COMPACTION MONITORING SYSTEM FOR ASPHALT PAVEMENTS

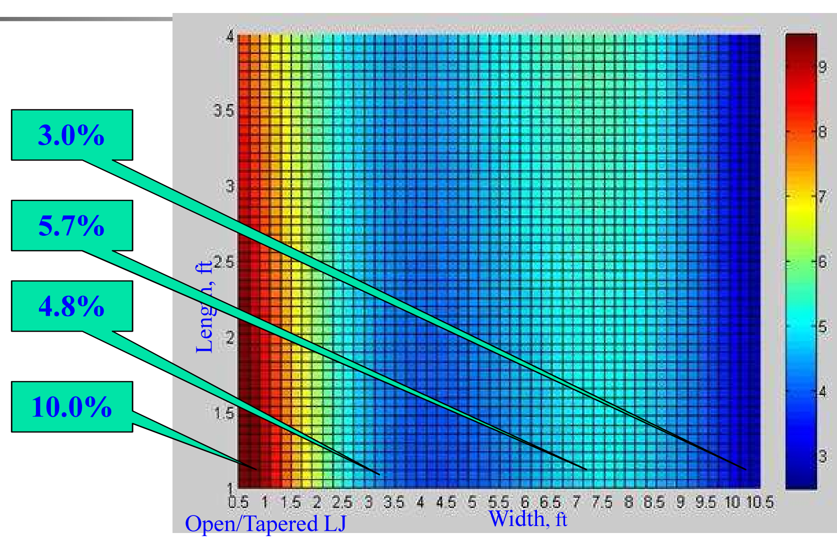
Emad Kassem, Tom Scullion, Eyad Masad, Arif Chowdhury, and Wenting Liu

October 22, 2015.

