Brick by Brick: Study of Modular Block Construction for Lunar Habitats. N. Caluk[1] and A. Azizinamini[2], [1]Florida International University, Department of Civil and Environmental Engineering, Miami, FL, 33174, ncalu001@fiu.edu, ORCiD: 0000-0002-7134-0593; [2]Florida International University, Department of Civil and Environmental Engineering, Miami, FL, 33174, aazizina@fiu.edu

Introduction: With the ongoing NASA Artemis program, the successful launch of the Artemis I, sending the Orion capsule to the Moon and back, and the exponential growth of commercial rocket companies, we are on the path towards setting foot on the lunar surface once again, with an intention to stay. One of the goals stated in the NASA Artemis Overview Plans [1] is to keep the astronauts on the lunar surface for up to two months, which leads to the requirement of having a pressurized habitat. The habitation modules will be required to provide acceptable safety from the lunar environment, together with psychological and physiological support for its residents in order to accommodate NASA mission objectives. Therefore, allowable structural integrity, predictable failure modes, inspection, and maintenance will all need to fall in line with the current launch system technology. Proposing a complex initial system for habitat with environmental conditions that are not well understood might lead to insufficient structural requirements, unreasonable costs, and misjudging of the time needed for construction. Based on the previously published, in-depth trade study by the same authors of this paper [2], it was concluded that the use of ISRU-based modular blocks for the construction of the lunar infrastructure shows the greatest potential. Designed as hollow bricks, optimized in a way that requires the least amount of construction material, accounting for redundancy and minimal space transportation, while being compatible with 3D printing techniques, the proposed modular blocks (Figure **1**) are intended to minimize on-site human construction and large robotic machinery for their manufacturing and assembly (Figure 2). This paper presents one potential design of a lunar habitat constructed using modular blocks, accounting for a practical assembly. Additionally, finite element analyses were conducted (Figure **3**), focusing on internal pressurization, gravity loads, meteorite impacts, temperature, and seismic loads. To provide for the material input for the FEA, lunar modular blocks are assumed to be made from lunar regolith and a low percentage of thermoset binder material, going in line with the existing technology. However, with the advanced development of microwave/laser/solar sintering techniques, the modular blocks could be fully built from the in-situ lunar regolith.

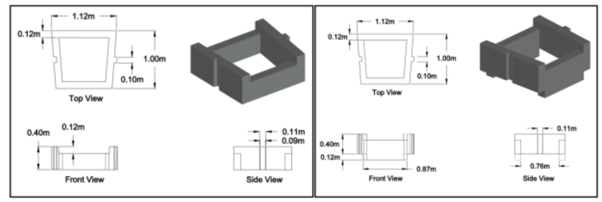

Figure 1. The initial design of the 1st layer of blocks (left) and upper layer blocks (right), optimized for weight and rover transport

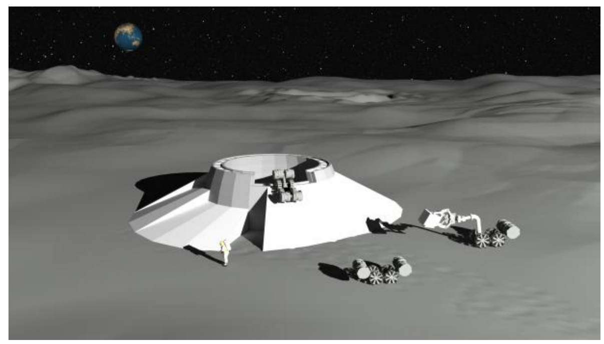

Figure 2. Utilization of the existing rover technology [3] for assembly and lunar regolith infill process of the modular blocks for lunar infrastructure

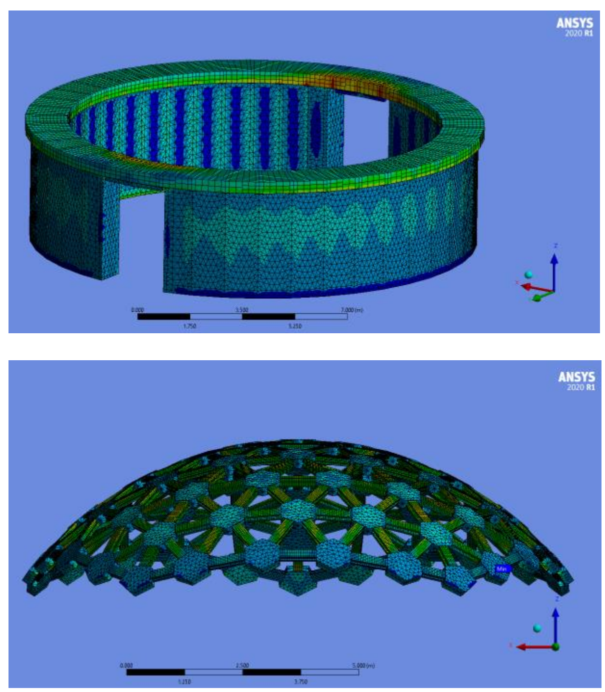

Figure 3. Pressure-induced stresses on the modular blocks (top) and roof system (bottom), conducted in ANSYS

References:

[1] NASA, "NASA's Lunar Exploration Program Overview," 2020. [Online]. Available: https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf

[2] N. Caluk and A. Azizinamini, "A summary of technical requirements, environmental factors and loading for lunar infrastructure," 2022.

[3] R. P. Mueller, R. E. Cox, T. Ebert, J. D. Smith, J. M. Schuler, and A. J. Nick, "Regolith Advanced Surface Systems Operations Robot (RASSOR)," 2013. doi: 10.1109/AERO.2013.6497341.