PROCESS FOR PRODUCING BUILDING ELEMENTS WITH MULTILAYER STRUCTURE FROM LUNAR REGOLITH BY MICROWAVE HEATING T. P. Varga[1], I. Szilágyi[1] Sz. Bérczi[2], T. N. Varga[2], [1]VTPatent Kft. H-1111 Budapest, Bertalan L. u. 20. Hungary, (info@vtpatent.eu) [2]Eötvös University, Institute of Physics, Dept. Materials Physics. H-1117 Budapest, Pázmány P. sétány 1/a. Hungary (bercziszani@ludens.elte.hu, vargatn@caesar.elte.hu)

Introduction: The Lunar regolith due to its composition can be utilized to construct building elements [1]. It is advantageous that the lunar gravity is only 1/6th of the Earth's, this enables the use of significantly larger building elements with the same supporting capacity and thus the construction of large structures [2]. In this study we focus on the structure and construction of building elements made of regolith.

Background: One of the most important requirements relating the building element is the proper load bearing capacity. The loading forces arise from the mass of the building and from external causes (Moonquakes). A very important factor in the load bearing capacity apart from the material, is the internal structure of these elements.

Already known experimental methods for the heating and sintering of Lunar regolith by microwave radiation [3], [4], [5]. These methods create solid regolith layers with the utilization of low power microwave radiation. The basis of this method is the nano-phase iron which is present in the regolith grains, and which can be heated with microwave radiation with great efficiency, thus the regolith layer can be sintered solid.

From the limited power available on the Moon an idea arises, that only the outer shell of such building element should be sintered solid, and the inner volume would remain filled with porous material. An element with such structure could be very easily produced by microwave sintering. However the inhomogeneous inner structure leads to problems with the loading capacity of such element, as shown in Fig.1. and 2.

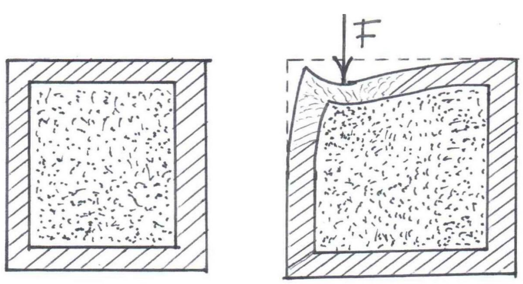

Fig. 1-2 Building element with a solid outer shell, and a porous inner volume, with shear forces present

In a given case a brake occurs from the result of the forces effected to the building element, which can result in the injure and damage of the whole building.

Problem to be solved: One of the necessary conditions of the use of these building elements is that they must be conveniently large, because this makes them more feasible, and manufacturing process more effective. The solidity and loading capacity of these elements can be enhanced by making them more homogenous. The relatively large size and homogeneity however are opposite criteria's, because the larger the element, the harder the homogeneity can be achieved.

If we aim to create building elements of larger scale (from 10s of cm to a few meters), then to achieve homogenous inner structure the proper heating and sintering of the entire volume is required. This process even with low power microwave sintering can lead to very high overall power requirement. The other problem is that the melting even with larger power input will not be evenly distributed. On the outer shell the regolith will melt for a greater extent, and this also leads to inhomogenity, which as mentioned before, weakens the elements against shear forces.

Our proposal: Arbitrarily large building elements can be created from Lunar regolith, if the elements are produced layer by layer in a way that every layer is heated individually by microwave, and the newer layers are placed over the older ones. This process can be repeated until the required thickness is reached, and thus the inner structure of the element is of equal supporting capacity and rigidity. (Fig 3.)

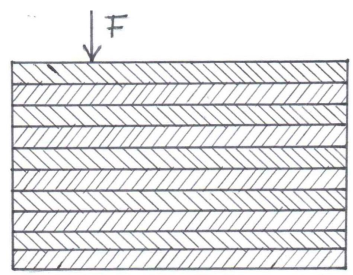

Fig. 3 Building element made from Lunar regolith composed of multi layers, showed with the force effected

As shown in the Fig. 3 the layers deposited on each other and the interconnected layered structure provides an even distribution of inhogomenities in the inner strucure, thus their effect cannot accumulate, but the effect is distributred among the layers. The sintering of the individual layers also ensures the connection to the neigbouring layers, producing an even quality building element, also with a proper load bearing.

