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

by W. L. Fendergast, R. A. Clevenger, Edward C. Tuma
The scope of activities of the National Bureau of Standards is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section is engaged in specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside of the back cover of this report.


Ordnance Development. These three divisions are engaged in a broad program of research Electromechanical Ordnance. and development in advanced ordnance. Activities include Ordnance Electronics. basic and applied research, engineering, pilot production, field testing, and evaluation of a wide variety of ordnance material. Special skills and facilities of other NBS divisions also contribute to this program. The activity is sponsored by the Department of Defense.

Missile Development. Missile research and development: engineering, dynamics, intelligence, instrumentation, evaluation. Combustion in jet engines. These activities are sponsored by the Department of Defense.

Office of Basic Instrumentation

Office of Weights and Measures.
QUARTERLY REPORT
ON
EVALUATION OF REFRACTORY QUALITIES OF CONCRETES
FOR JET AIRCRAFT WARM UP, POWER CHECK,
AND MAINTENANCE APRONS

by

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

Sponsored by
U. S. Naval Civil Engineering Research and
Evaluation Laboratory, Construction Battalion Center
Port Hueneme, California

Reference: NT4-59/NY 420 008-1
NBS File No. 9.3/1134-C

Approved:

R. A. Heindl, Chief,
Refractories Section

The publication, reprinting, unless permission is obtai
25. D. C. Such permisso prepared if that agency
Approved for public release by the Director of the National Institute of Standards and Technology (NIST)
on October 9, 2015.
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.
The results of tests given in the 1st were obtained after 26 days log-room curing: the 2nd treatment (1) plus 7 days.

<table>
<thead>
<tr>
<th>Duration (h)</th>
<th>Faded 0.0</th>
<th>Faded 0.1</th>
<th>Faded 0.2</th>
<th>Faded 0.3</th>
<th>Faded 0.4</th>
<th>Faded 0.5</th>
<th>Faded 0.6</th>
<th>Faded 0.7</th>
<th>Faded 0.8</th>
<th>Faded 0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>10.0</td>
<td>11.8</td>
<td>13.0</td>
<td>14.3</td>
<td>15.5</td>
<td>16.7</td>
<td>17.9</td>
<td>19.1</td>
<td>20.2</td>
<td>21.4</td>
</tr>
<tr>
<td>1.0</td>
<td>10.4</td>
<td>12.2</td>
<td>13.4</td>
<td>14.7</td>
<td>15.9</td>
<td>17.1</td>
<td>18.3</td>
<td>19.5</td>
<td>20.7</td>
<td>21.9</td>
</tr>
<tr>
<td>2.0</td>
<td>10.9</td>
<td>12.7</td>
<td>13.9</td>
<td>15.2</td>
<td>16.4</td>
<td>17.6</td>
<td>18.8</td>
<td>20.0</td>
<td>21.2</td>
<td>22.4</td>
</tr>
<tr>
<td>3.0</td>
<td>11.4</td>
<td>13.2</td>
<td>14.4</td>
<td>15.7</td>
<td>16.9</td>
<td>18.1</td>
<td>19.3</td>
<td>20.5</td>
<td>21.7</td>
<td>22.9</td>
</tr>
<tr>
<td>4.0</td>
<td>11.9</td>
<td>13.7</td>
<td>14.9</td>
<td>16.2</td>
<td>17.4</td>
<td>18.6</td>
<td>19.8</td>
<td>21.0</td>
<td>22.2</td>
<td>23.4</td>
</tr>
</tbody>
</table>

(The number x 10)

<table>
<thead>
<tr>
<th>Test</th>
<th>Mortar</th>
<th>Compressive strength</th>
<th>Loss</th>
<th>Stresses</th>
<th>Abrasion</th>
<th>Tearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-7 A</td>
<td>10.0</td>
<td>12.0</td>
<td>14.0</td>
<td>16.0</td>
<td>18.0</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>11.0</td>
<td>13.0</td>
<td>15.0</td>
<td>17.0</td>
<td>19.0</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
<td>12.0</td>
<td>14.0</td>
<td>16.0</td>
<td>18.0</td>
<td>20.0</td>
<td>22.0</td>
</tr>
<tr>
<td></td>
<td>13.0</td>
<td>15.0</td>
<td>17.0</td>
<td>19.0</td>
<td>21.0</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td>14.0</td>
<td>16.0</td>
<td>18.0</td>
<td>20.0</td>
<td>22.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