Texas Transportation Institute

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

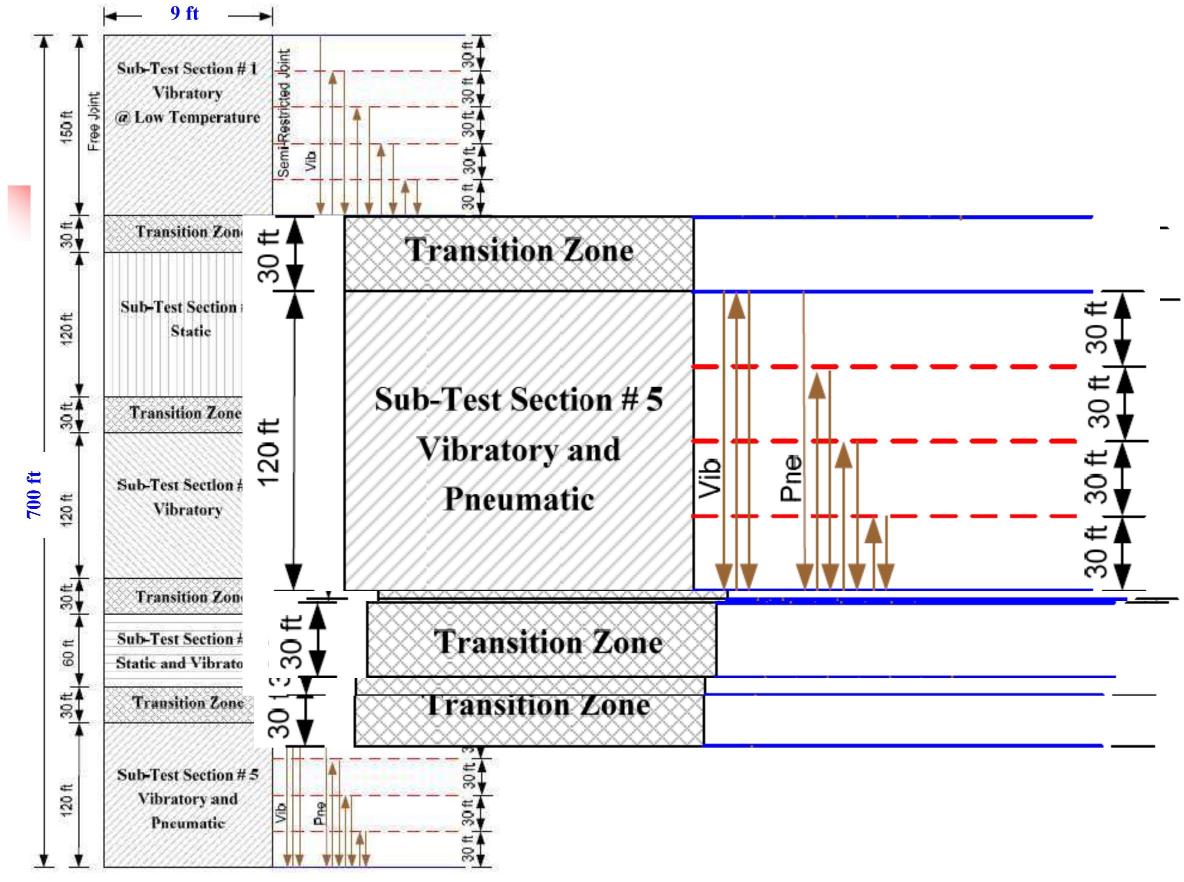
Objectives

- 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.

