32nd IAA SYMPOSIUM ON SPACE AND SOCIETY (E5)
Space Architecture: Habitats, Habitability, and Bases (1)

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PROJECT OLYMPUS: ISRU MATERIAL CONSTRUCTIBILITY AS A FRAMEWORK FOR HABITAT STRUCTURAL DESIGN

Abstract

In Project Olympus, ICON and SEArch+ develop design schematics for critical surface infrastructure necessary for the construction of a lunar base. In 2020 ICON initiated a multi-year effort collaborating with NASA Marshall's Moon-to-Mars Planetary Autonomous Construction Technologies (MMPACT) initiative, and as part of Project Olympus, ICON's technology development roadmap is positioned to deploy additive manufacturing technologies on the lunar surface within the next decade. In 2020, SEArch+ introduced the "Lunar Lantern" as a proposed habitat concept to be autonomously manufactured by the Olympus construction system. To ensure the cost-effectiveness and scalability of additive manufacturing as a construction method for the habitat, the team opted towards a fully indigenous, one-hundred percent in-situ resource utilization (ISRU) regolith material mix. To validate and inform structural design and analysis, a literature survey of experimental methods for heat-based regolith processing was conducted. The study generated several "lunar ashby charts" to comprehensively plot a range of material properties values directly affecting structural performance of the habitat. These properties included: material density, young's modulus, compressive and tensile strength, and fracture toughness. Other properties considered in structural design included the coefficient of thermal expansion, R-value, as well as porosity. Following a schematic design process to derive the architectural form of the "Lunar Lantern," several structural load cases were analyzed including the lunar environment's harsh temperature differentials as well as internal pressurization of the structure. The analysis encouraged the team to consider additional structural technologies mitigating structural vulnerabilities, and validated the necessity of a double-shell or protective whipple shield for the design. Overall, the project demonstrates a design methodology that leverages a fundamental understanding of material science in order to derive a targeted regolith material mix and inform structural performance. Eventually, planetary mineralogy and availability of materials for ISRU processing will further refine the material composition of structures as habitat design and construction work progress. In future work, as we consider more exotic composite material layups for autonomously constructed habitat shells and structural designs, materials-based design frameworks will play a necessary role in developing advanced structural capabilities. Next steps may include to map the ashby charts according to regional mineralogy in close proximity to anticipated landing sites in the lunar south pole.