# CONSTRUCTION OF A LUNAR ARCHITECTURAL ENVIRONMENT WITH JOINT CONSTRAINTS OF THERMAL BALANCE, ECONOMIC TECHNOLOGIES, LOCAL MATERIAL USING: STRATEGY, DESIGN AND ON SITE ASSEMBLY.

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**Abstract**: We studied the strategies, technologies, designs of the Lunar Base architectural construction from the viewpoint of physical constraints (i.e. energy balance, strength and insulating properties of the lunar materials), engineering constraints (i.e. building technology, transports, insulating layers) and geological environment (allocation of the buildings). Our results contain proposals on the general strategy, on the local production technology, on arrangement and insulation solutions and the emplacement of the lunar base.

**Introduction**: First data of the physical properties of the lunar environment were measured by Surveyors [1,2] and Apollo Missions, i. e. [3,4,5]. Surveyor mechanical and soil data were measured by their robotic arm and camera systems [6-11]. Further details were given by the Apollo Missions, on a wider range of the lunar surface environment characteristics - of lunar soil (Gast, PLSE Team) [12], of heat flow (Langseth et al) [13], of soil mechanics (Mitchell et al) [14]. Development of lunar soil simulants, like JSC-1 [15], a glass-rich basaltic ash sample, a chemical and mineralogical analog material was available for engineering experiments, and even its electrostatic characteristics and charging properties were measured [16] and were compared to those of Apollo-17 lunar dust [17]. On the basis of these data we made both calculations and modeling of the engineering of a permanent lunar base construction. The aim of our studies is to give a **complex project** plan for construction a lunar architectural environment, using local resources [18].

**Strategy for lunar architectural environment**: In our complex planning first we made a strategy study. The first architectural lunar base constructions of hability modul and structural materials are to be transported to the site. Structural materials are stress holding frames and insulating foliating materials.

For the hability modul the cylindrical geometry, size and arrangement of the International Space Station US and other units are the best first approach. The space station hability module units are economic preliminary lunar station candidates in our system.

From frame units a spatial skeletal structure is built on the site which holds the stresses and load of the weight of both the cylindrical modules and the other insulating layers.

For insulating material there is a free access for local regolith material. This should be used in two kinds of layers. The first layer is surrounding the ISS-like hability moduls by quilted-coat like insulating wall units. These units are on site prepared from the foliated stress holding material transported to the site and from the lunar soil. The modular units are attached to the outer wall of the ISS cylinder.

The second layer is a free large masses of regolith used to surround the ISS cylinders so that they became embedded and buried into the local regolith material. This outer insulating layer, which forms a thick regolith mass surrounding the living space bubble architecture has not only role of insulating, but radiation and impact bombardment shielding, too.

The whole living building architectural unit is emplaced into a smaller valley of one of the lunar rilles or rimas.

**Thermal equilibrium studies**: On of the main physical constraint of the lunar base architecture is the thermal balance. Surface temperature range, lunar heat flow [13,19], solar insolation, lunar soil insulating data together with the heat dissipation inside the lunar base architecture all were used in calculating the thermal balance of the base in our regolith-buried architectural arrangement. Thermal properties of the lunar regolith made it excellent insulator for the wall system. This is the first layer of insulation, attached to the wall system. The outer insulating layer is a thick regolith mass surrounding the living space bubble architecture. The depth of the regolith thickness was calculated from the thermal conductivity of the regolith measured at Apollo 15 and 17 missions, and from the lunar heat flow data [13,19]. With two insulating layer wall system the estimated burial depth was 6-8 meters from the top and 4-6 meters from the bottom of the groove found for the emplacement of the lunar base on geological basis.

**Structure of the building architecture:** Functional studies prefer two main energy sources for a lunar base. However the allocation of the nuclear source needs larger distances between the power station and the living units therefore the direct solar energy conduction was planned. Indirect heat sources may serve as long range containers of this source by phase changes in the salts used for this purpose. The salt layers serve also as units of the insulating system, too. So they are added as a third insulating layer to the two earlier proposed layers.

