ME – PhD Thesis Colloquium

Investigation of consolidation methods for developing load bearing structures from lunar and martian regolith simulants

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ABSTRACT

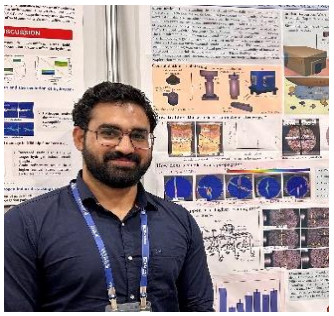
Lunar and martian surfaces provide ideal candidates for establishing extra-terrestrial human settlements, given their proximity to the earth and potential for harbouring water. Significant recent research has focused on using locally available resources for building structures – a paradigm termed in situ resource utilization (ISRU). A class of ISRU methods specifically aimed at developing inhabitable structures involves the creation of brick-like consolidates from local (lunar or martian) regolith. This work presents an investigation of ISRU based consolidation methods for regolith simulants, including development of standardized process protocols and quantification of final consolidate strength and failure mechanisms.

The first consolidation method investigated is muffle furnace-based sintering, which mimics firing processes for producing commercial clay-based bricks. A protocol for both green and brown part (bricks) production is first established, followed by evaluation of compressive (unconfined) strengths of the produced bricks. The micromechanics of particle coalescence in solid state sintering of lunar regolith is evaluated using techniques derived from classical ceramic sintering. Additionally, consolidation of regolith simulants rich in glassy basalt is studied using both solid state and liquid state sintering. Final failure modes via multiple crack nucleation and growth are also investigated. Production of bricks with compressive strengths of upto 55 MPa is demonstrated via the sintering process.

The second method involves the use of biopolymer binders to consolidate lunar and martian regolith simulants, termed biopolymer regolith composite (BRC). The use of guar and xantham gum is investigated, resulting in consolidated bricks with compressive strengths up to 15 MPa. Additionally, the consolidates are demonstrated to be resilient to large environmental changes, including thermal fluctuations and ultra-high vacuum. While the final consolidated brick strengths are lesser than that with sintering, the process is easily scalable and is significantly less energy intensive.

Finally, the use of BRC as a lower strength cementing material for joining sintered bricks in the form of a wall is studied. Failure mechanisms at the wall level, including crack paths and potential Cook-Gordon type strengthening are investigated under quasi static tension/ compression tests as well as high-velocity projectile impact.

ABOUT THE SPEAKER



Nitin is pursuing his PhD research at the Department of Mechanical Engineering at the Indian Institute of Science, Bangalore, under the guidance of Koushik Viswanathan and Aloke Kumar. Prior to this, he worked as an Assistant Professor in the Department of Mechanical Engineering at MIC College of Technology, Kanchikacherla, Andhra Pradesh. Nitin obtained his masters' degree in Materials Science and Technology from the National Institute of Technology Calicut, Kerala, 2018 and his Bachelors' degree in mechanical engineering from APJ Abdul Kalam Technical University, Lucknow, Uttar Pradesh, 2016. Apart from research, he represents IISc at various levels in cricket tournaments, including IISM and KSCA leagues and tournaments.