STRUCTUTAL SYSTEMS FOR LUNAR BASES. A. A. Mardon[1] and G. Zhou[2], [1]University of Alberta (116 St. and 85 Ave. Edmonton, Alberta T6G 2R3, CANADA, aamardon@yahoo.ca), [2]George Washington University (2121 I St NW, Washington, DC 20052, USA, gzhou@gwu.edu)

Introduction: Facilities on the lunar surface will challenge contemporary ideas of structural analysis by structural and civil engineers, as well as designers, constructors and logistics planners. Exposed habitation units will face many issues regarding the extreme lunar temperature cycles and effects of high vacuum. [1] Exposed material and structural fatigue due to extreme lunar temperature cycles and temperature sensitivity differential on continuous structural components must be addressed. Nighttime lows of -110°C (-170°F) would mean designers must look at the potential brittle fractures and stress concentrations within the potential material. [2] A potential partial solution would be to internally pressurize supporting members such as those for buckling, stiffening and bracing to meet safety and reliability requirement. The unpredictable nature of the lunar environment requires minimization of risk to an acceptable level. [3] Loading must take into account the 1/6 gravity of the moon. This means a structure will have six times the weight-beating capacity (dead weight) on the moon as on the Earth. However, it cannot be assumed that the structure is able to support more load due to this fact. This would only be true if the material is linearly elastic. However, most materials have a non-linear. Current engineering thinking and design is based on the limit-state conditions. Chua et al (1992) propose a nonlinear hyperbolic stress strain model to better reflect how structure-regolith simulations can be done using the finite element approach. This is exactly the reason explaining the implementation using kg-force (calculations without gravity component). Structural components must display a level of redundancy as in statically indeterminate structures. This implies that loads are redistributed to an equilibrium state when members are to fail. A level of acceptable risk and safety factors needs to be derived.

Research: Inflatables have long been proposed as a feasible and economic method for a permanent lunar base. [4] The inflatable pressurized tensile structure of fibre composites offers radiation shielding under native regolith and little temperature variations. Erectable tetrahedral, hexahedral, octahedral structures have also been proposed and offers many of the same benefits as inflatables. [5] The various geometrically configured space frame elements can be easily expandable and is quick to construct and install. As members of these structures are not natively found, it must be prefabricated and brought to the moon. Currently it is not economically feasible.

Conclusion: This paper presents a summary of pressing issues surrounding the designing, engineering and construction of lunar habitation units. Structural integrity depends on various unpredictable factors present on the moon. Temperature and regolith variations must be factored into the design criterion of the structure. Foundational, Material and Structural mechanics and behaviour are dependent on these variables. Due to different variables within the scope of designing of lunar structures, a method criterion for the consideration of failure modes that differ from terrestrial structures must be created. The challenge during the design phase is the inability to test design prototypes under lunar environment. A realistic testing scenario can be not realistically tested. This in turn does not allow engineers and designers to effectively and accurately evaluate the complete structural life cycle. The distance away from Earth in conjunction with high costs associated with transport of material to the lunar surface suggests the need for the use of native material. This is also known as In-situ Resource Utilization (ISRU). This will be extremely important but future feasibility analysis into this topic must be researched.

References:

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