STRUCTURAL STABILITY AND SULFUR BASED LUNAR CONCRETE COMPONENTS FOR LAVA TUBE SUITABILITY. G. Zhou[1] and A. A. Mardon[2], [1]The University of British Columbia (Department of Civil Engineering, Vancouver, British Columbia, Canada, gordonz@interchange.ubc.ca) [2]Antarctic Institute of Canada (PO Box 1223, Station Main, Edmonton, Alberta, Canada T5B 2W4, aamardon@yahoo.ca).

Introduction: Lava tubes are natural conduits formed from lava flows. When the supply source stops, this underground tube is formed as the outer surface of the lava cools and hardens. Unlike lava tubes on Earth which has a maximum diameter of 25 meters, lunar lava tubes can span several hundred of meters wide and tens of kilometers long. [1] This is due to the conditions of basaltic eruptions given the moon's lower gravity field and little atmosphere and low viscosity flows. Although the size differs, the formational processes appear to be similar. [2]

Evidence derived from the study of terrestrial lava tubes along the coast of Hawaii such as the east and southwest rift zones of Kilauea Volcano. Studying the structural stability of the Thurston and Kilauea Caldera Lava Tubes in this region under seismic activities for the past century leads to the conclusion that varied lunar seismic history have minimal effect on lava tubes generated by meteorite impacts and tectonically originated moonquakes. [3]

A variety of factors must be considered to determine the structural stability of lunar lava tubes. Generally, visual inspection identifying faults and slumps along lunar rilles will filter out candidates for feasible lava tubes. The ratio of roof thickness to interior tube width determines the feasibility of lunar lava tubes. Under lunar conditions, a ratio of approximately 0.17 is needed for the structure to remain stable. Depending on the arching of the roof, this ratio can decreased to 0.10 to 0.13 allowing for thinner roof depths. [4] Using the Lunar Orbiter and Apollo photographs, the tube lengths can be used and an estimate for the tube depth and roof thickness can be estimated following the crater-geometry *Horz* formula:

$$t = d \bullet 0.25 \bullet 2$$

where

d = maximum crater diameter
t = estimated minimum roof thickness

Using this equation, Coombs and Hawks have identified 90 lava tube candidates along 20 lunar rilles from the lunar regions of Oceanus Procellarum, Northern Imbrium, Mare Sereitatis and Mare Tranquillitatis.

Composition of lunar lava tube regolith is also a variable determinant of structural stability. After identifying intact lava tubes, the concept of “lunar concrete” is introduced to increase loading capacity. Cast regolith would be very similar to terrestrial cast basalt where the regolith is melted and let to cool to form a crystalline structure. The compressive and tensile building components are strengthened as a result. Advantages of sulfur based lunar concrete is its strength, durability and excellent shielding properties. In terms of economics, the construction and transport costs are both reduced using the concept of In-Situ Resource Utilization (ISRU).

Sulfur based concrete samples were created to study the feasibility of using lunar regolith and binders. The most important factor in using sulfur concrete compared to terrestrial hydraulic concrete is that it does not need water to gain strength through chemical reaction. The test shows that this type of concrete can gain full strength in a relatively short period of time and requires less heat to manufacture. [5] Because concrete of any sort is a rather brittle substance, Dr. Omar introduced metal fibres in the matrix to increase tensile strength and reduce brittleness. The finding concludes that the 25.4mm fiberglass fibres of 0.25% and 0.50% weight reduced compressive strength by 27% and tensile strength by 20%. [6]

Summary and Conclusion: More rigorous method of identification of structural stability of lava tubes must be identified. Loading capacity of identified lava tubes can be increased by using sulfur-based concrete based on lunar regolith. Sulfur based concrete has shown in labs to have higher compressive and tensile strength than hydraulic concrete. The maximum compressive strength found was 33.8 MPa with 35% sulfur by weight. [7]

References:

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Research Support: This research was supported by the Antarctic Institute of Canada and the Government of Canada CSJ Grant 9794595.