2022 Mid-Continent Transportation Research Symposium
Ames, Iowa
September 14–15, 2022
intrans.iastate.edu/events/midcon2022/

Gradation Optimization for Improved Performance of Granular-Surfaced Roads

Jeramy Ashlock, Iowa State University
Bora Cetin, Michigan State University

Abstract

Aggregates for surfacing granular roads can consume significant portions of county budgets. Improving the longevity of granular roads by optimizing the strength of surfacing materials will reduce the consumption of virgin aggregate required for surfacing, as well as the frequency of required maintenance. As a result, counties will consume fewer aggregates which are finite natural resources, leaving more funds to devote to other pressing social, economic, and environmental needs.

To this end, a Gradation Optimization tool was developed in IHRB Project TR-685 to help determine the optimal blends of granular roadway surfacing materials to give the tightest particle packing and highest strength as measured by California Bearing Ratio (CBR) tests. The tool allows engineers to input and analyze gradations of locally available virgin quarry materials, with the option to recycle existing surfacing materials into the mixture.

In the current Phase II Project TR-797, the accuracy of the Gradation Optimization tool is being expanded by more extensive testing of a wider range of granular surfacing materials than the low-strength crushed limestone that was originally used to develop the tool. The potential material types to be investigated include crushed river gravel, higher strength limestone, dolomitic limestone, and various other granular surfacing materials used in different regions of Iowa. Additionally, the optimization method will be expanded beyond CBR tests to include stiffness and permanent deformation properties from resilient modulus tests, as well as laboratory freeze-thaw and gyratory compaction tests. Image analysis of the gravel fractions will be performed before and after gyratory compaction tests to quantify changes in gradation as well as particle sphericity and roundness.

To measure the real-world performance of the gradation optimization tool for a range of surfacing aggregates, test sections will be constructed and monitored in two Iowa counties. Laboratory tests will be conducted on samples of surface and subgrade materials from the test sections collected before and after the winter-spring freeze-thaw period. Field tests will also be conducted to measure the relative performance of the test sections before freezing and after thawing. The field tests will include dynamic cone penetrometer (DCP) tests for strength profiles, lightweight deflectometer (LWD) and falling weight deflectometer (FWD) tests for stiffness, and nuclear gauge tests for density and moisture content. The gradations will also be measured after the spring thaw to determine how they changed due to material loss and breakage. The field test data will be analyzed to compare the performance of the control and test sections to quantify the amount of improvement offered by the optimized gradation method.

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The research project aligns with the Iowa DOT focus areas of sustainability and technology. This project will generate a more broadly applicable version of the Gradation Optimization tool, which county engineers can use to achieve improved longevity of granular roadway surfaces. The tool also represents a technological shift towards performance-based engineering design of granular roadways, which are typically constructed based on experience and rules of thumb. Overall, the long-term benefits of the proposed project will be to improve the quality, longevity, and state of good repair of Iowa roadways, which constitute a vital component of Iowaâ€™s infrastructure.

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