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PROTOTYPE TESTING OF AN INFLATABLE LUNAR HABITAT IN HIGHLANDS REGOLITH SIMULANT

Abstract

Inflatable structures are an attractive option for a habitable lunar base due to their low weight to habitable volume ratio, allowing transportation to the Moon with relative efficiency. However, inflatables provide little protection against radiation, extreme temperatures and micrometeorite impacts, all of which are of concern on the lunar surface. One solution is to bury the inflatable habitat under lunar regolith. Typically, it is assumed that the habitat would be inflated then buried. However, an internal pressure of one atmosphere could support regolith cover of up to 30 m on the moon. Cost savings in equipment payloads and regolith handling might be achieved placing a layer of regolith over the deflated structure and using internal pressure to lift the regolith as the structure is inflated. This study assessed the viability of this approach using physical experimental models buried in lunar regolith simulant in the EXTERRES (Extra-terrestrial simulation) laboratory at The University of Adelaide.

Particle size distribution testing was undertaken to characterise the engineered grade lunar highlands regolith simulant, LHS-1E, that was used in this study. Minimum and maximum density testing was undertaken to quantify how tightly packed the particles are at different densities, as this can significantly affect the strength and behaviour of the material. Additionally, direct shear testing was performed to obtain strength properties of the regolith simulant. For all scale model tests, a loose density of 1450 kg/m3 was adopted to allow the effects of other variables to be quantified.

Physical scale models consisting of a double membrane (inner plastic and outer fabric cover) were buried at varying depths, then inflated using an bury-inflate-deflate methodology. To analyse the behaviour during the inflation and deflation stages, measurements of surface displacement and inflation pressure were captured using a bespoke data acquisition system. During inflation, no vertical displacement was measured until the pressure was greater than the overburden pressure, after which the model inflates resulting in significant surface displacement, until such time that additional inflation caused no increase in surface level. This was the point at which cover depth measurements were taken. During deflation, significant changes in surface displacement did not occur until a much lower pressure was reached, indicating a hysteresis between the inflation and deflation stages. This hysteresis could increase the safety of buried inflatable structures since collapse would occur at a lower pressure than might be assumed.