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Development and Mechanical Properties of Construction

Materials From Lunar Simulants

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Abstract

The development of construction materials such as "concrete" from lunar soils without the use of water requires a different methodology than that used for conventional terrestrial concrete. At this time, this research project involves two aspects: (1) liquefaction of lunar simulants with various additives in a furnace so as to produce a construction material like an intermediate ceramic, and (2) cyclic loading of simulant with different initial vacuums and densities in a specially designed new device leading to a compacted material with different final densities with respect to the theoretical maximum densities (TMD). In both cases, bending, triaxial compression, extension, and hydrostatic tests will be performed to define the stress-strain-strength response of the resulting materials. In the case of the intermediate ceramic, bending and available multiaxial test devices will be used, while for the compacted case, tests will be performed directly in the new device. The tests will be performed by simulating in situ confining conditions. A preliminary review of high-purity metal is also conducted.

Introduction

Significant progress has been made in the area of space exploration in the past three decades. However, little has been done for development of construction materials for long-term shelters, work stations, pavements, excavation, and shielding materials for man on the Moon and other planets. For large-scale productivity on other planets, buildings and other structures are indispensable. Because of payload limitations on spacecrafts and the high cost of transportation, a prudent and efficient approach to construction on other planets requires that every effort be made to utilize the materials available on the planets themselves. The technique that is being developed in the Department of Civil Engineering and Engineering Mechanics is intended to utilize extraterrestrial "soils" to develop construction materials for building safe and serviceable structures and other systems.

The Lunar Soil Simulant

The simulant used in this study was crushed basalt rock from the Pomona Flow near Hanford, Washington. The chemical composition of the simulant and that of some

returned lunar soils are quite similar. Although the composition of the simulant did not exactly match that of lunar soil, the differences were not deemed significant enough to affect this investigation.

Every attempt was made to accurately simulate the grain size distribution of returned lunar soil. The crushed basalt rock was shaken through a stack of U.S. Standard sieves to separate the constituents by size. By re-combining the different-sized particles in the correct proportions, a satisfactory lunar soil simulant has been produced.

#### Progress to Date

The new test device for compression testing is ready. Two photographs showing the device are given in Figure 2.13.

The new furnace has been acquired. Preliminary molds made of tungsten are prepared for bending tests.

A draft report on high-quality purity metal is almost ready.

#### Planned Research

A series of laboratory tests will be performed in the new compression testing device with different initial vacuums and densities. Then, stress-strain behavior of each specimen will be obtained with different confining pressures.

