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HUMAN EXPLORATION OF THE SOLAR SYSTEM SYMPOSIUM (A5)
Human Lunar Exploration (1)

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ADVANCED DESIGN AND CONSTRUCTION OF LUNAR SURFACE STRUCTURES

Abstract

The next step for manned exploration and settlement is a return to the Moon. Such a return requires the construction of structures for habitation as well as for manufacturing, farming, maintenance and science. The Moon's extreme environment offers great challenges to the design engineers and, until now, the astronaut construction teams that must erect the structures. Therefore the question is: What is the best way to erect habitable structures on the lunar surface?

Given the cost associated with bringing material to the Moon, In-Situ Resource Utilization (ISRU) is viewed by most as the basis for a successful manned exploration and settlement of the Solar system and it has been a core component of the National Aeronautics and Space Administration (NASA). Along with these lines, we propose an advanced concept where the use of freeform fabrication technologies by autonomous mini-robots can form the basis for habitable lunar structures.

An igloo-shaped metallic structure that is covered by sandbags of regolith shielding is considered as a potential design of a lunar base, as well as the test bed for the proposed vision. Magnesium is selected as the structural material. While it is one of the most pervasive metal in lunar soil and has many characteristics that make it applicable to in-situ refining and production, magnesium has been only suggested, albeit briefly, as a viable option in the past. Therefore, two studies are carried out: first a static analysis to examine the feasibility of using magnesium as the structural material and utilizing freeform fabrication technologies for the construction method; and second a thermal analysis to study the effect of the regolith shielding as well as the sensitivity of such designs to measurement uncertainties of regolith thermal properties. A CAD (Computer-Aided Design) model of the proposed structure is drawn and finite element analysis is carried out using SolidWorks and ANSYS Workbench software, respectively.

The static analysis proved the feasibility of the proposed material and method. Also, the thermal analysis revealed that the uncertainties are in an acceptable range for the design of the thermal control system for a lunar base. Currently, in a parallel study, we have been considering lunar seismic effects on the proposed lunar base. A seismic model based on best available data has been developed and is to be applied to our typical structure to assess the vulnerability of designs that ignore seismicity.