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

by
W. L. Pendergast, E. C. Tuma, L. E. Mong

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
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 back 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 ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.
QUARTERLY REPORT
ON
EVALUATION OF REFRACTORY QUALITIES OF CONCRETES FOR JET AIRCRAFT WARM UP, POWER CHECK, MAINTENANCE APRONS, and RUNWAYS

by

W. L. Pendergast, E. C. Tuma, L. E. Mong
Refractories Section
Mineral Products Division

Sponsored by

Department of the Navy
Bureau of Yards and Docks

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

Approved:
Clarence H. Hahner
Assistant Chief
Mineral Products Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
1. INTRODUCTION

This phase of the project includes the determination of the cause or causes of failure that occur in concrete aprons and runways exposed to jet exhaust gases. A combustion chamber that delivers hot gases at velocities and temperatures approximating those of field conditions is being used. The approach includes instrumentation of the concrete test panels to determine the heat gradients and stresses set up during flame impingement at several locations on the test area and at varying depths below the surface.

2. ACTIVITIES

2.1 X-ray Examination of Neat Cements

X-ray examinations of three samples of Alcoa cement, after curing and exposure to a heating cycle of the bomb test, without mercury, drying at 100 and 200°C were made. The compounds, identified were the same as those appearing in N.B.S. Report 5736, Table II which were found in samples similarly treated except that those referred to in the table were exposed to the mercury used to transmit the pressure during the bomb test. The mercury is considered to be without effect on the compounds formed. Portland and Lummite cement after heating under pressure to approximately 300°C and further heating at atmospheric pressure to 800°C are being examined.
2.2 Water in Concrete During Curing and Drying

The drying, at 35% relative humidity and 77°F, of the concrete tile, 3 X 3 inches and 4 inches in depth, described in the N.B.S. Report 5855 has been continued. The correlation of the relative humidity in the mid-cavity with the water loss for the whole tile continues to be a straight line relation. The relative humidity in the cavity nearest the exposed surface of each of the five tiles is now approximately that of the humidity cabinet. The relative humidity of the mid-cavity varies among the five tiles from 46 to 48%. At the bottom cavity, the humidity ranges from 40 to 43%.

The tiles have lost from 5.0 to 5.8% in weight. Assuming this to be water, they have lost one-third of the mixing water during the year since these tests were started.

2.3 Blast Furnace Slag

In response to the request of the National Slag Association, the Bureau agreed to add blast-furnace slag to the list of aggregates included in the project. One ton of this material that was sized according to our instructions has been received. Preliminary examination has been completed on this "cold-pit" blast furnace slag. The following results were obtained.


<table>
<thead>
<tr>
<th>Coarse</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size</td>
<td>% Passing</td>
</tr>
<tr>
<td>1 1/2</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>78</td>
</tr>
<tr>
<td>3/4</td>
<td>48</td>
</tr>
<tr>
<td>1/2</td>
<td>30</td>
</tr>
<tr>
<td>3/8</td>
<td>15</td>
</tr>
<tr>
<td>No. 4</td>
<td>0</td>
</tr>
</tbody>
</table>

The following properties were determined on the fractions given in Table I.

<table>
<thead>
<tr>
<th></th>
<th>Coarse</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity</td>
<td>2.19</td>
<td>2.73</td>
</tr>
<tr>
<td>Absorption (S-SD)</td>
<td>5.60</td>
<td>3.66</td>
</tr>
<tr>
<td>Unit Weight, lbs./ft³</td>
<td>Rodded</td>
<td>73.19</td>
</tr>
<tr>
<td></td>
<td>Jigged</td>
<td>73.13</td>
</tr>
</tbody>
</table>

The loss during the Los Angeles Abrasion Test was 34.48%.

Trial batches of concrete were mixed, specimens fabricated, cured, and the flexural strength determined. These batches were designed using the aforementioned data and information furnished by the Youngstown Laboratories of the National Slag Association. Detailed information on the properties of four fresh concretes, together with flexural strength are shown in Table II.
TABLE II, Properties of Fresh Concrete

