Pre-Manufactured Cementitious Lunar Landing Pad Alternative

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- Introduction

Proposed lunar infrastructure is largely based on planned lunar ISRU production. Prior to large-scale production of regolith and resource extraction, within the scale of 100-1000 megatons annually[1], several equipment supply missions will land on the lunar surface to deliver the autonomous machinery. Leading designs by several groups, both private and government, have produced landing pad designs based on 3D printed regolith. These pads will be cementitious in nature and will be produced by mixing the regolith with an admixture compound[2]. Since these pads will require extensive autonomous machinery to be constructed, an alternative pad design was considered using pre-manufactured materials.

- Research Goal

Serving the function to provide a controlled landing surface for equipment missions prior to production of ISRU materials, a pre-manufactured landing pad design will incorporate characteristics relating to dust control and reusability. Dust control is essential to equipment longevity, astronaut health, and catastrophic failure mitigation. Artemis missions will require landing areas and roadways that exhibit dust control characteristics. As materials transportation to the lunar surface is a premium, and the lunar environment exhibits extreme temperatures, a robust and efficient material is needed for lunar dust control.

- Research & Planned Testing

Concrete cloth, a rolled cementitious material primarily used for water and fire protection, will be tested for strength in both original unhydrolyzed condition, as well as treated with dry-mix soil stabilizer. The material is commercially available in 5mm, 8mm, and 13mm thick sheets, with 8mm being the most suitable size for planned testing. Testing methods performed will follow ASTM D6685[4] "Standard Guide for the Selection of Test Methods for Fabric Formed Concrete". Standards used will be D4354 "Practice for Sampling of Geosynthetics and RECPs for Testing", D4533 "Test Method for Trapezoidal Tearing Strength of Geotextiles", D4595 "Test method for Tensile Properties of Geotextiles by Wide-Width Strip Method", and D5321 "Test Method for Determining the Shear Strength of Soi-Geosynthetic Interfaces by Direct Shear".

- Parameters

Nasa has preliminary parameters mentioned by Dr. Corky Clinton, of Marshall Space Flight Center[3] for lunar landing pad dimensions. The pad is to be 25 feet in diameter, possibly surrounded by a 25 feet diameter apron, with vertical blast shield walls. The purpose of these parameters is to guide research (DM-2) into 3D printed landing pads and evaluate capabilities of robotic ISRU construction. These parameters will be considered in the design of the alternative design proposed by this research so that the two methods of construction may be compared. Figure 1 shows a proposed landing pad parameters mentioned by Dr. Clinton[3].

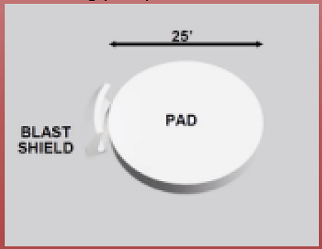

Figure 1: Lunar landing pad parameters including pad and blast shield, with no dust control apron.

- Application to Lunar Missions

As proposed and proven by Lee in 2012[5], cementitious materials can be a viable option for lunar landing pads. Whereas Lee proved the pads met strength requirements to supports landing modules, his work did not provide dust control measures, nor did it consider pre-fabricated techniques. The test performed by Lee used a regolith simulant hydrolyzed with water. This method is impractical for Lunar operations as it requires transporting either a hardened pad to the surface or transporting hundreds of pound of water to the Lunar surface and creating and using an on-site mixing process. As cementitious materials can be viable to Lunar operations, a method of utilizing a flexible, pre-fabricated approach should be considered. The use of soil stabilizer instead of water for hydrolyzation is so that the pad may remain flexible, while providing dust control characteristics. This combination would be best served as a landing pad and temporary roadway for Lunar craft. Figure 2 shows a rendering of what a concrete cloth pad and roadway may look like when used by landing vehicles and transportation vehicles.

- Potential Use With ISRU

If proven successful in strength testing, concrete cloth and dry-mix soil stabilizer have potential to meet the need of temporary landing areas and roadways for missions to Shackleton Crater. When 3D-Printed ISRU production is at the level of producing a pad, the pre-fabricated pad may be considered as an underlayment layer and be included directly beneath the printed pad. The concrete cloth layer may provide a stable, generally flat, surface that would be better suited as a printing surface than bare or scraped regolith alone. The layer could also provide protection for ISRU infrastructure against moon quakes.

Figure 2: Rendering of cementitious Lunar landing pad with temporary roadway. *Credit: Theo Wagner, Texas A&M University*

References: [1] Sanders J. (2022) LSIC, Regolith to Rebar Workshop. [2] Mueller R. (2016) ASCE Earth and Space, conference proceedings, pp 354-377. [3] Clinton C. (2022) LSIC, Excavation and Construction January subgroup meeting. [4] ASTM Compass. (2015) ASTM International, ASTM D6685-01. [5] Lee J. et al. (2012) ASCE Earth and Space, NASA/ASCE workshop on granular materials in space exploration, pp 128-134.