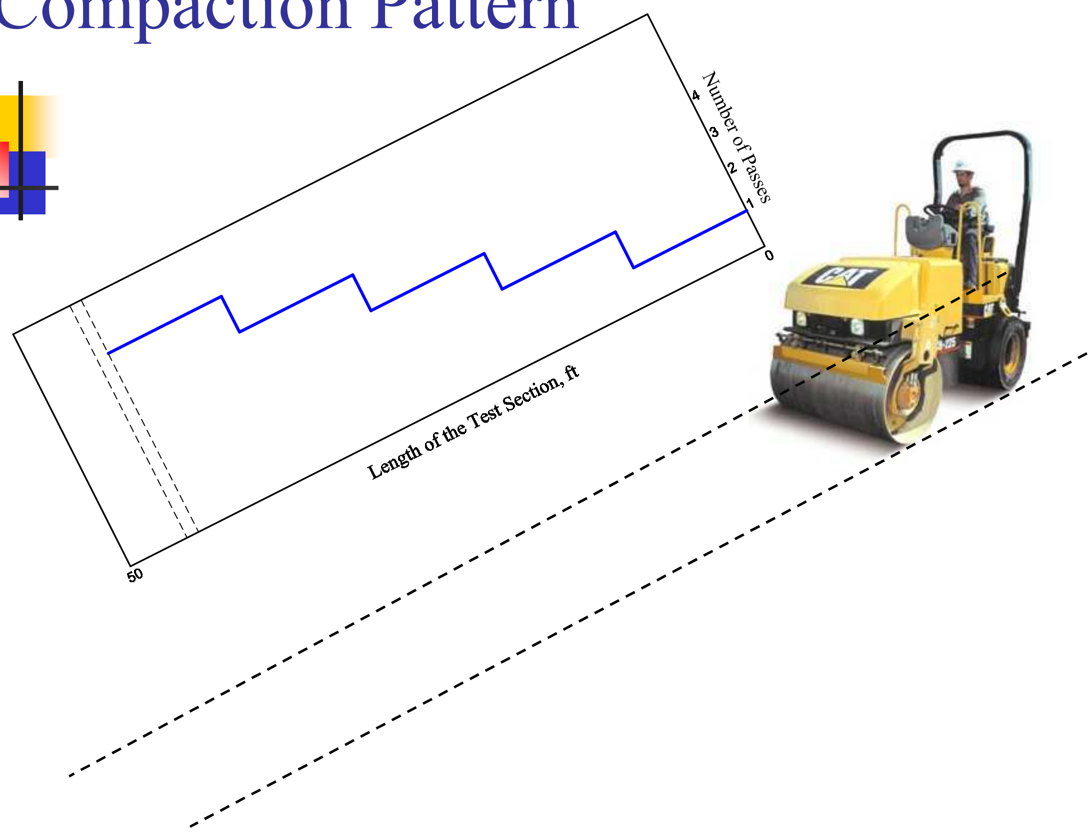
Construct Test Sections

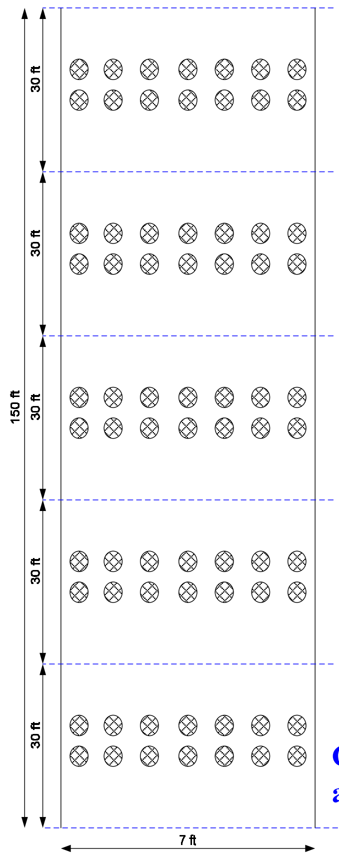
Test Section	Mixture Type	Support
1	2-in Type C PG 76-22, HMA	Concrete Runway
2	2-in Type D PG 64-22, HMA	Concrete Runway
3	2-in Type D PG 64-22, WMA	Concrete Runway
4	2-in Type C PG 76-22, HMA	Asphalt Taxiway
5	2-in Type D PG 64-22, HMA	Asphalt Taxiway

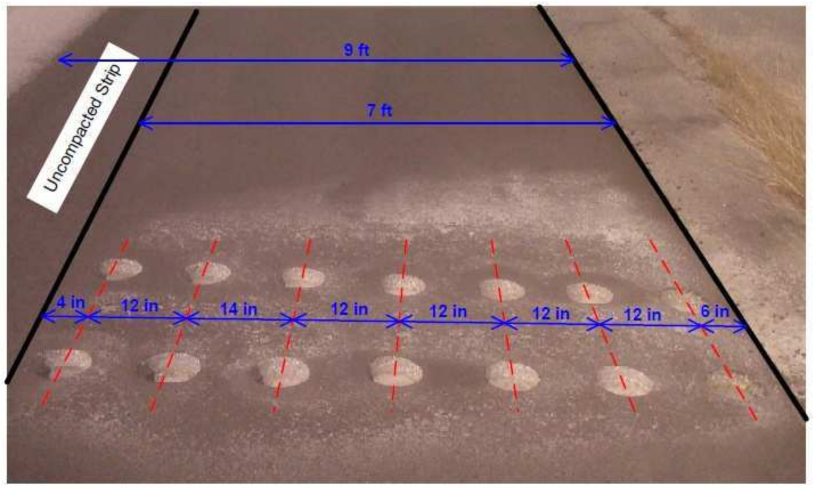
- Compaction methods; static, vibratory, and pneumatic
- Asphalt mixtures; HMA (Type C & D), and WMA (Type D)
- Base conditions; rigid and flexible
- Joint conditions; restricted, un-restricted
- Temperature; designed compaction temp & lower temp.