**Technology**: Using the insulating and strength data of the lunar soil the following main technology phases of construction of the lunar base architecture was pro-

posed. After transport of the primary container ISS type unit blocks from Earth to the lunar surface: 1) grading and basis forming in the bedrock for the frame, 2) assembly of the architectural constructions of the frame, 3) fixing the thermal balancing salt units on the cover of the ISS type hability modules, 4) parallel filling the insulating quilted-coat like units with lunar fine soil, 5) fixing the quilted-coat like second insulating units to the surface of ISS type unit blocks, 6) final emplacement of the container blocks on the frame, 7) burial of the living bubble units by the lunar regolith from the plains surrounding the valley of lunar base locality. For this a lunar rover type buldoser is used (Fig. 1.).

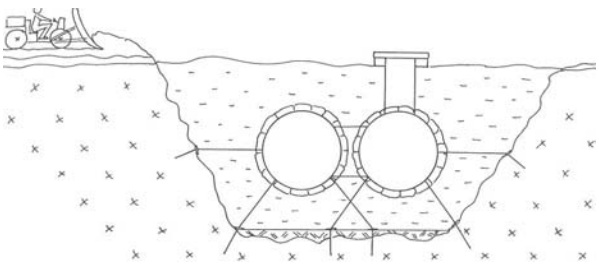

*Fig. 1. Arrangement of the hability modules and their embedding into the lunar regolith in a small valley on the Moon.*

**Geological environment and the allocation of the base**: It is economic to place the first long term used buildings below the surface. This way large mass of lunar soil can be used as insulator. Lunar soil can be moved by a lunar rover buldoser to cover the deposited container with regolith. The best geological site is at the mouth of a smaller valley which have about 10 meters width. We propose the locality of the Aristarchus crater, where several rilles can be found (Fig. 2. Lunar Orbiter 4, 151H, detail). Enlargement of Fig. 2. is shown on Fig. 3. with at least 10 larger rilles, where many larger valleys contain smaller central valleys on their floor.

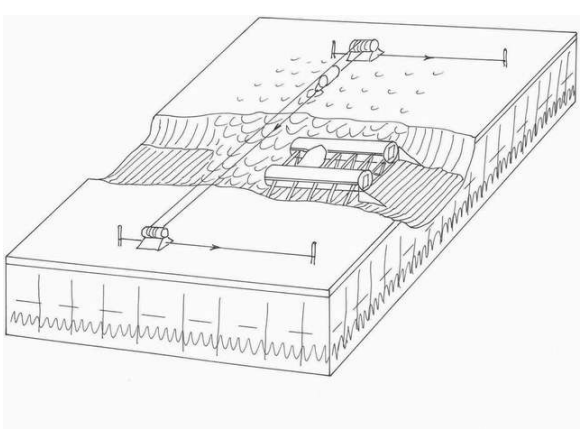

*Fig. 2. A proposed technology for the burial of the permanent lunar base into the lunar rille.*

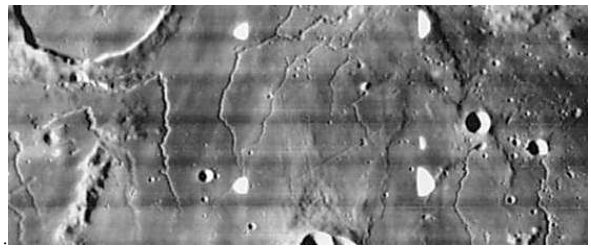

*Fig. 3. 10 Aristarchus rilles of enlarged details of LO-4, 151H image. South is up.*

**Summary**: We proposed a complex architectural design for the lunar environment: strategy, on site technologies, design, arrangements of the Lunar Base construction. Our concepts were studied from functional aspects and from thermal equilibrium, local material technologies and surface soil insulating aspects. We proposed a double insulating layer system both using lunar soil as thermal insulator and an additional third one with phase changing salt as energy storage material. We also proposed a geological setting of the implementation of the architectural units in a groove or small valley mouth where not only the deposition of soil is economic but the enlargement of the station is possible in valley direction.

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