Specific Gravity of Exolith Lab Lunar Regolith Simulants P. Easter[1], C. Lambert[1], J. Long-Fox[1], and D. Britt[1]
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Introduction: Lunar regolith simulants aim to replicate both geotechnical and mineralogical properties of Lunar regolith at the highest achievable fidelity. This is essential for testing hardware that will interact with the regolith, as it can be a hazard for surface operations as well as a tool for *in situ* Resource Utilization (ISRU). A fundamental property of the regolith is its specific gravity, which is the ratio of grain density to the density of water. From the specific gravity, we are able to derive the grain density of the regolith, as well as other properties such as void ratio, porosity, and saturation. Grain density is the density of the minerals within an aggregate, negating pore spaces and voids. These values are of great importance when comparing a Lunar regolith simulant to actual Lunar regolith, as they are the basis for much of the regolith's geotechnical behavior. In this experiment we find the specific gravity of Exolith Lab's Lunar Highlands Simulant (LHS-1) and Lunar Mare Simulant (LMS-1) in order to compare these values to those of actual Lunar regolith [1].

Methods: To test the specific gravity of both LHS-1 and LMS-1, the ASTM Standard Method 128 [2] was utilized. A flask was first filled with 50 mL of deionized water and weighed. An amount of regolith ranging from 15-25 grams was then weighed out. The regolith was added to the flask and stirred, allowing the water to fully saturate the regolith simulant. Deionized water was then added up to the 100mL mark, and the flask was weighed again. This data was recorded and the experiment was repeated 10 times for each simulant. From these values, the specific gravity of each simulant was derived. Using the specific gravity values as well as equations 1-3, the void ratio and porosity were found.

Figure 1. *Flask with LMS-1 and Deionized Water*

$$SG = \frac{\rho_s}{\rho_w} \quad (1)$$

$$n = 1 - \frac{\rho_b}{\rho_s} \quad (2)$$

$$e = \frac{n}{1-n} \quad (3)$$

Results: The values for the specific gravity, void ratio (n), and porosity (e) of both LHS-1 and LMS-1 are given in Table 1. Approximating the density of water as 1g/cm^3, grain density is equal to the specific gravity of the simulant. The values given for Lunar Regolith are representative of both Lunar Mare and Lunar Highlands. [1, 3].

Simulant	**Specific Gravity**	**Void Ratio**	**Porosity (g/cm^3)**
LHS-1	3.22 ±0.24	1.477	0.596
LMS-1	3.03 ±0.27	0.942	0.485
Lunar Regolith	3.20-2.30	2.40-0.40	0.70-0.25

Table 1*. Mass-Volume Relationships*

Discussion: The specific gravity, void ratio, and porosity of both LHS-1 and LMS-1 fall well within the range of values for actual Lunar regolith. This is important, as these properties determine aspects of the regolith such as relative density and saturation. These values provide a strong argument for mineralogical accuracy driving the geotechnical characteristics of a regolith simulant, as many are dependent on specific gravity. With water ice on the moon likely existing within the pore space of regolith, it is essential for these properties to be accurate when utilizing lunar simulants to test ice detection and extraction methods. By testing the effects of volatile content of simulants with accurate geotechnical properties, we are more likely to see important differences between volatile-laden and dry regolith that may indicate the presence of water, such as an abnormally low void ratio or grain density.

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References:

[1] Carrier et al. (1991) Lunar Sourcebook, Ch 9 Pg. 481
[2] ASTM Standard 128
[3] Carrier et al. (1991) Lunar Sourcebook, Ch 9 Pg. 498