DEVELOPMENT OF THE LUNAR SOIL IMITATORS FOR LARGE-SCALE FIELD EXPERIMENTS.

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Introduction: All lunar soil models and imitators are usually made for imitating one or two main properties required for research, modelling and carrying out experiments. It's almost impossible to make full analog of moon regolith which matches all main properties – physical, thermal, electromagnetic and also chemical and mineral composition [1]. Depending on objectives of research and required amounts or lunar soil imitator, used components and production technologies can vary significantly. For example, for testing instruments and soil intake devices using cryovacuum stands in low temperatures and with varying humidity, high quality lunar soil imitator is needed, similar not only by granulometric composition and main physical properties, but also by main rock forming mineral contents different for maria and highland areas of the Moon. For this types of research small amounts of lunar soil imitators of tens and hundreds of kilograms are required. For large-scale natural experiments, for example for drop tests and landing tests of «Luna» mission spacecrafts, building a moondromes(lunadromes) for testing self-moving and other vehicles made for movement on moon surface, for projecting and testing of moon infrastructure elements, for development and building processing facilities for extraction and enrichment of required resourses etc. significantly larger amounts of soil imitators (tens and hundreds of tons) are required. This means that technologies for making small amounts of soil imitators for more precise research are not applicable here, because fine milling of components in large quantities, spreading using sieves and partial mixing require expensive technologies and cost a lot.

Lunar soil imitators: Several main requirements were considered in process of choosing components of soil imitators:

1. Lunar soil model must imitate only main mechanical properties.
2. Components of soil imitators must be relatively cheap and easily obtainable in large quantities.
3. Making (mixing) of soil imitators and its laying must be doable using accessible industrial methods and instruments.

According to initial requirements next components were chosen: «Slag sand 0.1-5 mm», «Crashed stone and sand mixture 0.1-10 mm», «Granulated slag», « Fly-ash from Cherepetskaya State District Power Plant(SDPP)(№1)», «Fly-ash from Cherepetskaya SDPP (№2)», «Fly-ash from Ryazanskaya SDPP», « Quartz sand 0.5-1.0 mm». Product names were unchanged.

Next properties of chosen components were defined: granulometric composition, volumetric weight, specific gravity, porosity, humidity, modulus of deformation, static and dynamic modulus of elasticity, poisson's ratio, shear modulus, bearing capacity, angle of internal friction, cohesion, uniaxial compression strength (for cohesive soil components). After defining listed properties of each of chosen components, they were mixed in next mass proportions: lunar soil imitator №1 (LSI1) – «Slag sand 0.1-5 mm», «Fly-ash from Ryazanskaya SDPP», « Quartz sand 0.5-1.0mm»; lunar soil imitator №2 (LSI2) – «Crashed stone and sand mixture 0.1-10 mm», « Fly-ash from Cherepetskaya SDPP (№1)», «Quartz sand 0.5-1.0 mm» (Figures 1,2).

Summary: Both lunar soil imitators are almost similar to original lunar soil, measurement errors are acceptable for choosing lunar soil imitator for large-scale field experimental research.

Acknowledgements

This research was supported by Russian Science Foundation (project No. 17-17-01279).

References: [1] Slyuta E.N. (2014) Physical and mechanical properties of the lunar soil (A review). Solar System Research. V. 48, № 5. P. 330–353

Figure 1. Physical properties of soil imitators LSI1 and LSI2

Sample	Constitution	Humidity, %	Density of soil in loose constitution, g/cm^3	Density of air-dry soil, g/cm^3
LSI1	loose	0	1.50	1.50
	compact		1.93	1.93
LSI2	loose	0	1.35	1.35
	compact		1.71	1.71

Sample	Particle density, g/cm^3	Porosity, %	Porosity coeff., u.f.	Compactibility, u.f.
LSI1	2.56	41.30	0.70	1.14
		24.72	0.33	
LSI2	2.35	42.34	0.73	0.98
		27.02	0.37	

Figure 2. Strength properties of soil imitators LSI1 and LSI2

Sample	Constitution	Density, g/cm^3
LSI1	loose	1.52
	compact	1.91
LSI2	loose	1.38
	compact	1.67
Friction coeff., tg φ	**Inner friction angle, φ**	**Cohesion C, MPa**
0.39	21	0.000
1.04	46	0.011
0.36	20	0.000
0.69	35	0.034