NATIONAL BUREAU OF STANDARDS REPORT

7780

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

by
J. V. Ryan, E. C. Tuma and D. K. Ward

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

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The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (Includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

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NBS PROJECT | **NBS REPORT**

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Fire Research Section
Building Research Division

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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. Activities

One specimen was subjected to the simulated jet test; it and one other were subjected to jet impingement. Both specimens spalled. The temperature data from the instrumented specimen were similar to those shown in NBS Report 7744, but much higher pressures were observed than had been observed in earlier tests. This was believed to result from an improvement in the measuring technique.

Beams cut from specimens sent from Memphis NAS were tested in flexure, and compression tests were made on ends from the broken beams.

Most of the effort during the quarter was devoted to the preparation of specimens for future work. A total of 82 specimens were cast during the quarter.

2.1 Temperature Gradients

One cylindrical specimen was subjected to the simulated jet test. This specimen was identical to that shown in Figure 1 of NBS Report 7744. It was of Di-1 concrete and had been dried 84 days in an atmosphere at 70°F and 50 percent relative humidity. The temperature data were similar to those shown in Figure 2 of NBS Report 7744.

2.2 Pressure Measurements

Pressure measurements were made during the test mentioned in 2.1. The technique for obtaining these measurements had been modified, and apparently improved. A pulse of pressure over 750 psi, and sustained pressure of about 400 psi were observed. These are much higher than those observed in earlier tests, even though this specimen had been dried for a longer period.

2.3 Spalling Behavior

The specimen spalled, both when exposed to the simulated jet, and when exposed on the back surface to the jet impingement. The amounts of concrete displaced, as determined by sand volume, are given in Table 1. The data for earlier specimens of the same group, as given in NBS Report 7744, are repeated to facilitate comparisons.

The spalling behavior of the six specimens (Di-1 and BF-1) showed that the simulated jet test was more severe than the jet impingement. Therefore, future work will not include the use of the simulated test.

2.4 Strength Measurements

Strengths in flexure, shear, and compression on specimens of Di-1 concrete, the same batch from which the specimen tested above was cast, were completed in the preceding quarter, and were described in NBS Report 7744. However, the data are repeated in Table 1, for completeness of the latter.

2.5 Non-NBS Specimen

The last of three 18- by 18- by 6-in. specimens received from a contractor pouring concrete at the U. S. Naval Air Station, Memphis, Tennessee, was subjected to jet impingement, and spalled. The spalled volume and other data are given in Table 1, along with those for the first two specimens, which had been tested during the preceding quarter. The three specimens were each sawed into three beams approximately 6- by 6- by 18-in. These beams were broken in flexure, and the beam ends broken in compression.

The moduli of rupture, determined in flexure, ranged from 80 psi to 350 psi. Those of the three beams that included the jet damaged centers of the original specimens averaged 290 psi, whereas those of the other six beams averaged 180 psi.

Examination of the broken concrete after the flexure and compression tests substantiated estimates made after the jet impingement tests: that the coarse aggregate of the concrete contained approximately equal volumes of slag, glass, and gravel.

2.6 New Specimens Prepared

A total of 82 specimens were cast of diabase aggregate concrete. These include specimens for jet impingement, flexure, shear, and compressive strength tests, and permeability measurements. The jet impingement specimens were instrumented for temperature and pressure measurements, and some of them included probes to permit measurement of electrical resistance as an indication of the state-of-dryness at various depths during conditioning. A form with the described instrumentation is shown in Figure 1.

Table 1. Test Results

Concrete	Conditioning		Specimen	Spalling Loss by Sand Volume		Strength			Weight Change		
	Fog Room	73°F/50%rh	Size	Simul.	Jet	Shear	Rupture[a]	Comp.	Fog Room	73°F/50%rh	Net
	days	days	in.	cc	cc	psi	psi	psi	%	%	
BF-1	14	14	6 x 13 1/2	145	213	-	-	-	+0.28	-0.40	-0.12
	14	28	6 x 13 1/2	108	104	-	-	-	+0.40	-0.55	-0.15
	14	42	6 x 13 1/2	348	60	-	-	-	+0.28	-0.42	-0.14
	14	15	3 x 4 x 16	-	-	2440	-	6870[b]	+0.11	-1.91	-1.80
	14	15	3 x 4 x 16	-	-	-	-	7480[b]	+0.15	-1.77	-1.62
	14	18	3 x 4 x 16	-	-	-	570	8150[b]	+0.17	-2.05	-1.88
Di-1	28	28	6 x 13 1/2	350	73	-	-	-	+0.55	-0.25	+0.30
	28	56	6 x 13 1/2	220	32	-	-	-	+0.55	-0.85	-0.30
	28	84	6 x 13 1/2	210	30	-	-	-	+0.54	-0.54	-0.00
	28	36	3 x 4 x 16	-	-	2360		10070[b]	+0.70	-1.25	-0.55
	28	39	3 x 4 x 16	-	-	-	1010	7870[b]	+0.70	-1.20	-0.50
N.A.S.	28	21	6 x 18 x 18	-	136	-	240[c]	3810[c]	+1.43	-0.33	+1.10
Memphis	28	35	6 x 18 x 18	-	82	-	260[c]	4680[c]	+0.26	-0.45	-0.19
Tenn.	28	49	6 x 18 x 18	-	135	-	150[c]	3580[c]	+0.78	-0.59	+0.19

a/ Modulus of Rupture, $R = P\ell/bh^2$, determined from test in flexure.

b/ Average of 2 beam ends.

c/ Average of 3 beams or ends.

