

# TECHNOLOGY ASSESSMENT OF LUNAR RADIATION SHIELD CONSTRUCTION METHODS

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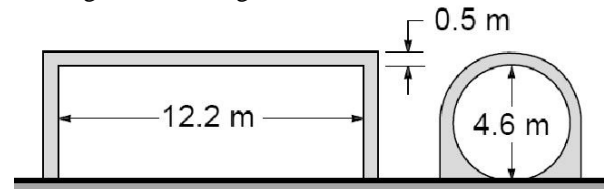
**Introduction:** This study is a technology assessment of the prevailing lunar construction techniques and includes cast basalt as a possible alternative. The purpose of the study is to explore the construction options for a lunar habitat's radiation and meteorite shield and seeks to assess these options on the basis of launch mass, power requirements, energy needs, and construction time. The study also aims to provide a view on the three best performing construction techniques via failure mode effects analysis (FMEA), in accordance with British Standard EN 60812:2006, to narrow the design options further. The best performing construction techniques are progressed to a second stage where FMEA is undertaken, and an evaluation of the prospective techniques and materials is delivered. Sensitivity analysis is then used to validate the FMEA work. Data has been collected via literature search and calculated from known geotechnical, thermodynamic and mechanical data, and assessed against viability criteria.

Extra-terrestrial construction is extremely challenging due to varying gravity, chemical, atmospheric and human conditions. The Moon, for example, effectively has no atmosphere, gravity that is around one sixth of Earth's, and very little of the chemical diversity of a terrestrial environment. This provides a series of challenging constraints for extra-terrestrial construction techniques, i.e., the use of materials to build human-scale structures on another planetary body or in space.

The research problem considered in this study is the construction of a lunar habitat's radiation and meteorite shield. One of the primary concerns with such a lunar habitat is the cost of taking mass up to the Moon via chemical rockets. This mass is referred to here as up-mass. Reducing upmass is a priority in the study of extra-terrestrial construction techniques, which has led to the drive for techniques based on in-situ resource utilization (ISRU); using local materials to build structures on planetary bodies [1]–[4]. The Moon is broadly uniform in terms of accessible materials, and the regolith that covers the surface is mostly similar across its surface [5], limiting the types of materials that can realistically be developed. The primary constraint regarding the radiation shield is the thickness required to effectively shield inhabitants from the radiation environment. This is thought to be somewhere between 99–400g/cm<sup>2</sup> [6], [7], which for a large habitat means a very large volume of material. This has major energy and time (and thus, power) implications.

In order to assess the thermal and chemical indigenous material processing techniques via hard systems

analysis tools, such as FMEA, a habitat scenario is necessary to standardize the results. The habitat scenario is an evolution of the one used in Montes, 2015, [6], with an additional 1m crawl space for maintenance. The original dimensions are shown in Figure 1. The additional crawlspace makes the new dimensions 14.2m long, and 5.6m high.



**Figure 1: Habitat scenario used in Montes, 2015 [6]**

The materials to be tested against this scenario are cast regolith, hot isostatically pressed regolith, geopolymers, and the ESA concept D-shape [8]. The materials will be assessed on their energy requirements, average power requirements, upmass, and construction time. The aim of the paper is to provide a novel, high level overview of extraterrestrial construction methods for mission planners, and provide a view on power systems for such missions.

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