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NATIONAL BUREAU OF STANDARDS REPORT

8041

Quarterly Report

on

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

BY

J. V. Ryan and E. C. Tuma



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT

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J. V. Ryan and E. C. Tuma
Fire Research Section
Building Research Division

Sponsored by:

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1. Introduction

The purpose of this project is the development of criteria for the fabrication of jet exhaust resistant concretes. Concretes under development are evaluated by exposure to hot gases from a combustion chamber. The combustion chamber delivers these gases at velocities and temperatures approaching field conditions.

2. Present Plan of the Investigation

In an attempt to gain more understanding of the mechanism of spalling and of the factors that determine whether or not a given concrete spalls under jet impingement, specimen sizes were chosen to provide different degrees of restraint to thermal stresses and to the escape of steam from within the concrete. The instrumentation was designed to provide data on pressures and temperatures, including temperature gradients in the 1/2 in. nearest the exposed surface. In addition, electrical resistance elements were embedded in some specimens to provide an indication of their drying. It was decided to keep some specimens in the fog room throughout their conditioning, to condition others in air at 73°F and 50% relative humidity, and to attempt to dry others thoroughly.

3. Activities

The specimens of diabase aggregate concrete (Di-2) cast late in December, 1962 were subjected to jet impingement; companion specimens were tested for shear, flexural, and compressive strengths, and for moisture content.

The specimens of blast furnace slag aggregate concrete cast in the preceeding quarter were conditioned throughout the quarter, and observations were made of changes that occurred in the specimens.

The study of the feasibility of accelerated drying by conditioning in atmospheres at reduced pressures was continued.

3.1 Diabase Aggregate Specimens

The diabase aggregate concrete specimens included cylindrical specimens for jet impingement tests, and various prisms for strength tests, dimensional changes, and moisture content.

The jet impingement specimens were cast in three diameters, (12, 6, 3 in), two thicknesses (6 and 2 in.), and were conditioned according to three schedules. The first schedule consisted of keeping the specimens in a room at 73°F and 100 percent relative humidity, the fog room, until they were tested. The second schedule consisted of keeping specimens in the fog room for 28 days after which they were stored in an atmosphere at temperature of 73°F and relative humidity of 50 percent until tested. The third schedule consisted of keeping specimens in the fog room until they were about the same age as those in the second schedule and then drying them to constant weight at 105°C. The prism specimens for strength tests and moisture content determinations were conditioned according to the same schedules.

The results of the tests are given in Tables 1 and 2. Evaluation of these data, both as to spalled volume and as to peak pressure, showed that reduction of diameter and of thickness each resulted in decreased effect of the jet impingement on the exposed surface of the concrete. Also, the shift from fog room, to 50 percent relative humidity, to oven drying lead to marked reduction in spalling and pressure. None of the specimens oven dried at 105°C showed visible spalling.

3.2 Blast-furnace Aggregate Specimens

The specimens of blast-furnace slag aggregate concrete were conditioned throughout the quarter, following the conditioning schedules described in the preceeding section. The plot of data obtained is similar to that of figure 1 in NBS Report 7878 for the last quarter, indicating that the specimens are nearly ready to be tested.

3.3 Vacuum Drying

The results obtained to date are only for diabase aggregate concretes kept in the fog room a minimum of 28 days to allow development of strength and then conditioned at reduced pressures in an attempt to accelerate the elimination of excess moisture. As reported for the previous quarter, those specimens kept at about 0.5 atmosphere for 28 days after the fog room showed greater moisture content than duplicates kept at 1 atmosphere in 73°F/50 percent relative humidity. The second set of specimens have been kept at pressures near or below the vapor pressure of water (21 mm Hg at 73°F) for much longer time. On the basis of electrical conductivity measurements, no appreciable change was observed during the first 28 days at reduced pressure. This is despite the fact that several fluid ounces of water were removed from a trap in the vacuum system daily. Comparison with conductivity data from Di-2 specimens conditioned at 73°F/50 rh indicated the latter were drying faster for about 70 days. However, beyond that time, the specimens in reduced pressure have been at much lower (factor of 4) conductivities than attained by specimens at 73°F/50 rh in comparable times. They have not attained conductivities as low (by a factor of about 100) as attained by oven drying.

Table 1. Data Summary for Di-2 Concrete Specimens

The data are presented to show first the effect of diameter and then that of thickness

Specimen Size	Oven Dried				73°F/50% RH				Fog Room			
	Spall Volume		Peak Pressure		Spall Volume		Peak Pressure		Spall Volume		Peak Pressure	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
	cc	cc	psi	psi	cc	cc	psi	psi	cc	cc	psi	psi
<u>Arranged by diameter</u>												
12 x 6	0	0	70	95	130	190	260	440	250	270	180	200
6 x 6	-	-	-	-	70	100	70	100	-	-	-	-
3 x 6	-	-	-	-	<10	<10	25	35	-	-	-	-
12 x 2	0	0	200	350	a/	90	220a/	350	110	140	260	360
3 x 2	0	0	0	0	0	0	55b/	55	<10	<10	70	100
<u>Arranged by thickness</u>												
12 x 6	0	0	70	95	130	190	260	440	250	270	180	200
12 x 2	0	0	200	350	a/	90	220a/	350	110	140	260	360
3 x 6	-	-	-	-	<10	<10	25	35	-	-	-	-
3 x 2	0	0	0	0	0	0	55b/	55	<10	<10	70	100

a/ Only 1 of 3 spalled; avg. pressure for 2 that did not spall.

b/ Only 2 of 3 showed pressure, average for those 2.

Table 2. Supplementary Data on Di-2

	<u>Oven Dried</u>			<u>73/50</u>			<u>Fog Room</u>	
	<u>Avg</u>	<u>Max</u>		<u>Avg</u>	<u>Max</u>		<u>Avg</u>	<u>Max</u>
Modulus of Rupture, Psi	795	890		795	895		830	920
Shear Strength, Psi	4380	4560		3680	3850		3670	4150
Compressive Strength, Psi	12700	13400		10500	11400		10900	11600
Moisture Content, %	-	-		3.03	3.27		5.33	5.73





THE NATIONAL BUREAU OF STANDARDS

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WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage. Absolute Electrical Measurements.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Volume.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING LABORATORY

Cryogenic Processes. Cryogenic Properties of Solids. Cryogenic Technical Services. Properties of Cryogenic Fluids.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Troposphere and Space Telecommunications. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Spectrum Utilization Research. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Standards Physics. Frequency and Time Disseminations. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Microwave Physics.

Radio Standards Engineering. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

Joint Institute for Laboratory Astrophysics-NBS Group (Univ. of Colo.).

