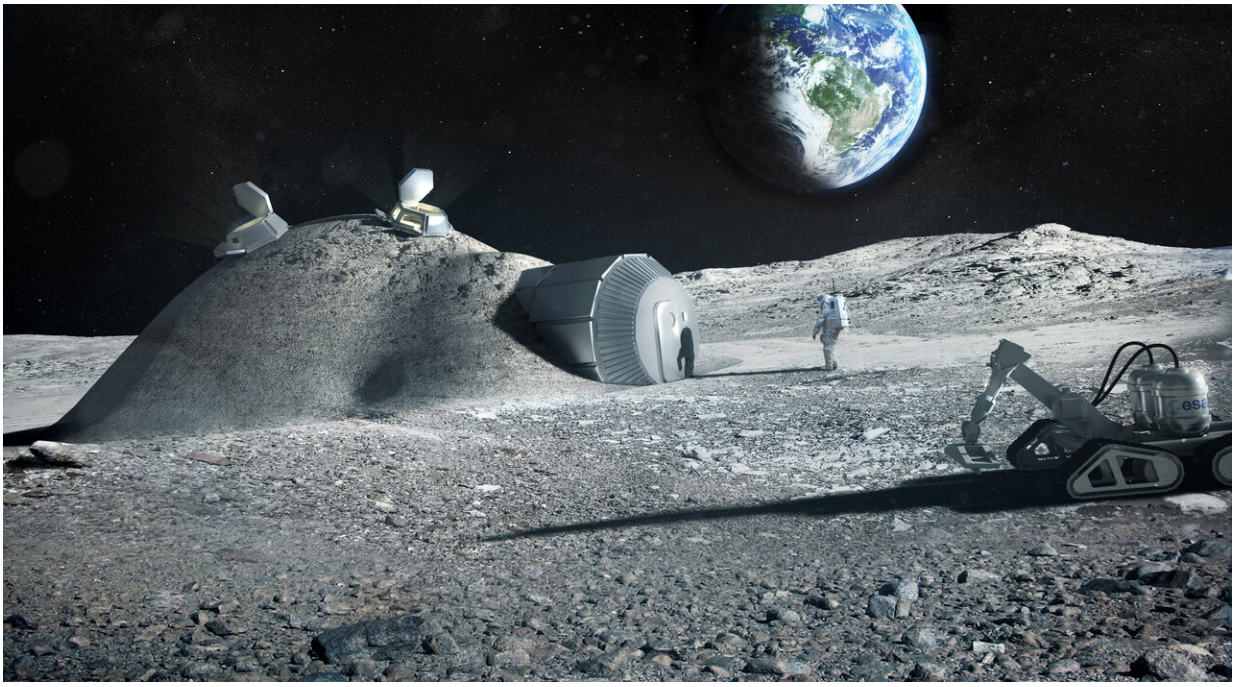
Geopolymer concrete: Building moon bases with astronaut urine and regolith

March 30 2020, by Enrique Sacristán



Future moon bases could be built with 3D printers that mix materials such as moon regolith, water and astronauts' urine Credit: ESA, Foster and Partners

The modules that the major space agencies plan to erect on the moon could incorporate an element contributed by the human colonizers themselves: the urea in their pee. European researchers have found that it could be used as a plasticizer for concrete used to build structures.

NASA, the European Space Agency (ESA) and its Chinese counterpart plan to build moon bases in coming decades as part of a broader space exploration plan that will take humans to more distant destinations such as Mars.

However, the colonization of the moon poses problems such as high levels of radiation, extreme temperatures, meteorite bombardment and a logistical issue: getting construction materials there, although it may not be necessary.

Transporting about 0.45 kg from the Earth to space costs about $10,000, which means that building a complete lunar module in this way would be very expensive. This is the reason that space agencies are thinking of using raw materials from the moon's surface—or even those that astronauts themselves can provide, such as their urine.

Scientists from Norway, Spain, the Netherlands and Italy, in cooperation with ESA, have conducted several experiments to verify the potential of urea as a plasticizer, an additive that can be incorporated into concrete to soften the initial mixture and make it more pliable before it hardens. Details are published in the *Journal of Cleaner Production*.

