# Validation of Gyratory Mix Design in Iowa – Phase II

tech transfer summary

**This project was primarily a laboratory-based validation study of the Iowa DOT's newer mix design specifications for asphalt pavements.**

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**RESEARCH PROJECT TITLE**
Validation of Gyratory Mix Design in Iowa – Phase II

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## Background and Problem Statement

The use of asphalt pavements, which cover about 94% of paved roads, have gradually increased since the late 19th century (Roberts et al. 1991). The mix design of asphalt pavements has undergone continual evolution since initial development, relying heavily on empirical knowledge. In the US, the Superior Performing Asphalt Pavement (Superpave) mix design method is used in most states.

One of the most important factors in mix design is the compaction effort, or number of gyrations of the asphalt mixture, which is denoted as the design number of gyrations ($N_{design}$). $N_{design}$ is one of the most significant design considerations/parameters in the laboratory and is selected based on the corresponding number of equivalent single-axle loads (ESALs) for the proposed pavement structure.

## Study Overview and Objectives

All mixes used for this study were field-produced and laboratory-compacted for both new and old $N_{design}$ values. The field-produced mixes were collected from Iowa Department of Transportation (DOT) storage units, and asphalt remix and compaction were according to Superpave mix design and Iowa local performance testing.

Performance tests will help to evaluate the effect of changing the $N_{design}$ value on mixture performance. The laboratory-compacted mixes were used for all performance tests. The key objective of the study was using performance tests at the optimal binder content for a given $N_{design}$ to indicate the differences due to changing the number of gyrations.

Performance tests such as dynamic modulus, flow number, Hamburg wheel track, 4-pt beam fatigue and disk-shaped compact tension were used to evaluate stiffness, rutting/moisture susceptibility, fatigue resistance, and resistance to low-temperature cracking; the results helped in determining if significant differences exist between the old and new $N_{design}$ specifications.

The last objective of the laboratory study was to take results from dynamic modulus testing and site location information to use in The American Association of State Highway and Transportation Officials' (AASHTO's) AASHTOWare Pavement Mechanistic-Empirical (ME) Design software to forecast long-term pavement performance impacts in changing the asphalt content or $N_{design}$. The mixture properties and binder data from the supplier were used to forecast the pavement performance in 20 years. If differences were detected between material properties, the computer model helped to show how material properties would influence performance over time.

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The Asphalt Materials and Pavements Program (AMPP) at InTrans specializes in improving asphalt materials and pavements through research and technology transfer and in developing students' technical skills in asphalt.



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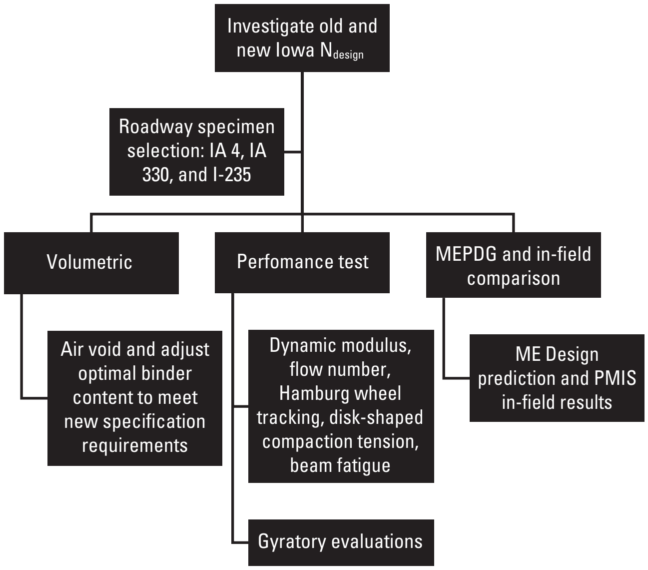


*Experimental plan for the study*

## Experimental Plan Summary and Goal

This Phase II study included performance evaluation of the field mixes being produced to ensure performance expectations were being met for rutting, moisture susceptibility, fatigue and low-temperature cracking. Phase II was conducted as a laboratory study with the goal of addressing the mix design process and identifying how changes in $N_{design}$ influence performance over a pavement's lifetime.

The differences between AASHTOWare Pavement ME Design software predictions and Iowa DOT Pavement Management Information System (PMIS)-field performance data were also investigated.

Loose mixes were sampled for subsequent testing. Concurrently, a mix design analysis for each of the new ESAL levels using the source aggregates and binder from the field construction projects were re-evaluated for mixture design. The $N_{design}$ was validated using traditional mix design procedures by varying asphalt content to compact to 4% air voids. The four tasks that were part of the first and second objectives in the study were about the mix design analysis, as follows:

- Evaluate the ultimate in-place densities by performing volumetric testing on ≤1 million ESALs (on IA 4 pavements), 1–10 million ESALs (on IA 330 pavements), and >10 million ESALs (on I-235 pavements) for design level surface mixes
- Determine the compatibility of the mixes under the existing mix design procedures by recalculating the gyratory slope from the quality control and quality assurance (QC/QA) data
- Estimate and compare the post-construction compaction effort for each selected project and determine the theoretical $N_{design}$ at construction and post-construction
- Evaluate the optimal asphalt contents and aggregate structures due to different $N_{design}$ values adopted for the mixtures under the three different traffic levels

## Key Findings

- New $N_{design}$ mixtures had higher dynamic modulus than old $N_{design}$ mixtures. However, the differences were not significant according to statistical analysis.
- New $N_{design}$ mixtures had better rutting resistance than old $N_{design}$ mixtures according to flow number test results. The statistical analysis showed only IA 4 (lowest traffic level) mixtures had a significant difference between old and new $N_{design}$ specifications. IA 330 and I-235 (with medium and highest traffic level) mixtures showed no statistical differences.
- With the Hamburg wheel tracking tests, new $N_{design}$ mixtures showed better performance and lower rutting than old $N_{design}$ mixtures. IA 330 and I-235 had statistical differences between the two specifications. No significant difference was found with IA 4 specimens.
- New $N_{design}$ mixtures showed better low-temperature performance than old $N_{design}$ specimens according to DCT results. New $N_{design}$ specimens had higher fracture energy than old $N_{design}$ specimens.
- Better fatigue cracking resistance was observed in new $N_{design}$ mixes based on beam fatigue test results. New $N_{design}$ mixtures afforded more cycles to failure than old $N_{design}$ mixtures.

## Implementation Readiness and Benefits

The results of this study provide detailed information verifying current $N_{design}$ levels in Iowa and provide glimpses into how $N_{design}$ might be improved based on performance testing data and $N_{design}$ correlations to field density. The advantages of the new $N_{design}$ included reduced gyratory compaction cycles and increased binder content, while the binder type and gradation did not change within specimens made using the old and new $N_{design}$ levels.

The results also showed how changes to $N_{design}$ impact rutting and mixture stiffness as well as predicted pavement performance. However, Iowa DOT PMIS and AASHTOWare Pavement ME Design result comparisons were not perfect.

The possible reasons could be that there is insufficient level 1 input data into ME Design or there could be other reasons that need to be further investigated. In this study, only laboratory-measured values such as dynamic modulus and dynamic shear rheometer (DSR) were used in ME Design as level 1 inputs. Additional research should be undertaken.

## Reference

Roberts, F. L., P. S. Kandhal, E. R. Brown, D.-Y. Lee, and T. W. Kennedy. 1991. *Hot Mix Asphalt Materials, Mixture Design, and Construction*. 1st edition. National Asphalt Pavement Association (NAPA) Education Foundation, Lanham, MD.