MONTANA
Department of Transportation
Research

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Performance Measures Report

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More Info:

The research is documented in Report FHWA/MT-20-008/9890-784
https://www.mdt.mt.gov/research/projects/deicing-geothermal.aspx

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A FEASIBILITY STUDY OF ROAD CULVERT/BRIDGE DECK DEICING USING GEOTHERMAL ENERGY

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Montana's extreme winter weather presents persistent challenges for maintaining safe and reliable bridge infrastructure. Snow accumulation and ice bonding on bridge decks not only reduce roadway safety but also contribute to long-term concrete deterioration through freeze–thaw cycling and thermal cracking. Traditional deicing practices, such as salting and mechanical removal, are reactive, environmentally damaging, and often ineffective under extreme conditions. As an alternative, this project investigated the use of shallow geothermal energy for bridge deck deicing, offering a passive, sustainable approach to maintaining safe and durable bridges. This research established the technical feasibility of geothermal heating systems in Montana through laboratory experiments, numerical modeling, and predictive machine learning analyses. Controlled tests showed that the system can raise and maintain bridge deck temperatures above 0 °C when ambient temperatures range from 0 °C to –10 °C, using fluid inlet temperatures around 10 °C, typical of shallow wells across much of the state. Under more extreme conditions (e.g., –20 °C), the system still raised deck temperatures compared to unheated conditions, though supplemental measures may be required. Seasonal analysis suggests the system is most effective from October through November and March through April, with reduced standalone performance during peak winter months.

If implemented, geothermal heating systems could reduce reliance on chemical deicers, thereby lowering corrosion-related maintenance costs and extending bridge service life. They also reduce freeze–thaw damage and thermal strain, contributing to long-term structural integrity. Life-cycle cost-benefit analyses from other states show favorable return on investment for high-traffic locations, and ongoing work will develop a Montana-specific framework integrating machine learning and local climate and infrastructure data. This research provides MDT with a performance-validated alternative to conventional deicing methods. As the next step, mock-up field tests at sites with typical (10 °C) and elevated (50 °C) ground temperatures will validate the system under real weather conditions, followed by a full-scale implementation to assess long-term durability, safety impact, and operational reliability. The findings lay the groundwork for a more sustainable and resilient winter maintenance strategy, with the potential to reduce long-term infrastructure deterioration, enhance public safety, and optimize operational costs.

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