

LUNAR SOURCED INORGANIC COMPOSITES FOR SPACE CONSTRUCTION,
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The moon can be viewed as the local quarry for space structural materials like building stone, cements, metals, glasses and ceramics for construction projects over the entire range of cislunar space (lunar surface to low earth orbit) and perhaps beyond (planetary expeditions) (1,2,3).

There has been a recent emphasis on the development of inorganic composites like cements/concretes (3) and glass/glass composites (4) from surface lunar materials because the components are accessible and fabrication energies are low compared with the extraction and refining of metals.

For example, concrete fabrication and placement requires less than 1/35 the energy to refine aluminum (5). Abundant lunar surface glasses may be natural cements due to their rapid quenching like the terrestrial volcanic pozzolans used to cement Roman structures that are still standing. And there are abundant aggregates in lunar rocks, soils and oxides. A study to evaluate lunar soil as concrete aggregate is in progress (6). Unlike many metals, concretes can retain their toughness over the temperature extremes of orbital and lunar day-night cycles (5). Moreover, some formulations are vacuum tight (7). As to the question of water availability, cured and dried concrete has 5 wt% water of hydration which is vacuum hard (8). 8/9 of that water can be made from lunar derived oxygen and perhaps even the hydrogen can be lunar sourced. The <20 micrometer size fraction of lunar soil has over 150 ppm of absorbed solar wind hydrogen (9) enough, when combined with lunar oxygen, to make an all lunar water lake at least 39 x 39 km x 10 meters deep from the top meter of soil over the entire lunar surface. Since water will be required for all lunar operations, otherwise unusable aqueous wastes might be reserved for cements/concretes which could become the waste repositories in orbital and lunar facilities.

Glass/glass composites can be made with reinforcing fibers drawn from lunar basalts and anorthosites at 1000 - 1200 C and set in a low melting glass matrix or frit at 315 - 375 C. Fabrication techniques are being developed with terrestrial simulants (4). Melt temperatures could be obtained using light weight solar space furnaces (10) which, at higher temperatures, could also serve to extract oxygen, iron and silica from lunar basalts and anorthosites (11). It is expected that habitats and other simple structures could be made by bending, forming and welding glass/glass composites in the cislunar environment. In addition, basalt fibers might be used to reinforce concrete while finely divided iron and silica obtained from basalt prolysis could be used to densify and toughen cement pastes. It is also possible that a tough light-weight lanxide mixture (12) of iron and its oxides might be formed using proper proportions of lunar iron and oxygen in a solar furnace charge.

All the above materials can be developed and terrestrially sourced for near term commercial, scientific and defense space structures. For example, cements and concretes can provide superior radiation, thermal and impact shielding as well as inertial stability, chemical inertness and hazard isolation for human-tended long term space operations. Inorganic composites requiring low to modest formation energies may be the cheapest structural mass to orbit because the ingredients can be shipped in small odd volumes on every shuttle flight to build up an orbital inventory that can be fabricated and deployed in situ. The desirability and success of such terrestrially sourced materials in near term Space Station and SDI applications may prove a powerful incentive for lunar sourcing.

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