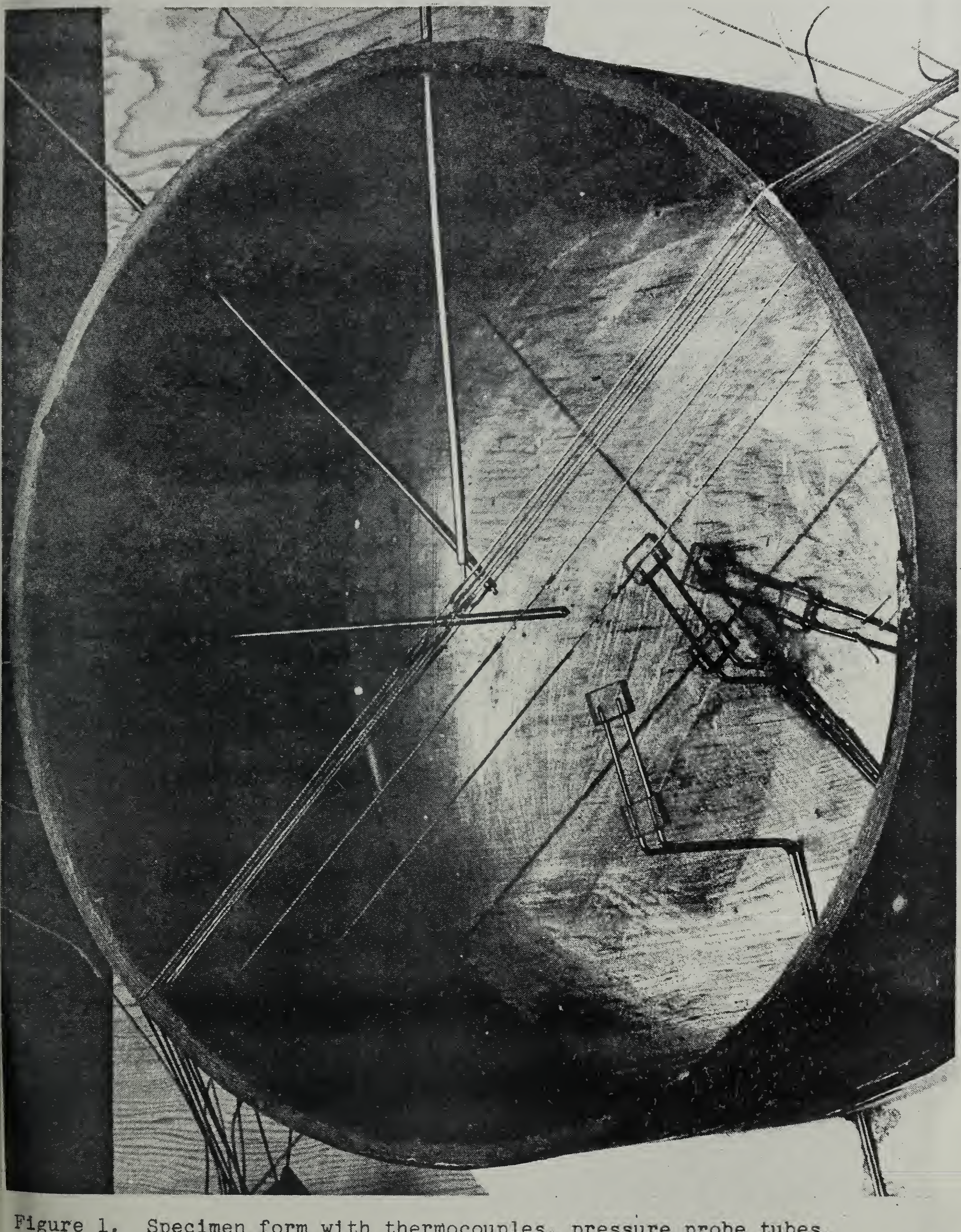

Figure 1. Specimen form with thermocouples, pressure probe tubes, and electrical resistance elements.

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THE NATIONAL BUREAU OF STANDARDS

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WASHINGTON, D. C.

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

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

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. Microscopy and Diffraction. 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 Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

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.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. 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 Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

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

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