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 of 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.

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 this research so that the two methods of construction may be compared. Figure 1 shows a proposed landing pad by Dr. Clinton[3].

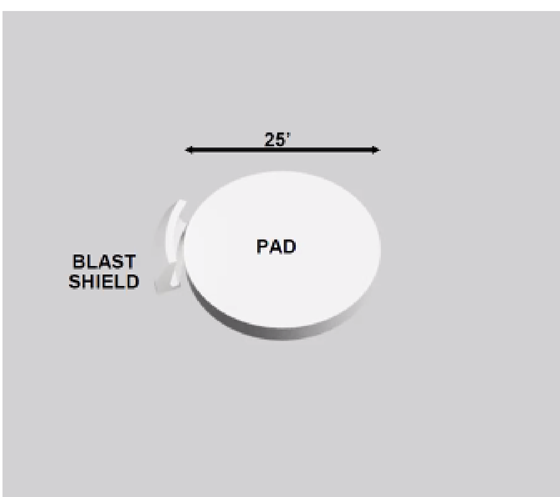

Figure 1: Lunar laning pad parameters including pad and blast shield, with no dust control apron.

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.

Material 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 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 eotextiles by Wide-Width Strip Method", and D5321 "Test Method for Determining the Shear Strength of Soi-Geosynthetic Interfaces by Direct Shear".

Results: 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. 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.

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.