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Project: CMPCTR

Website Article

Reference	CMP-FR-HO-005
Issue	1.0
Issue date	14/12/2022
Document type	HO
Status	Released
Classification	Unclassified

APPROVALS

	Name	Project Position	Date
Prepared by	G. Wasilewski	Project Manager	14/12/2022
Checked by	G. Wasilewski	Project Manager	14/12/2022
Approved by	G. Wasilewski	Project Manager	14/12/2022

CHANGE LOG

Change reason	Issue	Revision	Date
Initial issue	1	0	14/12/2022

CHANGE RECORD

Issue		**Revision**	
Change reason	Date	Paragraph	
-	-	-	

1 Draft Website Article

Earthworks are the primary construction method on Earth and the basis for other fields in construction and civil engineering. They rely on development of buildings and sites with soils, which then are typically improved with more elaborate methods. With thousands of years in traditions and experience, we need to adapt terrestrial earthworks to solve problems beyond Earth – starting on the Moon.

One of the key technology and knowledge gaps in lunar In Situ Resource Utilization (ISRU) is horizontal construction and site preparation. We need to be able to build roads, landing-launch pads, berms, and other infrastructure elements of the lunar base as we intensify its development under NASA Artemis and ESA Moon Village programmes.

That is why Astronika focused on investigation of regolith compaction as the most basic earthworks method for large-scale horizontal construction.

Top surface of the Moon is made of lunar regolith – a fine dust made of various minerals during continuous bombardment of the Moon called impact gardening. This layer poses many threats to our exploration systems, particularly influencing their thermal and mechanical behaviour when they are exposed to dust. But lunar regolith is also an opportunity – we can use it as a source of multiple different lunar resources, such as oxygen and metals.

We can also alter the uppermost lunar regolith to improve its properties, as the first 50-100 cm of dust is typically porous, has low cohesion and relatively low bearing capacity. A rocket landing on the lunar surface can create a plume of dust and gas, which will move some of the fine dusty particles even hundreds of kilometres away from the landing site. Moreover, the porous structure may cause the lander, especially when it is heavy like Starship to immerse its legs in the material or even skew the whole structure, posing a great risk to exploration systems and astronauts.

Regolith compaction can prove extremely valuable with that regard. Utilizing energetic impacts many times per minute, we can level the ground and densify the regolith, making it hard as a rock. During compaction, porous space in the regolith is filled with various regolith particles, while those particles interlock each other, making the material stiffer and more cohesive, which is less prone to deformations and dust uplifting.

Astronika has adapted the design of commercial plate compactors and developed a rover-mountable prototype of a regolith compactor. The device was tested in two different lunar regolith simulants – one simulating lunar Highland materials and another simulating lunar Mare – to investigate the device performance and response of those materials to compaction.

The device was moved by the testbed to simulate rover pushing-pulling similar to work performed by humans at a terrestrial construction site. Hundreds of such trips and data gathered during those tests allowed us to understand that compaction can truly improve regolith properties. But what is more important, the inherent differences between various lunar regoliths will not only influence the compaction performance but also will be visible during dynamic compaction measurement. Such measurement allows to utilize vibration acceleration data to monitor the compaction progress even in real time, thus offering an ability to perform construction work and scientific prospecting at the same time.

The device has reached TRL 4 late 2022. Further investigations are needed to better understand regolith behaviour in simulated lunar conditions, such as thermal and vacuum. The study was part of ESA's Off-Earth Manufacturing and Construction campaign launched by the Agency on the Open Space Innovation Platform in 2020.

2 Visual materials

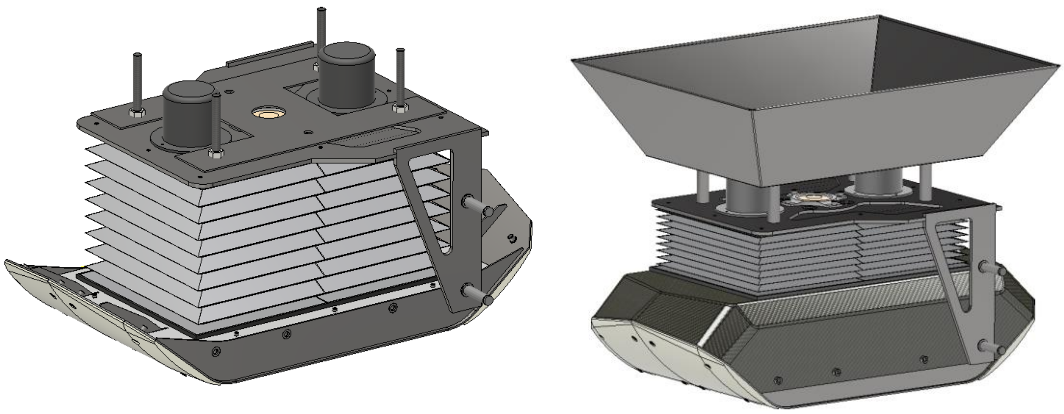

Figure 1. Regolith compactor - left: laboratory version of the prototype, right: lunar version with a regolith container for in situ mass increase.

