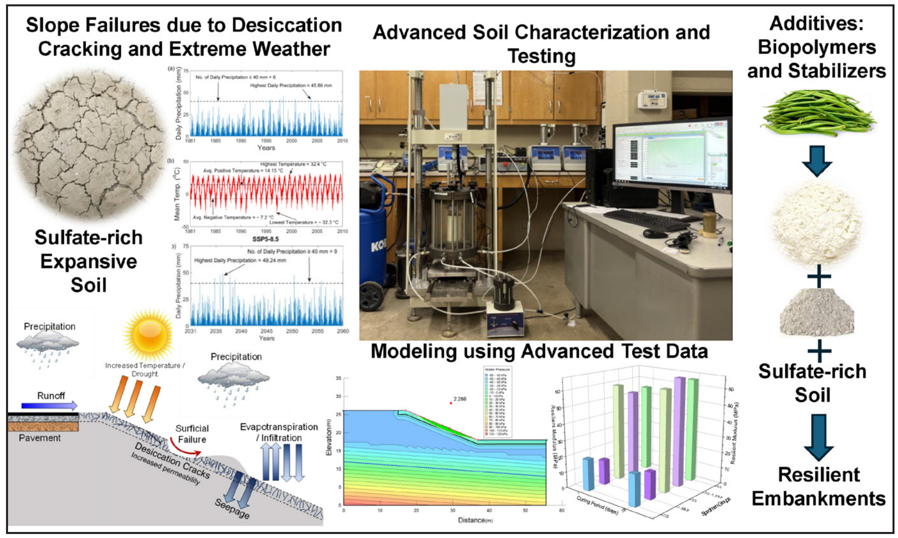
MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-530 (project 687) | July 2024

Enhancing the Resiliency of Pavement Infrastructure Built on Sulfate-Rich Expansive Soil Subjected to Climate Change



the ISSUE

Expansive soils have caused significant damage to civil infrastructure like dams, levees, pavements, bridges, retaining walls, and others. Traditional calcium-based stabilizers like lime and cement are used to enhance soil strength, reduce the plasticity of clays, and reduce the volumetric changes in soils. However, in sulfate-rich soils, these calcium-based stabilizers react with alumina and sulfate to become highly expansive in the presence of water and can cause significant issues due to their swell-shrink properties. With climate change, soils will be exposed to temperature extremes and more frequent and more significant precipitation events. Understanding how to enhance the resiliency of civil infrastructure like embankments built with sulfate-rich expansive soils when subjected to extreme weather conditions from climate change is critical.

the RESEARCH

A series of suction-controlled triaxial tests were performed to demonstrate the behavior of clayey soil from the region with varying suction levels. The stability of an embankment was analyzed based on low to moderate emissions and high emissions until the end of the century. The feasibility of using an alternative treatment method using biopolymers as a co-additive to cement was studied as a potential candidate for the treatment of sulfate-rich expansive soils.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

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North Dakota State University
South Dakota State University
University of Colorado Denver
University of Denver
University of Utah
Utah State University
University of Wyoming

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Project Title

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Civil & Environmental Engineering, SDSU

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the FINDINGS

Using climate change prediction models, a 23% increase in maximum daily precipitation and a 31% increase in the number of extreme precipitation events for high emission levels at the end of the century – compared with historical precipitation between 1981 and 2010 – was observed. In the future, precipitation intensity is predicted to be higher, with shorter intervals between extreme precipitation events. This may result in higher stresses in civil infrastructure such as embankments as compared with the original designs.

Adding cement and biopolymer proved effective in reducing the plastic characteristics and increasing the strength of the sulfate-rich expansive soil. Notably, the study revealed the effective stabilization by incorporating 6% cement and 3% cement with 1.5% biopolymer, thereby reducing the plasticity index to less than 18%.

the IMPACT

The issues with volume changes in cement-stabilized sulfate-rich soils have been demonstrated. This highlights the risk of using traditional stabilizers for soils with more than 10,000 ppm sulfate concentration. This may be applied to reduce distress on pavements and improve ride comfort. The anticipated stresses due to climate change have been demonstrated in the study. A high-emissions scenario results in a 23% increase in maximum daily precipitation and a 31% increase in the number of extreme precipitation events for a high emissions scenario. This may reduce the safety factor of embankments built with expansive soils by nearly 30%, which may be catastrophic.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1238

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.