

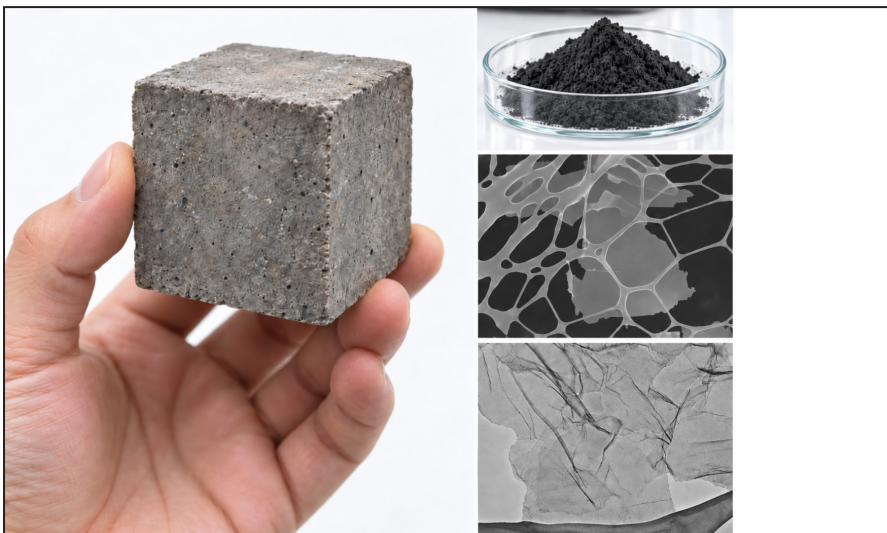
RESEARCH BRIEF

CTIPS-26-008

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September 2026

Development of an Advanced
Snow-Melting Geopolymer
Mortar Utilizing Graphene



the ISSUE

Winter road maintenance often relies on salts to melt snow and ice, but repeated salt use can damage concrete infrastructure and increase long-term maintenance needs. Researchers are exploring electrically conductive cementitious composites for self-heating, deicing, self-sensing and structural health monitoring. While fly ash, a byproduct of coal combustion, has been widely examined for beneficial use in construction materials as a replacement for concrete, researchers have not studied whether a fly ash-based low-clinker geopolymer mortar can also provide electrical functionality for smart construction applications.

the RESEARCH

This project examined whether fly ash-based geopolymer mortar containing graphene nanoplatelets (GNPs) could be developed as a lower-cement, electrically responsive material for future snow-melting applications. A key challenge in electrically functional geopolymer mortar is incorporating GNPs without reducing workability or mechanical performance. This study addresses the need to identify GNP-surfactant formulations that balance dispersion, strength, ultrasonic response, and electrical resistivity.

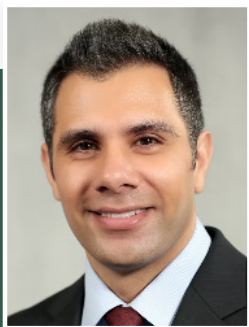
This research investigated surfactant-assisted incorporation of GNPs into fly ash-based geopolymer mortar for electrically functional construction applications. The experimental program was conducted in three phases. First, the commercial GNPs were characterized using transmission electron microscopy, scanning electron microscopy, Raman spectroscopy, and X-ray photoelectron spectroscopy to evaluate morphology, graphitic structure, and surface chemistry. Second, 48 aqueous GNP dispersions were prepared, and their macroscopic stability,

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Lead Investigator(s)

Mahmoud Shakouri, PhD
mahmoudshakouri@boisestate.edu

Research Assistant(s)

Mohammad Wais
Sulaimani, GRA, MS

Project Title

Development of an
Advanced Snow-Melting
Geopolymer Concrete
Utilizing Graphene
Nanoplatelets and
Landfilled Fly Ash

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the **RESEARCH** cont.

electrical conductivity, and pH were evaluated to select a surfactant system for mortar production. Third, 16 sodium dodecyl sulfate (SDS) GNP geopolymer mortar mixtures and four SDS-only control mixtures were produced. The mixtures were evaluated for flow-table workability, 28-day compressive strength, ultrasonic pulse velocity, and bulk electrical resistivity under two moisture conditions. Statistical analysis included two-way ANOVA, Tukey-adjusted comparisons, response-surface regression, and multi-response desirability analysis to assess formulation interactions and identify promising combinations of GNP concentration and surfactant dosage.

the **FINDINGS**

The results showed that geopolymer mortar performance depended on the combined GNP concentration and SDS-to-GNP ratio rather than GNP dosage alone. Compressive strength ranged from approximately 5.5 to 16.8 MPa, with lower GNP concentrations generally producing better strength and ultrasonic pulse velocity than the 1.00% formulations. Electrical resistivity was strongly affected by moisture condition and did not decrease consistently with increasing GNP content. Statistical analysis confirmed significant interactions between GNP concentration and SDS-to-GNP ratio for strength, ultrasonic pulse velocity, and log-transformed resistivity. Multi-response desirability analysis identified M2, containing 0.10% GNP relative to dispersion water and an SDS-to-GNP ratio of 0.5, as the highest-ranked formulation. Overall, the most promising mixtures were concentrated around 0.05%–0.10% GNP, corresponding to approximately 0.0042%–0.0085 wt.% relative to fly ash.

the **IMPACT**

This research provides a practical basis for developing electrically functional geopolymer mortar using very low GNP dosages. The study identified 0.05%–0.10% GNP relative to dispersion water, equivalent to approximately 0.0042–0.0085 wt.% of fly ash, as the most promising range for balancing mechanical and electrical performance. These findings can reduce unnecessary use of GNPs and narrow the formulation space for future testing. The results also support continued development of geopolymer-based materials for sensing, heating, and other electrically functional infrastructure applications such as snow and ice melting and structural health monitoring.

For more information on this project, download the Main report at <https://www.ugpti.org/resources/reports/details.php?id=1291>

For more information or additional copies, visit the Web site at www.ctips.org, call (701) 231-7767 or write to Center for Transformative Infrastructure Preservation and Sustainability, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.



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