Figure 2. Prototype during tests on a regolith.

Figure 3. Dusty environment of the work with regoliths. Particulate matter concentration in the lab room always exceeded safe values. Tests always need to be performed in full personal protective gear.

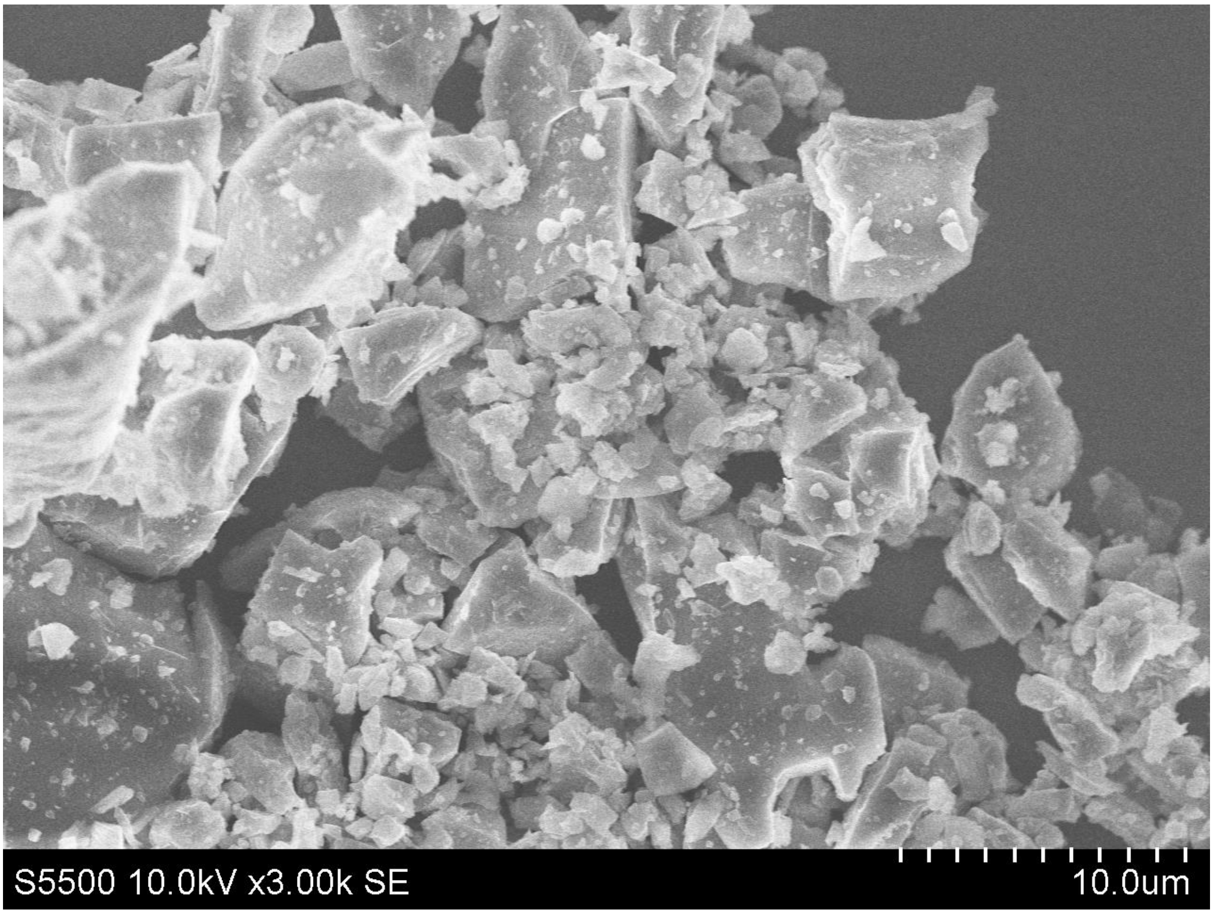

Figure 4. Scanning Electron Microscopy image of AGK-2010 simulant. Lunar simulants are composed of extremely fine particles with irregular sharp shapes. This recreates some of the properties of lunar regoliths.