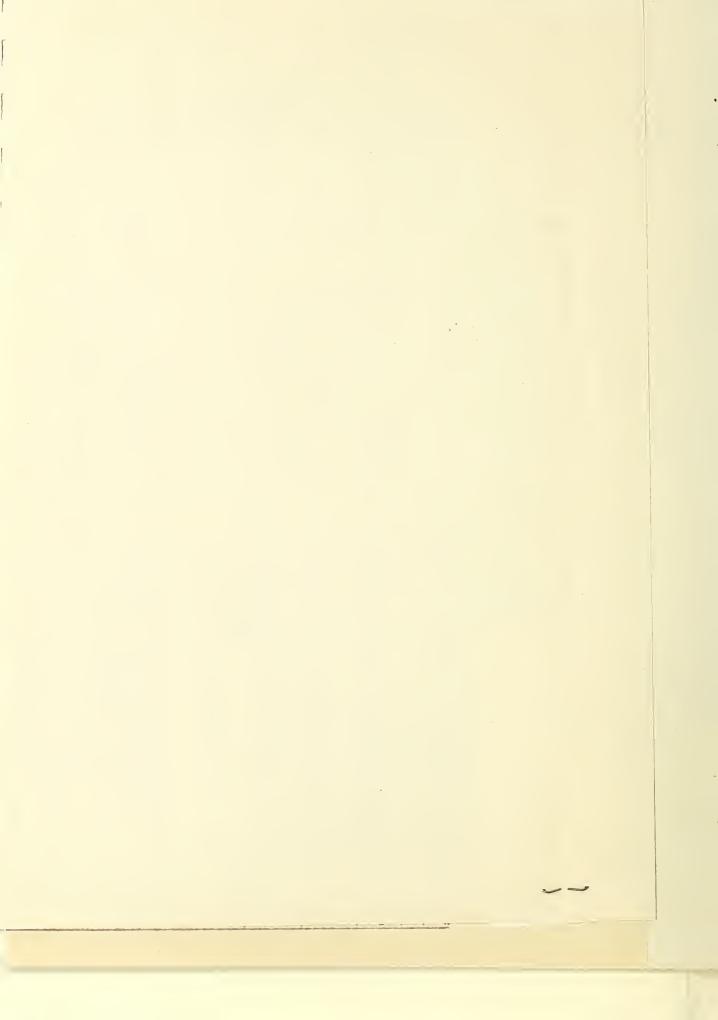
The last numeral 1 to 3 inclusive, indicate final selected mix made in a 5-cubic foot mixer.

Three batches of the selected mix were necessary to fabricate the required number of test specimens.

c/ Above the capacity of air-meter.

d Concrete set in air meter.

e/ Plenural strongth was determined after four days curing in fog-room.



In designing these particular concretes, air content and slump results obtained from trial batches were the criteria. At that time the strengths of trial concretes were not determined due to the smallness of the batch. In attempts to design a concrete of the specified strength the cement content was based both on work in this project and the results of other research projects. As a result of this practice the flexural strength was often lower than anticipated and below that specified. Consequently a procedure has now been established that also includes flexural strength tests of enlarged trial batches after 28-day fog-room curing

Table II gives the results of tests on the 25 trial batches of concretes. Also some results are given for the three concretes selected as having the specified requirements and from which specimens for a complete series of tests were fabricated. These results indicate that from the data on trial batches, concretes of the portland or portland pozzolan type may be designed that will meet the technical requirements.



Although concretes have been designed with the high alumina hydraulic cement that develop 675 psi flexural strength, the air content is low and the placability is not good. Several methods have been used in mixing this type of concrete. The results indicate that charging the mixes in the following order yielded the most workable concrete: (1) fine aggregate and cement, mix thoroughly (2) coarse aggregate and mix again (3) water and air entraining agent and mix for 1 1/2 minutes only. It is possible, however, that the difficulties encountered in designing and especially mixing concrete containing high alumina hydraulic cement, and using a limestone aggregate, may not be encountered with other aggregates.



- ∠1.7. The five conditions of exposure are given in a letter dated June 26, 1953 from U. S. Naval Civil Engineering Research and Evaluation Laboratory, Construction Battalion Center, Port Hueneme, California, signed by Perry H. Petersen, Director Materials Division, Structures Research Department.



THE NATIONAL BUREAU OF STANDARDS

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Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards (\$1.00). Information on calibration services and fees can be found in NBS Circular 483, Testing by the National Bureau of Standards (25 cents). Both are available from the Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.





