FIELD DENSITY INVESTIGATION OF ASPHALT MIXTURES IN MINNESOTA

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Importance of Field Density

Durability related distresses has become the most prevalent distresses since the implementation of Superpave mix design in the late 1990s [4]. Durability issues, to a great extent, can be attributed to inadequate field density. The importance of the as-constructed field density is emphasized by Linden et al. [2] who found that "a 1 percent increase in air voids (over the base air-void level of 7%) tends to produce about a 10 percent loss in pavement life."

To improve durability, many agencies have proposed modifications to the traditional Superpave mix design to improve field densities. For example, WisDOT implemented a method called "regressing air voids" [3]; INDOT implemented the "Superpave 5 mix design method" [1].

Minnesota Department of Transportation (MnDOT) and University of Minnesota have started working on developing a high-density mix design method based on the use of locally available materials.

Objectives

This study investigates the current situation of field density in Minnesota, with the goal of answering the following questions:

- What is the current level of field density in Minnesota? How much improvement is needed to achieve the desired field density?
- Are field compaction (field density) consistent with laboratory compaction (N_{design}) ?
- What options are available in the current mix design, to increase compactability and field density?

Field Density Distribution

15 projects in Minnesota constructed in 2018 and 2019 were investigated. Densities of 1354 field cores were collected from the QC&QA phase of the 15 projects. The density ditribution is shown in the following figures.

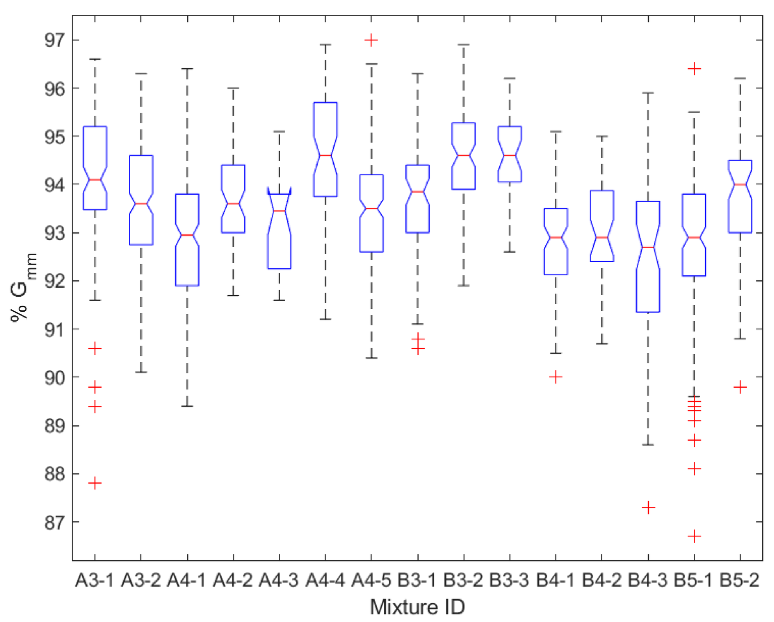

Fig. 1: Boxplots of the 15 projects studied

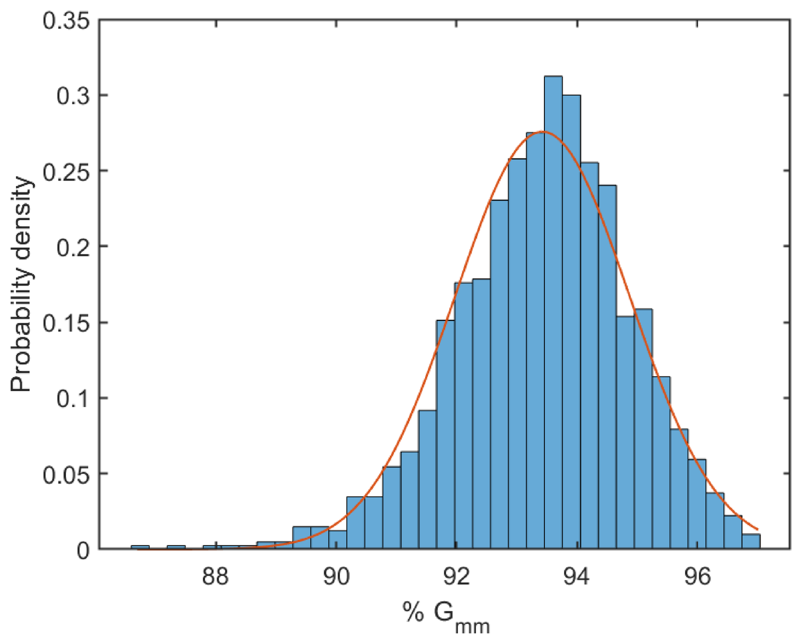

Fig. 2: Field density distribution of all field cores

Statistics of the field density data

Statistics	Mean, %	Median, %	Std., %	Skewness	Kurtosis
Value	93.4	93.5	1.45	-0.44	3.68

