21st IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Sustainable Space Development and Settlement - Technologies (2B)

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DEFINITION OF REQUIREMENTS FOR PAVEMENT AND TAKEOFF/LANDING AREAS ON THE MOON AND STUDY OF APPLICABILITY OF REGOLITH SINTERED MATERIALS

Abstract

Our lunar activities are envisioned to include resource exploration, infrastructure, fuel production facilities, and construction of structures conducive to short-term stays on the Moon in the short term, and construction of structures for habitation in the long term. Energy and other facilities that need to be built in stages from short term to long term must also be considered. In this report, we studied the possibility of using regolith, which can be procured on the Moon without the cost of transportation from the Earth, for the purpose of fabricating construction materials on site. Construction materials using lunar resources include lunar concrete, geopolymer, sulfur concrete, polymer concrete, sintered regolith, and non-metallic inorganic fibers. The applications for which construction materials were studied were pavement materials for the haul road, pavement materials for the takeoff and landing sites of lunar landers, protective layers for habitation facilities, and habitation in lava tubes. For the pavement material of the transportation route, the required ground bearing capacity and required strength of the surface block pavement, the required ground bearing capacity for the takeoff/landing site of the lunar module, the required protection performance against cosmic radiation and micrometeorites for the protection layer of the habitation facility, and the required soil cover thickness when 1 atm internal pressure is applied for the lava tube were considered. For the firing method of the regolith, we investigated heating methods such as microwave heating, laser heating, and furnace heating. Microwave heating mainly consists of single-mode heating and multi-mode heating, with multi-mode heating providing more homogeneous heating. Laser heating is mainly divided into powder bed fusion bonding (PBF) and directed energy deposition (DED), with the DED method being more suited to the molding of large products and more applicable

to moon-simulated sand. Based on the above research results, we decided to adopt microwave heating by multimode and laser heating by the directed energy deposition method in this study. Test production was conducted using moon-simulated sand (FJS-1), and compressive and flexural strengths were evaluated, respectively. With microwave heating, compressive and flexural strengths of 312N/mm2 and 36.7N/mm2 were obtained, satisfying the performance requirements assumed for pavement materials for transportation routes and protective layers for residential facilities. By laser heating, compressive strength of 46.4N/mm2 and flexural strength of 0.88N/mm2 were obtained, which did not meet the performance requirements for pavement materials for transportation routes, but satisfied the requirements for the protective layer for residential facilities.