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Knowing how oversized superloads impact pavements will help road engineers quantify damage and associated repair and rehabilitation costs.

RESEARCH SOLUTIONS

New approaches to quantify impacts of superloads on Iowa's roads

The varied configurations and heavy weights of modern agricultural vehicles and industrial equipment create a significant risk to the sustainability of roadway surfaces. A new tool will help transportation agencies quantify the damage that results from these oversized vehicles and allocate resources toward sustainable maintenance strategies for the state's road network.

THE NEED

Vehicles that exceed standard weight and dimensions — or superloads — can significantly impact road surfaces. Modern farm implements transported on tractors or tractor-trailer combinations and industrial loads such as wind turbines can equal the weight of 10,000 passenger vehicles and create substantial damage to Iowa's roadways. Fees collected through overweight vehicle permitting cover only a small fraction of road repair costs. Enforcing weight and size limits is challenging, particularly for county agencies with limited resources.

The diversity of superload characteristics prevents accurate estimations or quantification of impacts to understand the road damage and rehabilitation costs. Axle configurations and load distributions, tire types and pressures, and even vehicle travel speeds determine whether both paved and granular road surfaces can withstand the pressures of superloads. Iowa county engineers wanted a systematic approach to quantifying structural damage from superloads and associated road repair and rehabilitation costs.

RESEARCH APPROACH

To understand the impacts of superloads on the structural conditions and service lives of concrete, asphalt, and granular roads, researchers used the findings of numerical analyses to predict road surface performance when subjected to a variety of loading scenarios. A range of superload types and configurations commonly seen on Iowa county roads, including 18 agricultural and 16 industrial loads, were used to analyze approximately 33,000 concrete, 25,000 asphalt, and 3,300 unpaved road segments.

(continued)

"This project has provided a true understanding of the impacts and resulting costs of superloads on our roads."

– LEE BJERKE,
Secondary Roads Research Engineer

A life cycle analysis determined road damage costs and reductions in service lives on the three road surface types. Researchers analyzed superload-induced damage, including bottom-up and top-down fatigue cracking on concrete pavements, bottom-up fatigue cracking on asphalt pavements, and rutting on unpaved road surfaces.

Next, artificial neural network (ANN)-based models for each superload and road-type combination allowed researchers to predict road damage responses. Field data from three types of Iowa road systems, including jointed plain concrete pavement, full-depth flexible pavement, and granular road sites, validated the models by indicating the extent of structural responses such as stresses, strains, and deflections before and after a superload passed. Additionally, long-term performance monitoring data collected through remote-sensing systems, including environmental conditions and traffic loadings, supported evaluation of the data acquisition system reliability and further verified the model results.

WHAT IOWA LEARNED

Using the ANN-based models and supporting analyses, researchers created the Road Infrastructure Superload Analysis Tool (RISAT), a user-friendly spreadsheet tool, to quantify potential pavement damages, treatment costs, and reductions in road service lives due to superload stresses. With the RISAT, users can choose pavement type and properties, including layer thickness; concrete temperature gradient of layers, shoulder type, and transverse joint information; and asphalt air voids, binder, and water contents of base layers. While rutting damage supported the assessment of service life reductions of granular roads, researchers decided other distresses such as loose aggregate or washboarding would enhance predictions and did not include unpaved roads in the RISAT.

Users can identify one of seven superload types and its properties such as number, weight, and spacing of axles and number, width, and pressure of tires. Adding road and traffic information allows users to predict damage, reductions in road service life, and road damage costs associated with superloads. Validated by the field data, prediction models proved highly accurate for pavement responses.

PUTTING IT TO WORK

While some refinements to the RISAT would support ongoing work to improve pavement preservation programs, some Iowa counites are already using the tool to understand the impacts of superloads. As agricultural and industrial equipment transportation needs evolve, county engineers and Iowa DOT will be supported in determining appropriate weight limits or permit fees for superloads, making informed decisions regarding road repair and developing sustainable strategies for the state's road network.

ABOUT THIS PROJECT

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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:
Karen Albert, Lee Bjerke, Zach Gunsolley, Todd Kinney, Brian Moore, Mark Nahra, John Riherd, Brad Skinner, Jacob Thorius, and Danny Waid.

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:
Halil Ceylan, Ph.D.
Iowa State University
hceylan@iastate.edu
515-294-8051

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

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