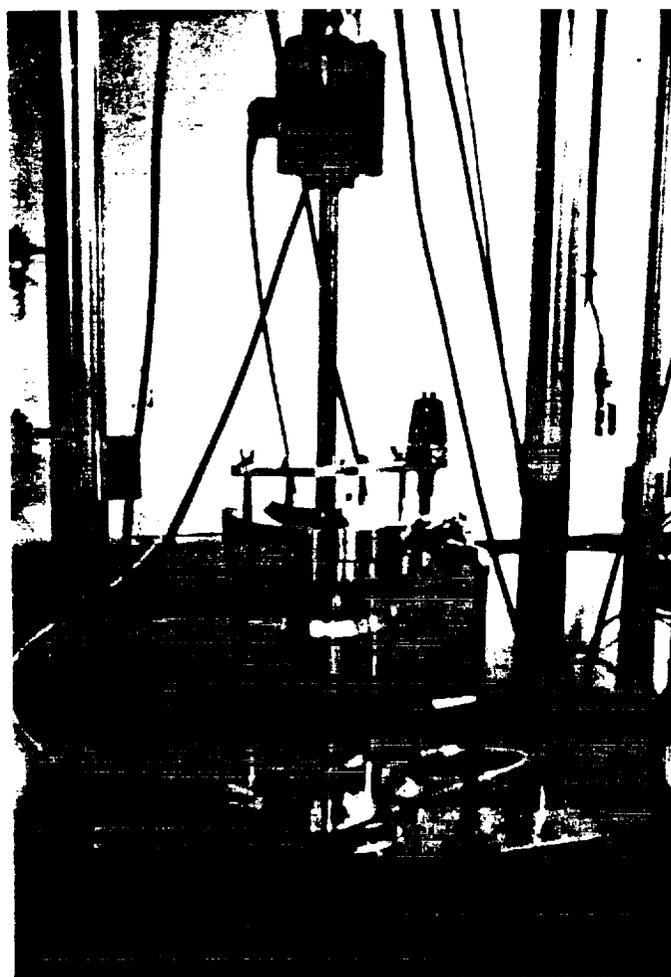
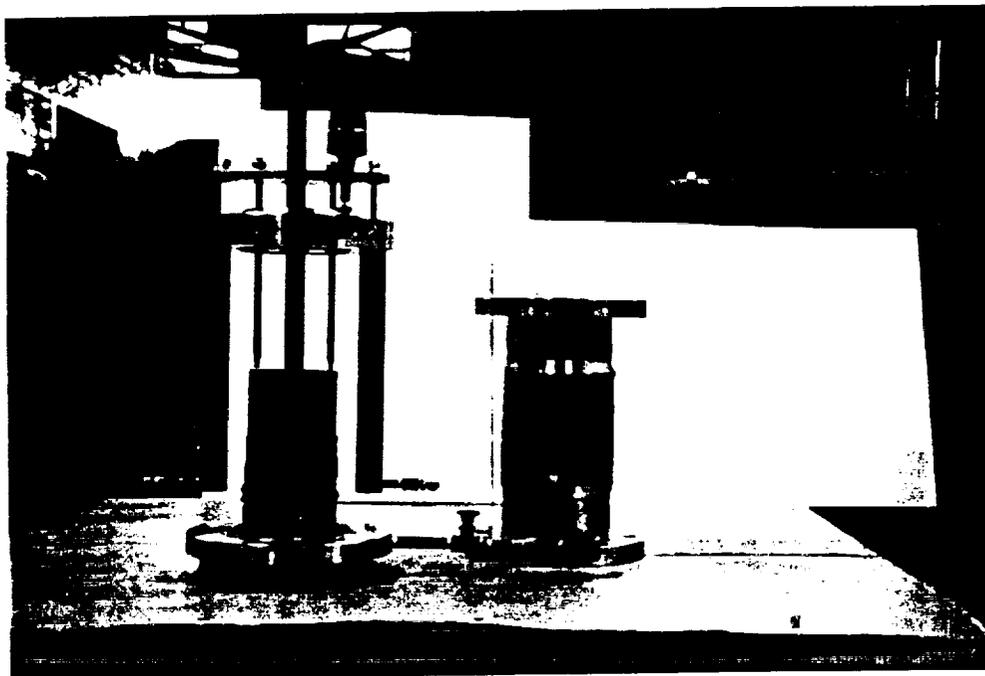
The furnace will be used to obtain a number of specimens for bending and multiaxial tests.

The literature review of high-purity metals will be finalized.

#### Approach and Test Procedure

The locally developed lunar simulant with additives will be placed in molds of different sizes for bending and multiaxial tests and will be liquefied in a furnace with Argonne environment around a temperature of about 1100°C. A number of combinations of simulant and additives will be tried, and the resulting specimens will be tested for their stress-strain-strength properties.

For the cyclic loading in the new test device (Figure 2.13), specimens (under different initial vacuums and densities) of about 3" diameter and 6" height will be subjected to cycles of loading until an equilibrium compaction is achieved. The resulting density will be compared with the TMD. Then, a specially designed sleeve will be extracted and the specimen will receive a rubber membrane around it. A confining pressure will be applied, and the specimen will be subjected to increasing shear stress until failure.



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Figure 2.13 New device for cyclic compression testing with initial vacuums, densities, and confining pressures.

Expected Results

In both cases, the test results will lead to stress-strain-strength response including pre-failure, failure, and ultimate response. These results will be used to evaluate deformation parameters such as modulus of elasticity, Poisson's ratio, cohesive and frictional constants, and other plasticity constants. These constitutive constants will permit evaluation of the applicability and use of the resulting materials for construction such as shielding, structures, pavements, and excavation systems.

Participants

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