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Using Martian and Lunar Soils as Building Blocks for Future Habitats

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Abstract

By using locally available resources, such as soils, carbonates or perchlorates, and water, large and strong living structures can relatively easily be constructed on the lunar or Martian surface. Before trying this in-situ, conducting as many tests as possible on analogue soils here on Earth is therefore of the utmost importance.

1. Introduction

Ever since humanity went to the moon in 1969, we have dreamt of making Moon-cities and Mars-villages. As taking (living) people up into space takes up a lot of weight, energy, and money, very little can be spared to be used for any habitat. A few thousand years of housing on Earth taught us that rocks, wood, or concrete are the most cheap, sustainable, and strong options. Rocks are often porous, making them less attractive for a pressurized habitat and wood is not yet available in such quantities on the lunar or Martian surface that we can use it as building material. Making concrete buildings is therefore the most prominent option. This would mean that the future Martians will either need to import concrete blocks from Earth, or make their own 'building blocks'.

As shooting stones from the Earth to the skies is not the most practical, cheap, nor safe way to bring enough building material into space, one would ideally want to be able to make their own concrete while on the planet or moon. A few years after the first samples of lunar soil were returned to Earth, people started experimenting with it to make concrete 'sandcastles' [1,2,3]. This 'lunarcrete' was comparative in strength with early 20th century concrete, and could therefore be used to make small houses.

2. Concrete

Making concrete is relatively easy, and has been done since the beginning of the Roman Empire in 500 B.C. It only requires three basic ingredients: An aggregate, water, and a binding agent – most commonly (sintered) Calcium carbonate. To fully optimize the binding qualities of the agent, it is best to use a fine-powdered dust that is mixed with the aggregate before mixing in the water. After a period of 'setting', the concrete will harden out to resist enormous compressive strengths. Increasing the tensile or shear strength of the concrete is often done by reinforcing it with steel beams or fibers from within. As on any lunar or Martian outpost, this would mean that either heavy machinery should be used to fabricate steel, or that reinforcement beams should be shipped to the outpost from Earth – which again requires excessive amounts of energy and money Therefore, any concrete that will be built, will likely just use the materials present in-situ.

3. Building Blocks

For this project, the focus laid on testing which simulant soil will result in the strongest concrete. At the moment of writing, only four soil simulant concretes have been tested, three of which are pictured in figure 1. The tests consist of tensile, compressive and point strength tests, as pictured in figure 2.

Figure 1. The three building blocks produced in September 2018; f.l.t.r.: Moon Terrae simulant-1, Mars-Jezero simulant 1 and 2. Made with Portland cement. Their strength profiles are comparable to low-grade industrial concrete on Earth.

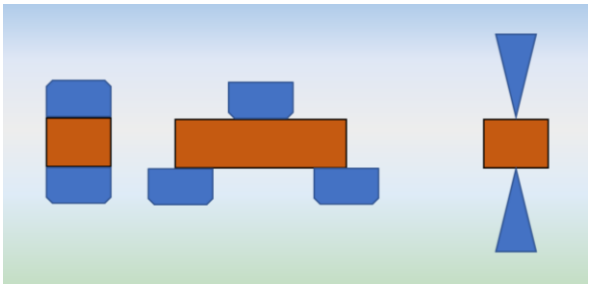

Figure 2. A schematic display of the three tests that were conducted on the building blocks.; compressive, tensile, and point strength test. These tests were done on small standard concrete prisms of 40 * 40 * 160 mm.

4. Results

The concrete has thus far only been tested with regular, Earth-like Portland cement. Further tests, to be condoned in June and July 2019, will also include Calcium perchlorate based cements for Mars simulants, and Calcium oxide based cements for the moon. The tests will be finished in August 2019, after which the first results can be published and presented at the EPSC-DPS in Geneva.

5. References

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