Compaction Pattern



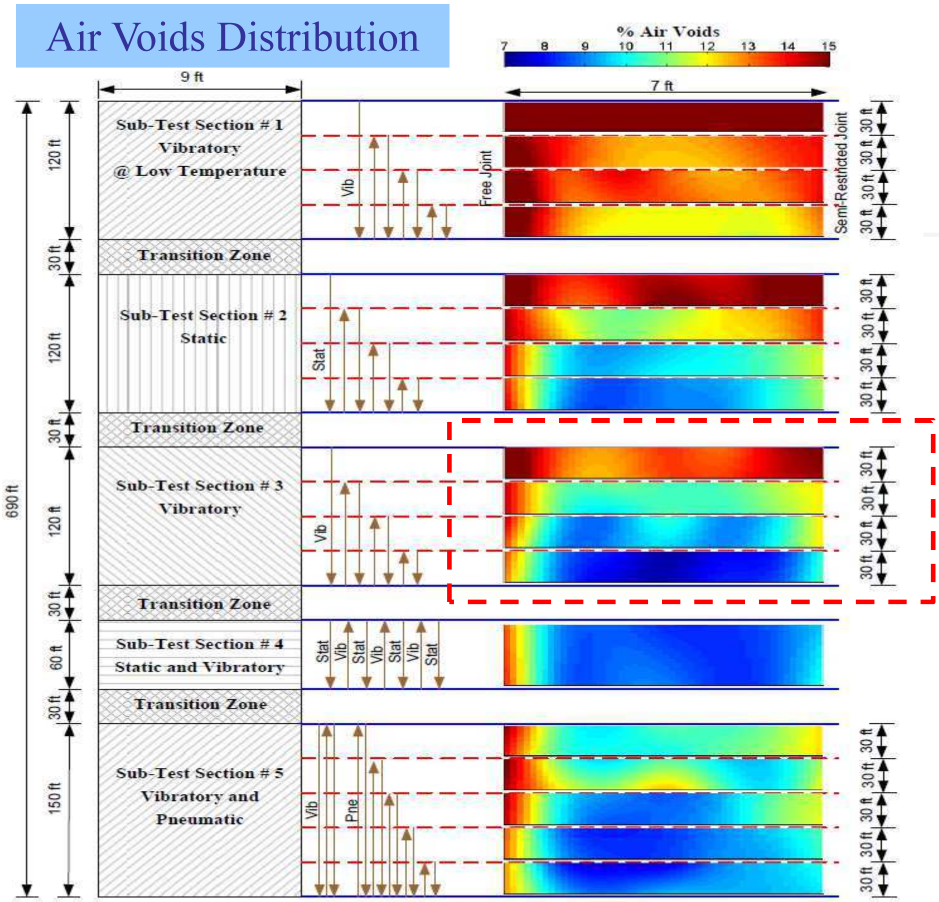




Coring Layout

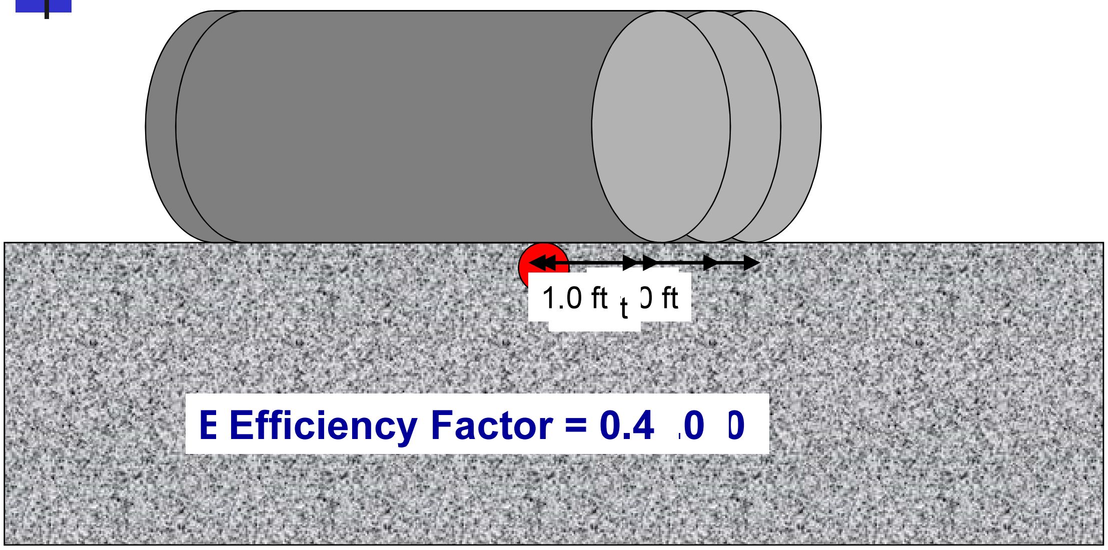
Coring Layout of
a Sub-test Section

Air Voids Distribution



Efficiency Distribution of the Compactive Effort

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



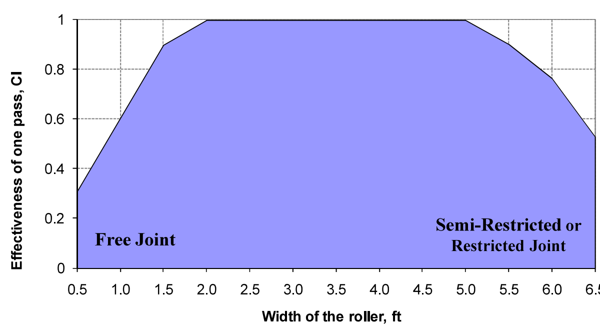
Evaluate the Efficiency Distribution of the Compactive Effort across the Roller Width

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

R-squared Values