Note: 1. Materials of concrete in ENF-RENEWED CONDITION.
<table>
<thead>
<tr>
<th>Identification No.</th>
<th>Proportions by Weight: Cement : Aggregate and Water</th>
<th>Cement Content</th>
<th>Visual Sands by Weight of Cement</th>
<th>Water Content</th>
<th>Air Content</th>
<th>Slump</th>
<th>Weight of Fresh Concrete</th>
<th>Water-Cement Ratio</th>
<th>Remarks</th>
<th>Fresh Concrete</th>
<th>Pleural Strength</th>
<th>Remarks</th>
<th>Dural Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-55-1</td>
<td>1 : 3.50 : 1.70</td>
<td>6.66</td>
<td>0.28</td>
<td>38.0</td>
<td>6.20</td>
<td>3.05</td>
<td>163.07</td>
<td>0.55</td>
<td>Over mixed; slightly high in air content and slump.</td>
<td>130.08</td>
<td>Gals</td>
<td>130.08</td>
<td>20 percent pull-out; small aggregate fractured.</td>
</tr>
<tr>
<td>R-55-3</td>
<td>1 : 3.50 : 1.70</td>
<td>6.66</td>
<td>0.28</td>
<td>38.0</td>
<td>6.20</td>
<td>3.05</td>
<td>163.07</td>
<td>0.55</td>
<td>Over mixed; slightly high in air content and slump.</td>
<td>130.08</td>
<td>Gals</td>
<td>130.08</td>
<td>20 percent pull-out; small aggregate fractured.</td>
</tr>
<tr>
<td>L-B3-A</td>
<td>1 : 3.00 : 1.00</td>
<td>6.20</td>
<td>0.25</td>
<td>36.8</td>
<td>6.15</td>
<td>3.00</td>
<td>130.08</td>
<td>0.55</td>
<td>Good workability for this type aggregate; slightly low in air content and slump.</td>
<td>120.08</td>
<td>Concrete</td>
<td>120.08</td>
<td>Large aggregate pull-out; over 60 percent fines.</td>
</tr>
<tr>
<td>L-B3-B</td>
<td>1 : 3.00 : 1.00</td>
<td>6.20</td>
<td>0.25</td>
<td>36.8</td>
<td>6.15</td>
<td>3.00</td>
<td>130.08</td>
<td>0.55</td>
<td>Good workability for this type aggregate; slightly low in air content and slump.</td>
<td>120.08</td>
<td>Concrete</td>
<td>120.08</td>
<td>Large aggregate pull-out; over 60 percent fines.</td>
</tr>
<tr>
<td>L-B3-C</td>
<td>1 : 3.00 : 1.00</td>
<td>6.20</td>
<td>0.25</td>
<td>36.8</td>
<td>6.15</td>
<td>3.00</td>
<td>130.08</td>
<td>0.55</td>
<td>Good workability for this type aggregate; slightly low in air content and slump.</td>
<td>120.08</td>
<td>Concrete</td>
<td>120.08</td>
<td>Large aggregate pull-out; over 60 percent fines.</td>
</tr>
<tr>
<td>L-B3-D</td>
<td>1 : 3.00 : 1.00</td>
<td>6.20</td>
<td>0.25</td>
<td>36.8</td>
<td>6.15</td>
<td>3.00</td>
<td>130.08</td>
<td>0.55</td>
<td>Good workability for this type aggregate; slightly low in air content and slump.</td>
<td>120.08</td>
<td>Concrete</td>
<td>120.08</td>
<td>Large aggregate pull-out; over 60 percent fines.</td>
</tr>
<tr>
<td>L-B3-E</td>
<td>1 : 3.00 : 1.00</td>
<td>6.20</td>
<td>0.25</td>
<td>36.8</td>
<td>6.15</td>
<td>3.00</td>
<td>130.08</td>
<td>0.55</td>
<td>Good workability for this type aggregate; slightly low in air content and slump.</td>
<td>120.08</td>
<td>Concrete</td>
<td>120.08</td>
<td>Large aggregate pull-out; over 60 percent fines.</td>
</tr>
<tr>
<td>L-B3-F</td>
<td>1 : 3.00 : 1.00</td>
<td>6.20</td>
<td>0.25</td>
<td>36.8</td>
<td>6.15</td>
<td>3.00</td>
<td>130.08</td>
<td>0.55</td>
<td>Good workability for this type aggregate; slightly low in air content and slump.</td>
<td>120.08</td>
<td>Concrete</td>
<td>120.08</td>
<td>Large aggregate pull-out; over 60 percent fines.</td>
</tr>
</tbody>
</table>

Notes:
- For convenience, the flexural strength of specimens of the trial batches after 28-day flexural strength was included. If a specimen did not fit the standard size, the flexural strength of the specimen was calculated.
- The last letter 'A' to 'K' inclusive, indicate trial mix made in 1 cubic foot mixer.
- The last numeral 1 to 3 inclusive, indicate trial made in a 1 cubic foot mixer.
- Three batches of the selected mix were necessary to fabricate the required number of test specimens.
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. 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.

2. NBS Report 2632.
THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

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.