Effect of NMAS & Traffic Level on Field Density

The 15 projects can be grouped by their nominal maximum aggregate size (NMAS) and traffic level. A two-way ANOVA is conducted in this section to investigate effect of these two factors on the variation of field densities.

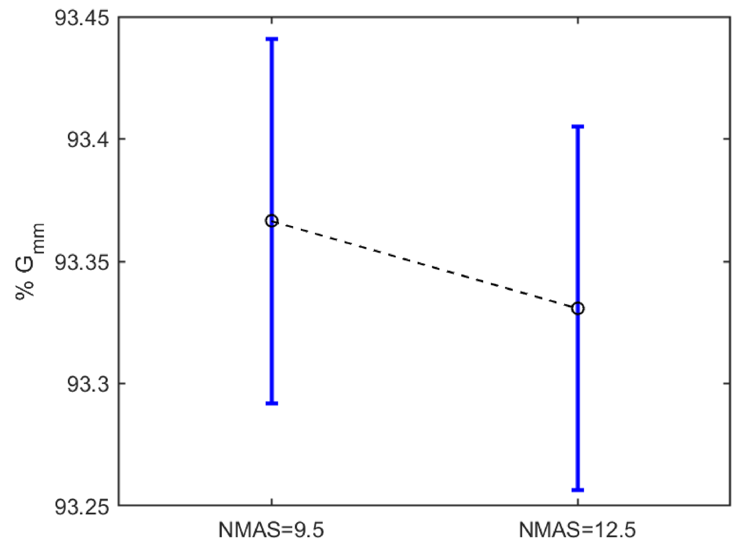

Fig. 4: Effect of NMAS on field density

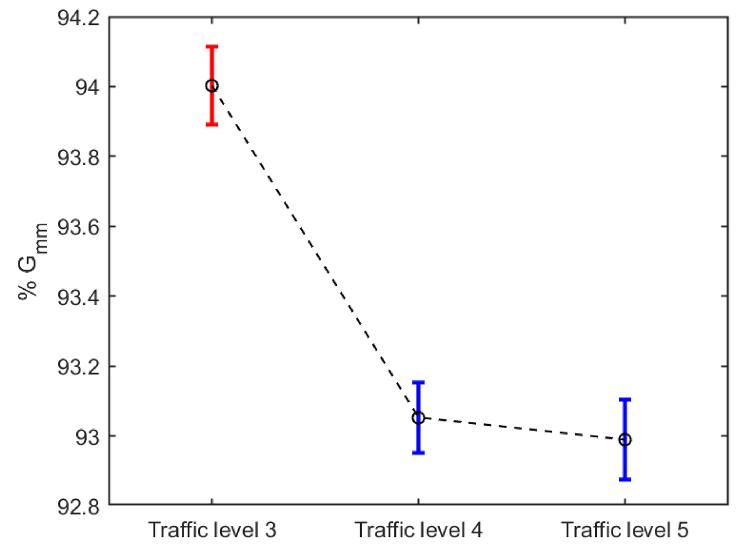

Fig. 5: Effect of design traffic level on field density

Fig. 4 shows that there is a slight downwards trend in field density as NMAS increases. Fig. 5 shows that field density is lower for project of higher traffic levels.