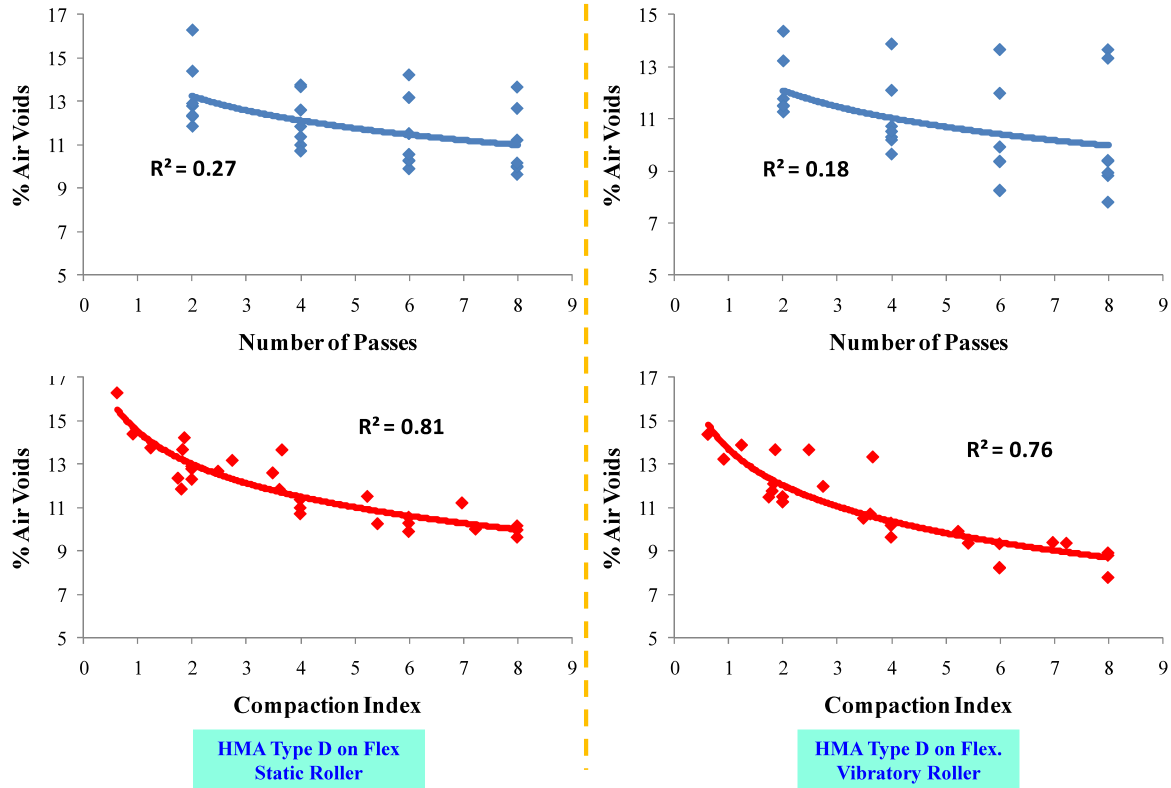
Test Section #	Compaction Method	R-squared	
		%AV vs. N	%AV vs. CI
Type C HMA on Rigid	Static	0.44	0.82
	Vibratory	0.52	0.83
Type D HMA on Rigid	Static	0.60	0.63
	Vibratory	0.68	0.81
	Vibratory*	0.81	0.88
Type D WMA on Rigid	Static	0.87	0.79
	Vibratory	0.89	0.87
	Vibratory*	0.84	0.91
Type C HMA on Flex.	Static	0.64	0.93
	Vibratory	0.57	0.93
	Vibratory*	0.47	0.75
Type D HMA on Flex.	Static	0.27	0.81
	Vibratory	0.18	0.76
	Vibratory*	0.27	0.76

