

Design and construction approaches of foundations in permafrost with an application for a 3-D printed habitat on Mars.

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Abstract

This research is part of TUDelft Robotic Lab Rhizome 2.0 and assists Arwin Hidding's Ph.D. research work, Scaling-up Capability of Human-Robot Interaction Supported Approaches for Robotically 3D-printing Extraterrestrial Habitats. The design and construction of buildings on Mars is a significant engineering challenge due to the complexities of the harsh environments and limited construction materials and equipment. A novel exploration is to build habitats through 3-D printing. This paper presents various shallow foundation approaches, ventilation systems and initial Voronoi interlocking shallow foundations for 3-D printed habitats on Mars.

Key words: foundation; permafrost; 3-D printing; Mars terrain; Voronoi base; interlocking

Research Methods

First, Mars's terrain and possible environment are reviewed based on the available literature. The review discusses descriptions of the morphology of the surface on Mars and explains the thermal contraction of polygonal terrain and drainage/channel incision.

Second, the permafrost terrain between Mars and Nordic is compared to. The research investigates Nordic architecture foundation regulations and construction methods due to their similar permafrost condition.

Third, the typical design construction of shallow foundations on permafrost construction is reviewed through case studies in the Arctic and Nordic. Shallow foundation types include slurred piles, driven piles, slab on grade, continuous, and mat foundations are discussed, and examples of such foundations are presented and discussed what foundations are used for different soil conditions (soft, medium and firm)

Fourth, the research investigates other case studies of 3D printing foundations on Mars. 'Designing a Habitat for 3D Concrete Printing in Permafrost Regions' by Jose Duarte (July 2023) from the University of Pennsylvania.

Fifth, describe the general thermal design concept and considerations for the design of a heated, on-grade shallow building foundation on the thaw-unstable ground in a permafrost region; three case studies are discussed this including thermosyphon system, ventilated duct system, heat pump cooling system. Reviews how the new systems are used in the Arctic and Nordic and can be implemented into the Voronoi-based foundation. This research is a preliminary design document for foundations in permafrost for 3-D printing habitat on Mars.

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