Moon Geo From the Ground Up: Geotechnical and Seismic Considerations for Lunar Structures

Friday, October 16 | 11:00 AM - 1:00 PM Pacific | Virtual

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Members	**$100**
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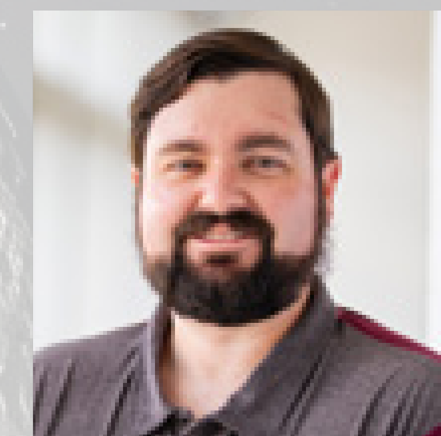
As plans advance for long-term lunar infrastructure, engineers face a familiar question in an unfamiliar environment: how do you design safely on the Moon? This two-part webinar covers lunar geotechnical history, foundation design, and seismic hazard analysis. Dr. Ryan Beemer (Virginia Tech) will cover the history of lunar geotechnical engineering and present CPT-based direct design methods for bearing capacity and settlement of shallow foundations, using data from the Apollo 16 Self-Recording Penetrometer. Tessa Williams (Slate Geotechnical Consultants) will discuss the history and characteristics of moonquakes recorded by the Apollo seismic network, then walk through a probabilistic seismic hazard analysis for lunar structures using a ground-motion model developed for shallow moonquakes.

The lunar geotechnical engineering was important for early landers and the Apollo missions. Neil Armstrong commented on the embedment of the Apollo lander footpads into the lunar regolith prior to stating his more famous quote. Our knowledge of the mechanics of regolith comes from in-situ testing or laboratory tests conducted on samples brought back to Earth during the Apollo mission. In-situ geotechnical testing of regolith will be a priority during future lunar missions to effects of sample disturbance, provide higher resolution spatial data, reduce silicosis risk in the habitats, and allows for direct transmission of geotechnical data to teams on Earth. This presentation will discuss the history of lunar geotechnical engineering, the potential for using CPT-based direct design methods on the moon, and present examples for assessing bearing capacity and settlement of shallow foundations. These simple examples are provided using data collected from the Self-Recording Penetrometer (SRP) conducted on the Moon at Station 10 of the Apollo 16 missions. Although these direct design methods were developed based on correlations from terrestrial soils, not lunar regolith the results show good agreement with traditional methods for predicting the bearing capacity and settlement of shallow foundations. These examples do not attempt to perform detailed structural or geotechnical design of any lunar foundation system. Instead, they aim to show how CPT-based methods may be used to expedite foundation assessment and to inform the next generation of lunar in-situ geotechnical testing hardware.

NASA's Apollo seismometers were deployed with a simple question in mind: is the Moon seismically active? Six years of data gave a resounding yes, including quakes whose vibrations lingered for tens of minutes to over an hour, far longer than anything recorded on Earth, and a class of shallow moonquakes that behave more like tectonic events than anyone anticipated. As plans advance for long-term lunar infrastructure, understanding this seismic environment becomes critical to structural design. Of the four known types of moonquakes (deep, shallow, thermal, and impact-induced), shallow moonquakes produced the largest signals recorded by the Apollo network and pose the greatest potential seismic hazard to future lunar structures. This presentation begins with an overview of shallow moonquake characteristics and the unique aspects of lunar ground-motion propagation, including minimal seismic attenuation compared to Earth, before discussing how this hazard is quantified for design. Building on the first ground-motion model (GMM) developed specifically for shallow moonquakes, this talk walks through a probabilistic seismic hazard analysis (PSHA) for design of new lunar structures, following the same general framework used in terrestrial seismic hazard practice: seismic source characterization, ground-motion characterization, and development of hazard curves and design response spectra. A sensitivity analysis is also presented to identify which modeling assumptions contribute most to uncertainty in the hazard estimates, highlighting priorities for future lunar seismic instrumentation and moonquake research. This talk aims to show how established terrestrial seismic hazard methods can be adapted to the unique lunar environment and to highlight the importance of considering seismic loading in the design of lunar infrastructure.



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