Feasibility study: Inside a frame required for the production, the granular Lunar regolith is placed. A microwave radiating line is placed above the frame, sintering the regolith layer. This line can be moved sideways. The thickness of an individual regolith layer can range from few cm to few 10 cm depending on the used microwave radiators. In this process we can use the fact that to melt the lunar regolith only few 100 W or few kW are required, and it does not require significant power supply.

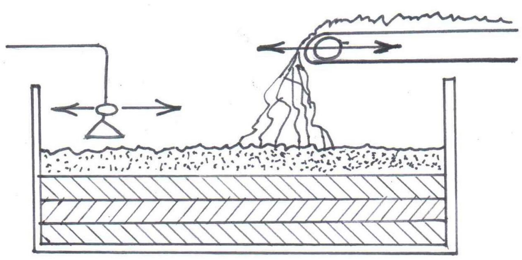

Fig. 4 The process of creating a multilayered building element from Lunar regolith

The used regolith transmitted and spread into the frame via a proper conveyor belt. During the sintering process the radiator line is moved sideways to reach every part of the regolith surface. This sideways motion can be repeated several times to ensure the required rigidity. After one such process, another layer of regolith is poured over the previous one, and the whole sintering process is repeated. This overall procedure can be repeated several times depending on the desired thickness. Sideways dimensions of the used frames can be chosen freely to the size of the element, thus building elements with surface area of few dm^2 or m^2 can be created where the final height is also freely determinable.

Preferable applications: The layered building elements providing homogenous inner structure could enhance the implementation of arched structures with large inner spaces [1], [2].

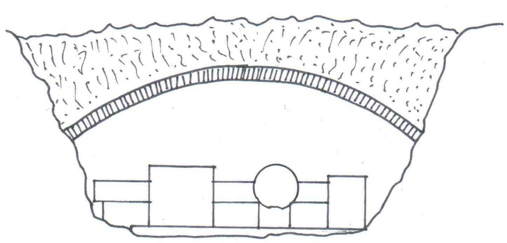

Fig. 5 Full arched structure in a Lunar valley built with layered building elements, covered by Lunar regolith

In the case of the arched structures the support against shear forces can be critical. Inhomogenities or faults in rigidity can lead to cracks and to the collapse of such structures. In the Moon the resistance of the buildings to moon quakes and abrupt outside forces (meteorites) are very important.

The building elements created according to our proposal can be positioned in such a way that the aforementioned layers are perpendicular to the arch, and so the individual elements receive the load in a favorable way (perpendicular to the layers).

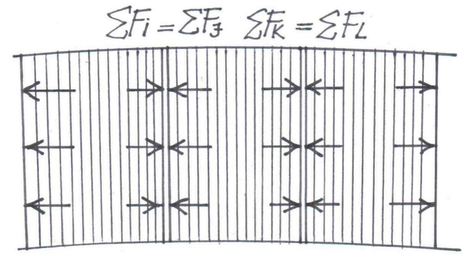

Fig. 6 The enlarged part of the arched structure made of multi layered biuilding elements, placed in vertical position; the loading forces are shown

Advantages: The building elements created with this method could be large enough to enable the construction of buildings with large inner spaces, which could be used for further industrial or human activities.

The utilization of this technology can be done in arbitrary sizes, so the construction of building elements for the given building is possible. The required tool: frame, microwave radiator line, transportation vehicle, which transports the regolith, and pours it evenly to the frame. After the element is finished it can be removed from the frame.

In another preferable application we can produce extra large building elements, or a part of a complete building with multi layers on a required place.

References: [1] Boldoghy et al. “Construction of a lunar architectural environment…” 37. LPSC 2006 #1152. [2] Boldoghy et al. “Complex architectural concept and technology for creating buildings of great inner space on the moon…” #4074 Joint Annual Meeting of LEAG-ICEUM-SRR 2008, [3] L. A. Taylor et al. Microwave processing Apollo soil… Earth and Space 2006, [4] M. Barmatz et al. Development of a microwave facility for processing Lunar Regolith Habitation 2006 Conference, [5] L. A. Taylor Microwave sintering of Lunar soil… ” JOURNAL OF AEROSPACE ENGINEERING ASCE / JULY 2005