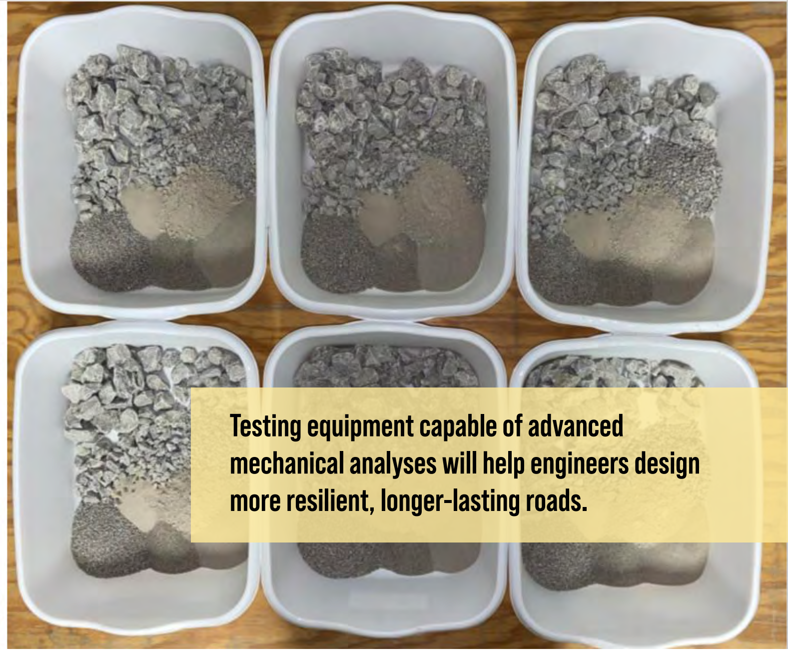

Testing equipment capable of advanced mechanical analyses will help engineers design more resilient, longer-lasting roads.

RESEARCH SOLUTIONS

Advanced testing helps characterize Iowa road base materials for improved performance

Sustainable roads depend on base, subbase, and subgrade geomaterials that provide a strong and durable foundation. Vehicle traffic and environmental conditions create complex and varied directional stresses. Iowa DOT wanted to understand how local sand, soil, and aggregate materials performed in the field. Advanced testing equipment identified the variations in stiffness against deformation of materials subjected to horizontal and vertical stresses. Testing also simulated the effect of multiple freeze-thaw cycles. The results of this research give road engineers important information to support road base material choices.

THE NEED

The performance of concrete and asphalt pavement is dependent on the foundation layers — the base, subbase, and subgrade — that support the road. The soil, stone, crushed gravel, and other geomaterials that make up the foundation layers must maintain sufficient stiffness to prevent deformation and provide durability through freeze-thaw cycles and varying traffic levels and loads. Additionally, geomaterials may exhibit different degrees of stiffness, depending on whether force or pressure is exerted from a vertical or horizontal direction (or cross-anisotropic behavior).

The characteristics of road base material are traditionally obtained from laboratory test methods, which may differ from material performance in the field and don't always meet the road design service life. Standard lab material classification techniques have not adequately replicated the loading complexities of actual traffic and environmental conditions, nor assessed the materials for force applied from different directions.

Iowa DOT and county road engineers wanted a more comprehensive testing method that would consider field stress conditions to more accurately evaluate and predict the stiffness performance of foundation materials throughout the service life and multiple seasonal changes.

(continued)

> **"This research, using equipment that can more precisely replicate actual conditions, has really changed the way we look at material strength. Results have given us strong confidence in the materials we use to support our roads."**
>
> **– LEE BJERKE,**
> **Iowa County Secondary Roads Research Engineer**

RESEARCH APPROACH

A review of the current literature on geomaterial behaviors relating to stiffness and permanent deformation under stress revealed the gap in understanding of the directional attributes of the materials. Investigators gathered 10 geomaterials (aggregates, sand, and silt), including both fine- and coarse-grained soils, from mines and quarries across Iowa. Geomaterials included six well-graded base (including variety of particle sizes), two poorly graded subbase (aggregates with uniform particle sizes), and two subgrade materials.

In the laboratory, the physical characterization of the geomaterials included particle size assessments, classification of the materials, and other physical attributes. Mechanical testing and advanced characterization of geomaterials simulated the fluctuating and multidirectional stresses of traffic loading and other field conditions on road bases. This helped measure geomaterial stiffness response to three-dimensional stress-strain.

The environmental chamber simulated eight freeze-thaw cycles on materials with differing levels of fine aggregate. Researchers measured material stiffness and other characteristics after one, four, and eight cycles, and recorded heave and settlement data during freezing and thawing.

WHAT IOWA LEARNED

Standard testing showed that base materials had the highest levels of stiffness while subgrade materials exhibited low levels. Subbase materials, although stiffer than subgrade, were less stiff due to the lack of small particle aggregates.

The advanced testing identified values of the stiffness, permanent deformation, and ratio of horizontal stiffness to vertical stiffness of each material. Differences in material stiffness increased or decreased with higher stresses depending on the direction (vertical or horizontal) that the stresses were applied. The freeze-thaw testing demonstrated that as fine aggregate increased in material, the material stiffness decreased, which has significant implications for designing roadways that are resilient to environmental conditions.

PUTTING IT TO WORK

Knowledge of the directional properties of road base materials will help engineers understand material behaviors to design more resilient and sustainable roads.

Iowa DOT is considering a second phase of this research to test more materials with a variety of gradations, including recycled aggregate, chemically stabilized soils, and geosynthetic additions to road base material. Field observations and measurements could also be integrated into the lab material characterization process and a database of cross-anisotropic (or directional) material properties developed.

ABOUT THIS PROJECT

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Final Report | Technical Brief

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PROJECT CHAMPION:
Lee Bjerke, P.E.
Secondary Roads Research Engineer
Iowa County Engineers Association Service Bureau
lee.bjerke@iceasb.org
515-239-1419

TECHNICAL ADVISORY COMMITTEE:
Chris Brakke, Mark Dell, Jeff De Vries, Todd Kinney, Ron Knoche, Brian Moore, Melissa Serio, Jacob Thorius, Wade Weiss, and Robert Younie.

PROJECT MANAGER:
Vanessa Goetz, P.E.
State Research Program Manager
Iowa Highway Research Board
Iowa DOT
vanessa.goetz@iowadot.us
515-239-1382

PRINCIPAL INVESTIGATOR:
Bora Cetin, Ph.D.
Michigan State University
cetinbor@msu.edu
336-686-1361

IOWA DOT RESEARCH:
iowadot.gov/research
ideas.iowadot.gov

IHRB IOWA HIGHWAY RESEARCH BOARD