Lunar Concrete

A Means to Reduce the Dust Hazard

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Lunar Concrete

- Use in situ resources to create a paved lunar playground
- Attainable achievement which greatly aids lunar exploration
- A flat, smooth lunar surface will…
  - Eliminate lunar topsoil
  - Aid landing operations
  - Aid surface operations
  - Increase geological data

- Production capability proven with Apollo samples
- Structural / construction constraints very flexible
- Able to be feasibly integrated with current architecture

Advantages of Concrete

- Economic
  - Less energy required for formation
- Compartmentalization
  - Can be molded into any shape
- Thermal strength
  - Can survive high and low temperatures
- Radiation shielding
  - Excellent barrier
- Abrasion resistant
  - Protects from micrometeorite debris
- Vacuum resistant
  - High environmental tolerability

Water vs. Sulfur?

- Concrete is…
  - Aggregate + Cement (15%) + Water (7%)
  - Aggregate + Sulfur (35%)

	Water based concrete	Sulfur based concrete
Minerals	Ilmenite, Ice	Troilite, SO_2, H_2S
Supply	Medium-High	Low
Required	Low	Moderate-High
Outside Demand	Very High	Low
Architecture Integration	Easy	Moderate

- Both designs could lead to spin-off technologies for Earth-based construction in dry regions

Performance

	Using Lunar soil and alumina cement	Earth materials
Compressive Strength	10.9 ksi	7.96 ksi
Static Modulus of Elasticity	1100 ksi	1800 ksi
Dynamic Modulus of Elasticity	3120 ksi	2810 ksi
Poisson’s ration at Peak Load	0.39	0.27
Modulus of Rupture	1.21 ksi	1.24 ksi
Coefficient of Thermal Expansion	$2.9*10^{-6}$ / ºF	$3.5*10^{-6}$ / ºF

Data from Lin, Construction Technology Laboratories, 1986

- Lunar based concrete is comparable to Earth based concrete
  - True for water and sulfur mixtures
- More than adequate for paving
  - Reinforcing glass fibers may be required for large structures

Architecture Integration

- ISRU Rover Tools:
  - Excavator
  - Collector
  - Grinder
  - Filter
  - Processor
  - Separator
  - Storage
  - Ejector
- Additional tools for concrete capability:
  - Mixer
  - Layer / Sprayer
  - Curer

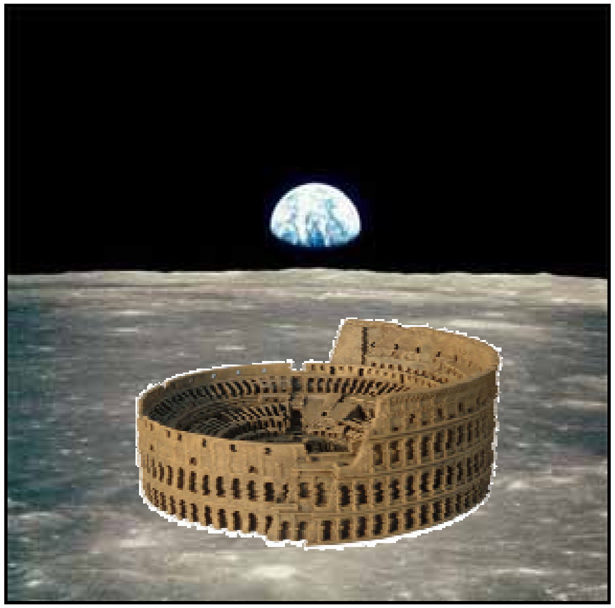
Digital Space / Colorado School of Mines

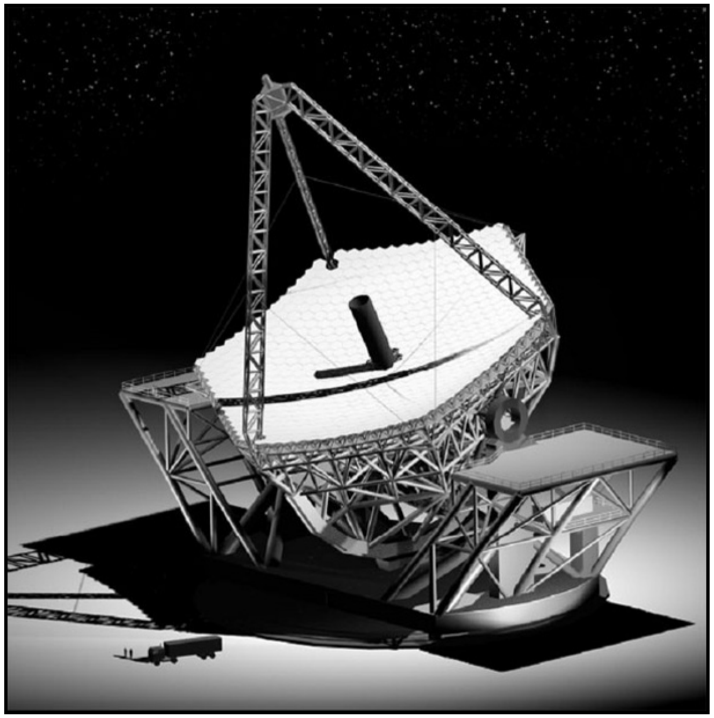
Carnegie Mellon University

Carnegie Mellon University

Research Pathway

- PAST
  - Apollo proved need for dust suppression
  - Post-Apollo proved concrete capability
- PRESENT
  - Applied concrete research
  - Integrate ISRU research
  - Increase geological data
  - Significantly aid Constellation
- FUTURE
  - Large playground
  - Launch pad barrier
  - Inflatable structure cover
  - Pressurized structure
  - Stepping stone to Mars





Challenges

- Adequate material availability?
- Appropriate processing method?
- Sufficient production rate?
- Enough operational payback?
- Amount of future infrastructure required?