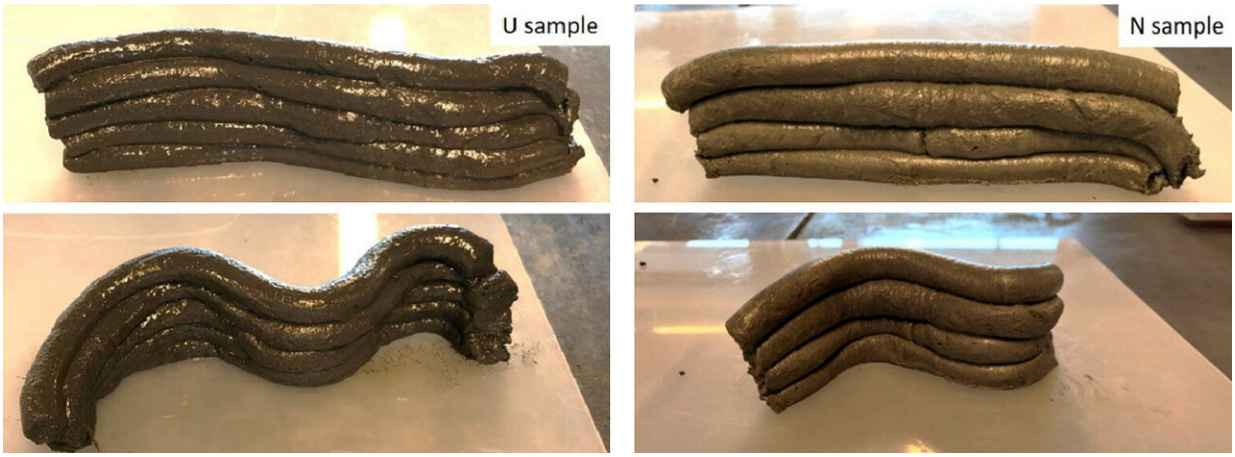
Device for printing 3D samples Credit: Shima Pilehvar et al./ *Journal of Cleaner Production*

"To make geopolymer concrete that will be used on the moon, the idea is to use what is already there: regolith (loose material from the moon's surface) and the water from the ice present in some areas," explains one of the authors, Ramón Pamies, a professor at the Polytechnic University of Cartagena (Murcia), where various analyses of the samples have been carried out using X-ray diffraction. "But moreover, with this study, we have seen that a waste product, such as the urine of the personnel who occupy the moon bases, could also be used. The two main components of urine are water and urea, a molecule that allows the hydrogen bonds to be broken and, therefore, reduces the viscosities of many aqueous mixtures."

Using a material similar to moon regolith developed by ESA, together

with urea and various plasticizers, the researchers manufactured various concrete cylinders using a 3-D printer and compared the results.

The experiments, carried out at Østfold University College (Norway), revealed that the samples made with urea supported heavy weights and remained almost stable in shape. Their resistance was also tested at a temperature 80°C; it was found to increase even after eight freeze-thaw cycles like those on the moon.



Tests to see the ability to form layers of a mixture of material with 3% urea (sample U) and another with 3% naphthalene, a common plasticizer (sample N) Credit: Shima Pilehvar et al. / *Journal of Cleaner Production*

"We have not yet investigated how the urea would be extracted from the urine, as we are assessing whether this would really be necessary, because perhaps its other components could also be used to form the geopolymer concrete," says one of the researchers from the Norwegian university, Anna-Lena Kjøniksen, who adds: "The actual water in the urine could be used for the mixture, together with that obtained on the moon, or a combination of both."

The scientists stress the need for further testing to find the best building material for the moon bases, where it can be mass-produced using 3-D printers.

More information: Shima Pilehvar et al, Utilization of urea as an accessible superplasticizer on the moon for lunar geopolymer mixtures, *Journal of Cleaner Production* (2019). DOI: 10.1016/j.jclepro.2019.119177

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