Lunar Habitat Construction Using Lunar Regolith

**Supervision team:** Dr James Bowen, Dr Andrew Morse

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![Concept image of a settlement on the Moon.](image)

**Project highlights:**
- Construction of habitats and power-plant infrastructure on the Moon;
- High-temperature processing of lunar regolith;
- Characterisation of physical and chemical properties.

**Project description:**
Over the last decade, Space Architecture – the theory and practice of designing and building an environment for humans in outer space – has become an emerging issue in the context of future space exploration. Habitat construction in resource-poor environments is viewed as a fundamental challenge for enabling long-term space settlement and exploration on other planetary bodies. The challenges associated with construction processes in extra-terrestrial environments must be investigated and overcome here on Earth to mitigate the risks involved. Developing processes suitable for manufacturing airtight structural elements will undoubtedly include the use of high temperatures, typically over 1200 °C, at which the lunar regolith melts and can be processed as a viscous liquid.

Construction processes and materials for Space Architecture, particularly on the Moon, are likely to use the resources already existing there, i.e. the native lunar regolith. Many different local regolith compositions exist, consisting of minerals including olivine, pyroxene, plagioclase, and ilmenite, each of which exhibit a spectrum of compositions and physical properties. Reliable technologies such as nuclear power, offering high energy densities capable of supporting long-duration Moon missions, will be enabled by *in situ* construction of power plant infrastructure. The energy cost and capital cost of transporting all the resources required to build a nuclear reactor are prohibitive. Developing processes in which material microstructure can be precisely controlled is crucial for manufacturing safety-critical buildings.
This project will investigate the structure and composition of lunar regolith simulants during their melting and solidification. The rate of cooling will influence the shape and size of any crystallised phases which form during solidification. This information, when transposed to manufacturing processes such as casting, can be used to generate specific microstructures within manufactured components. The macro-scale physical properties of materials created from solidified regolith simulants will be investigated, which will assist in the design of processes for *in situ* construction in hostile environments. The OU STEM Faculty have recently commissioned a high-speed, high-temperature X-Ray Diffraction facility, which this project will use extensively. Analytical techniques including nanoindentation, Raman microscopy, and electron microprobe analysis will also be used extensively. Simulation of macro-scale physical properties of the molten and solidified regolith will be conducted using COMSOL Multiphysics software.

This research will play an essential role with regard to the durability and structural integrity of new human habitats to be executed over the lunar surface environment, to constitute a future development of improved methodologies and guidelines for lunar surface construction processes. The data will inform a theoretical exploration of the architectural structures which are achievable using these materials on the lunar surface. Particular emphasis will be given to load transmission from an above-surface structure to the structure’s foundation with an optimal architectural design.

References:

The project team consists of Dr James Bowen, Dr Andrew Morse, and Dr Sungwoo Lim (Surrey Space Centre). The following list includes some of the critical literature associated with this project.