<table>
<thead>
<tr>
<th>Laboratory Identification</th>
<th>Combined Fineness Modulus</th>
<th>Proportion of cement to fine to coarse</th>
<th>Cement Content by weight</th>
<th>Vinsol Resin Content</th>
<th>Water Content</th>
<th>W/C Ratio</th>
<th>Air Content</th>
<th>Slump</th>
<th>Remarks on Fresh Concrete</th>
<th>Flexural Strength</th>
<th>Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sacks/yd^3 of concrete</td>
<td>%</td>
<td>Gal/yd^3 of concrete</td>
<td>%</td>
<td>in.</td>
<td>lb/in^2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-BF-1</td>
<td>5.36 1:1.59:1.59</td>
<td>7.91 0.01</td>
<td>5.40 0.48</td>
<td>4.25 2.75</td>
<td>good placeability</td>
<td>620</td>
<td>aggregate fracture pull-outs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-BF-2</td>
<td>5.58 1:1.43:1.75</td>
<td>8.08 do</td>
<td>5.12 0.45</td>
<td>2.45 1.75</td>
<td>do</td>
<td>670</td>
<td>aggregate fracture few pull-outs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-BF-3</td>
<td>5.80 1:1.36:2.04</td>
<td>7.69 do</td>
<td>5.11 0.45</td>
<td>2.57 none</td>
<td>Harsh but placeable; vibrated</td>
<td>765</td>
<td>mostly aggregate fracture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-BF-4</td>
<td>6.03 1:1.27:2.37</td>
<td>7.26 do</td>
<td>5.12 0.45</td>
<td>2.82 do</td>
<td>Very harsch but placeable vibrated</td>
<td>685</td>
<td>aggregate fracture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1/ The first letter P = Portland, type III; the second letter BF = blast furnace aggregate; the numbers denote variation in design.

2/ Gravimetric method. 3/ Since type III Portland cement was used the flexural strength was determined after 7 days fog-room curing.
2.4 Examination of Aggregates

Three rock samples were submitted for examination by your laboratory at Port Hueneme, California. The samples (1) Napa Basalt (2) Juarez Basalt (3) Napa Quarry where submitted to determine which of the three deposits might be best for use as an aggregate in concrete designed to withstand jet exhaust gases. The results of the tests completed follows. For comparative purposes the results determined on a Virginia diabase is included in the Table.

TABLE III, Properties of Rock Samples

<table>
<thead>
<tr>
<th></th>
<th>Napa Basalt</th>
<th>Virginia Diabase</th>
<th>Juarez Basalt</th>
<th>Napa Quarry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity</td>
<td>2.81</td>
<td>2.96</td>
<td>2.65</td>
<td>2.43</td>
</tr>
<tr>
<td>Absorption</td>
<td>0.43</td>
<td>0.6</td>
<td>0.34</td>
<td>3.6</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>15.3</td>
<td>15.3</td>
<td>16.0</td>
<td>31.6</td>
</tr>
<tr>
<td>Results of exposure to jet blast</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
</tr>
</tbody>
</table>

\(^1/\) Due to the size of the samples submitted determination of Bulk Specific Gravity and Absorption were made on coarse fraction only (+ No. 4).

\(^2/\) The sample was 2500 grams instead of the 5000 grams specified in the test.

\(^3/\) Samples were (-1 +3/4 inches) retained in a steel wire basket. They were exposed to a jet blast at 1200 ft/sec at 1200°F for a period of five minutes.
In all three rocks, plagioclase was dispersed in a matrix. The matrix was crystalline feldspar and pyroxene except for Juarez Basalt which had a glassy matrix. Distinctions in mineralogical composition are given in the following results from petrographic examinations.

Sample 1

Napa Basalt. Figure 1, coarser grained than Sample 2, entirely crystalline, irregular fracture with rough surface.

Sample 2

Juarez Basalt. Figure 2, fine grained feldspar and pyroxene in a glassy matrix, no quartz, with irregular fracture, but conchoidal over small areas.

Sample 3

Napa Quarry. Figure 3, weathered porous basalt, irregular in fracture, may contain secondary quartz.
2.5 Miscellaneous

Data, from the work thus far completed in the project, is being tabulated and studied for a publication.
Figure 1. Photomicrograph of Napa Basalt (300x) (Crossed Nicols). Showing zoned Plagioclase in Matrix of Feldspar (F), Olivine or Pyroxene (O) and Magnetite Crystals.
Figure 2. Photomicrograph of Juarez Basalt (300x) (Crossed Nicols). Rock consists of Plagioclase, Feldspar (F) and Pyroxene crystals (P) in a matrix of glass (dark areas). Occasional large zoned Feldspars and large Pyroxene crystals with inclined extinction. No Quartz observed.
Figure 3. Photomicrograph of Napa Quarry (800x) (Crossed Nicols). Showing zoned Plagioclase Feldspar crystals (F) in a matrix of fine feldspar and pyroxene (F & P). Secondary quartz may be present. Rock in hand specimen appears porous and altered.
THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

WASHINGTON, D. C.


- Office of Basic Instrumentation.

- Office of Weights and Measures.

BOULDER, COLORADO


