COMPACCTION MONITORING SYSTEM FOR ASPHALT PAVEMENTS

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Motivation

Variability of field density due to unequal coverage and overlapping

Density has a great effect on the performance

Typical Air Void Distribution in a Field Project
Objectives

- Study the effect of the following factors on mixture compactability: compaction method, mixture type, support condition, temperature

- Verify the concept of the Compaction Index; as a tool to control uniformity of asphalt pavement compaction

- Study the effect of joint conditions (restricted vs. unrestricted) on the density of the longitudinal joints

- Propose a method for predicting the density of asphalt pavements in the field.

Construct Test Sections

<table>
<thead>
<tr>
<th>Test Section</th>
<th>Mixture Type</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2-in Type C PG 76-22, HMA</td>
<td>Concrete Runway</td>
</tr>
<tr>
<td>2</td>
<td>2-in Type D PG 64-22, HMA</td>
<td>Concrete Runway</td>
</tr>
<tr>
<td>3</td>
<td>2-in Type D PG 64-22, WMA</td>
<td>Concrete Runway</td>
</tr>
<tr>
<td>4</td>
<td>2-in Type C PG 76-22, HMA</td>
<td>Asphalt Taxiway</td>
</tr>
<tr>
<td>5</td>
<td>2-in Type D PG 64-22, HMA</td>
<td>Asphalt Taxiway</td>
</tr>
</tbody>
</table>

- Compaction methods; static, vibratory, and pneumatic
- Asphalt mixtures; HMA (Type C & D), and WMA (Type D)
- Base conditions; rigid and flexible
- Joint conditions; restricted, un-restricted
- Temperature; designed compaction temp & lower temp.
Compaction Pattern

- Transition Zone
- Sub-Test Section #5: Vibratory and Pneumatic
Efficiency Distribution of the Compactive Effort

The center of the roller has better compaction effectiveness than the edge.

Efficiency Factor = 0.4 0 0

Evaluate the Efficiency Distribution of the Compactive Effort across the Roller Width

Compaction Index (CI) = Σ (number of passes * EF of each pass)

<table>
<thead>
<tr>
<th>Test Section #</th>
<th>Compaction Method</th>
<th>R-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type C HMA on Rigid</td>
<td>Static</td>
<td>0.44 0.82</td>
</tr>
<tr>
<td></td>
<td>Vibratory</td>
<td>0.52 0.83</td>
</tr>
<tr>
<td>Type D HMA on Rigid</td>
<td>Static</td>
<td>0.60 0.63</td>
</tr>
<tr>
<td></td>
<td>Vibratory</td>
<td>0.68 0.81</td>
</tr>
<tr>
<td></td>
<td>Vibratory*</td>
<td>0.81 0.88</td>
</tr>
<tr>
<td>Type D WMA on Rigid</td>
<td>Static</td>
<td>0.87 0.79</td>
</tr>
<tr>
<td></td>
<td>Vibratory</td>
<td>0.89 0.87</td>
</tr>
<tr>
<td></td>
<td>Vibratory*</td>
<td>0.84 0.91</td>
</tr>
<tr>
<td>Type C HMA on Flex.</td>
<td>Static</td>
<td>0.54 0.93</td>
</tr>
<tr>
<td></td>
<td>Vibratory</td>
<td>0.57 0.93</td>
</tr>
<tr>
<td></td>
<td>Vibratory*</td>
<td>0.47 0.75</td>
</tr>
<tr>
<td>Type D HMA on Flex.</td>
<td>Static</td>
<td>0.27 0.81</td>
</tr>
<tr>
<td></td>
<td>Vibratory</td>
<td>0.18 0.76</td>
</tr>
<tr>
<td></td>
<td>Vibratory*</td>
<td>0.27 0.76</td>
</tr>
</tbody>
</table>

*These test sections were compacted at lower temperatures
Influence Compaction Method and Temperature

Vibratory rollers applied more compactive effort on the mat than the static rollers.

On average, there was 10% increase in the measured percent air voids per 30°F reduction in the compaction temperature.

Influence of Mixture Design and Base Type on Density

WMA is easier to compact than the HMA; vibratory rollers.

HMA over a rigid base, had slightly higher density than the corresponding mixtures on a flexible base.
Proposed Method for Prediction of the Density Level in Real-Time

Test Section # 5

No. of Passes | Compaction Pattern | Predicted %AV | Measured %AV
--- | --- | --- | ---
4 | Static | 10.5 | 8.9
5 | Vibratory | 9.8 | 9.6
6 | Static | 9.2 | 8.9
7 | Vibratory | 9.2 | 8.9

Proposed Method for Prediction of the Density Level in Real-Time

Predicted and Measured Percent Air in the middle of the mat
Field Validation

- Good correlation between predicted and measured air voids
- This prediction is based only on one compaction curve (BD); for more accurate prediction, separate compaction curves required

An example of Compaction Curve for BD Roller; SH 31

Correlation between predicted and measured % air voids for some field projects
Phase II: Compaction Monitoring System

Compaction Index

Number of Passes

Mat Temperature

X-axis is the width in feet

Color-Coded Coverage
Real Time Display

Roller Paths
Number of Passes
Compaction Index
Mat Temperatures

Compaction Data from US 87 recorded using CMS
Roller equipped with GPS and IR sensors

Efficiency distribution of the compactive effort

Location of the roller in real-time

Temperature of the mat in real-time

CMS Software

Roller compaction curve

\[ y = 11.64x^{0.33}, \quad R^2 = 0.93 \]

No. of Passes

Account for density reduction due to compaction

Density prediction in real-time

% Air Voids

No. of Passes

GPS Satellite

Main Station
Questions