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# INNOVATIVE DESIGN AND CONSTRUCTION METHODOLOGIES FOR IN-SITU MANUFACTURING OF LARGE SENSORIZED STRUCTURES IN FUTURE HUMAN HABITAT ON THE MOON

**Abstract**

Over 50 years have passed since humankind last walked on the Moon during the Apollo 17 mission but space exploration is still among the most important challenges for our technological and scientific evolution. National space agencies identified Moon colonisation and the development of a sustainable lunar economy as top priorities for their programs. Exploiting in situ resources will be the enabling factor in this scenario for limiting Earth-dependability. Consequently, future outposts will require in situ sourced and processed materials. Furthermore, surface outpost maintenance activities will force settlers to build spare parts, day-use tooling, and safety-critical parts using local resources. Challenges and goals brought by the hostile lunar environment prompt disruptive design methods, and their novelty urges effective monitoring systems. This paper investigates how large structures of a foreseeable human lunar surface outpost can be realised, such as shells of habitation modules, landing pads, roads, and pavements. They require construction-scaled manufacturing technologies, thus moving beyond laboratory-scaled experiments but keeping robustness, low-power demand, automation, and adequacy to cope with the Moon extreme environment. The experience gained with compressed earth blocks and polymeric cement in terrestrial applications has driven the development of bricks made from regolith and scarce percentages of an organic phase. This solution has already demonstrated valuable flexural and compressive properties for construction manufacturing, also enabling the production of hollow bricks with inter lockable shapes. Interlocking bricks ease the assembly process and can be mortar-less. Hollows and cavities bring lightweight products, which further ease the assembly of large structures and reduce the amount of material to process; play a significant role in thermal insulation; pave the way towards instrumented and multifunctional parts. Indeed, the cavities can easily host Fiber Bragg Grating (FBG) sensors that evaluate strains, temperature, and humidity in real-time. This monitoring plays a significant role in safety as it allows constant tracking of the long-term effects of thermal vacuum and enables targeted maintenance. It also enables assessing the occurrence of micrometeoroid impacts on the structure, flagging whether this exceeded the designed impact strength. A reliable, fast, and automatable process for applying the fibres and the architecture monitoring solution are also discussed. The present research work aims to cast some light on disruptive designing and manufacturing methodologies for constructing smart habitat elements in permanent human lunar surface outposts.