Correlation Analysis

A correlation analysis is conducted between mixtures' compaction properties and material properties. Field and lab compaction properties are represented by field densities (FD) and N_{design} respectively. The following material properties are investigated:

- Binder content: AC
- RAP content: RAPC
- NMAS
- Aggregate angularity:
  - Fine aggregate angularity: FAA
  - Coarse aggregate angularity of one and two faces: CAA1 and CAA2
- Aggregate gradation:
  - Bailey method parameters: PCSI, CA, FA_c, and FA_f
  - Distance to maximum density line: D_{mdl}

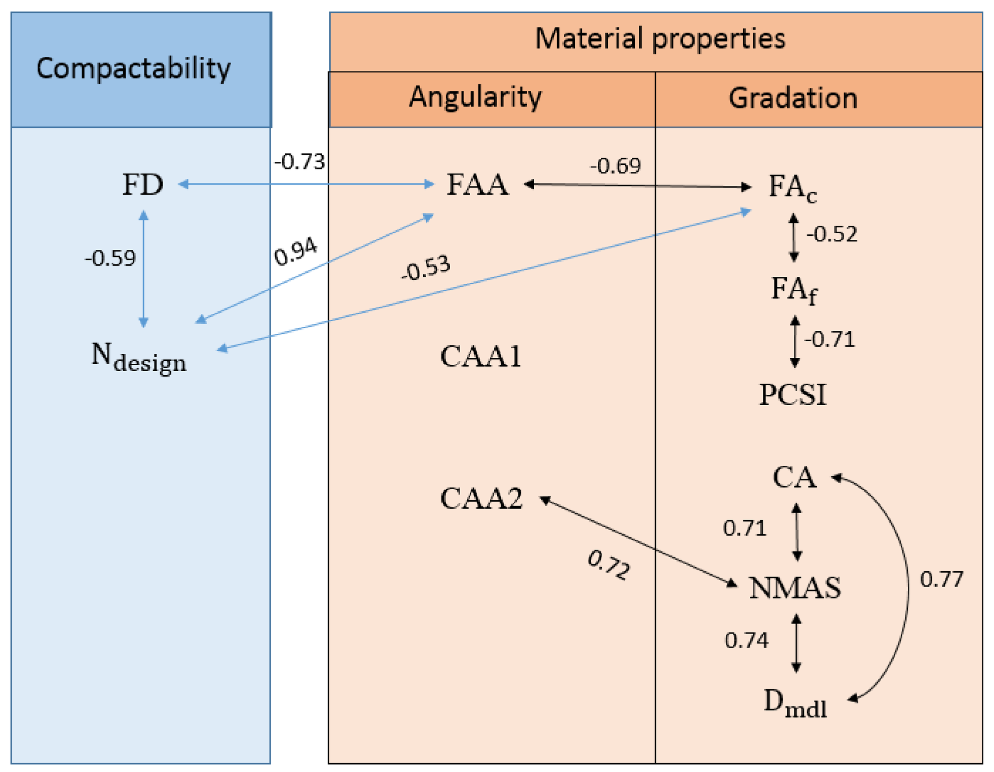

Fig. 6: Correlations between compactability and material properties

Fig. 6 illustrate the identified correlations. Values above the arrows are the correlation coefficients.

Conclusions

The following conclusions were drawn from this study.

- The as-constructed field density data obtained from 15 projects in Minnesota, approximately follows a **normal distribution**, with a **mean** of **93.4** % G_{mm}, and a standard deviation of 1.45 % G_{mm}.
- The **vast majority** (87%) of field cores are **less dense** than the **desired** field density level, 95% G_{mm} [1]. We suggest that compactability of mixtures to be considered in the mix design process.
- Field densities vary significantly between mixtures designed for different traffic levels. **Higher field densities are achieved for mixtures designed for lower traffic levels**, which can be **attributed to** the different requirements for $\mathbf{N_{desing}}$ and **aggregate angularity** compared to mixtures designed for higher traffic levels.
- Field density is significantly correlated to N_{desing} of mixtures. **Higher field density is achieved with lower $\mathbf{N_{desing}}$**, which shows the **consistence between field compaction and laboratory compaction**, and indicates that **field density can be controlled in the mix design phase choosing an appropriate $\mathbf{N_{desing}}$**.
- Field density is significantly correlated to fine aggregate angularity and fine aggregate gradation. **Higher field densities are achieved using a lower fine aggregate angularity and a finer coarse portion of fine aggregate**. Both fine aggregate angularity and fine aggregate gradation affect **fine aggregate packing**.

The results of this research indicate that a possible way to design more compactable mixtures, is to optimize fine aggregate packing to improve compactability, while concurrently optimizing coarse aggregate packing to ensure that rutting resistance is not sacrificed.

Acknowledgements

The authors gratefully acknowledge MnDOT for providing the financial support, and materials and data collection. The authors also acknowledge the input provided by Gerry Huber, and by Dr. Reyhaneh Rahbar-Rastegar, and Dr. Ervin Dukatz during this investigation.

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