*These test sections were compacted at lower temperatures

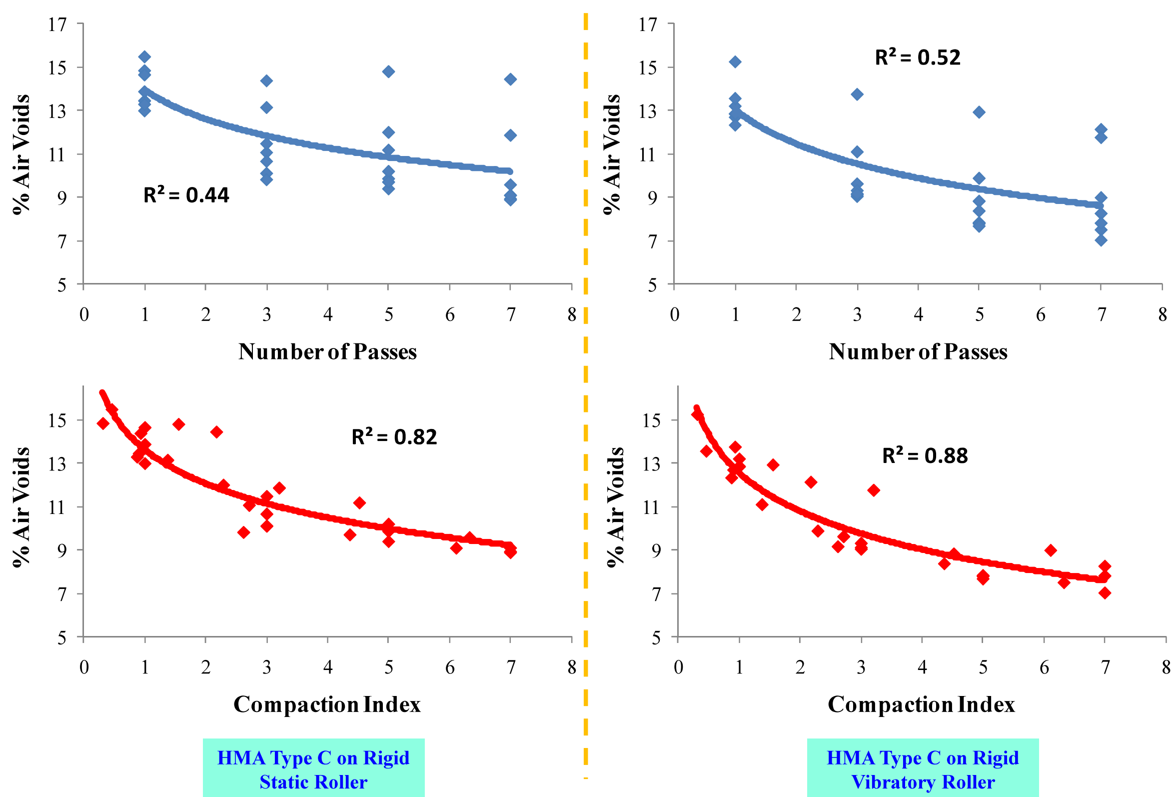


Efficiency Distribution of the Compactive Effort across Roller Width

Examples of Correlations

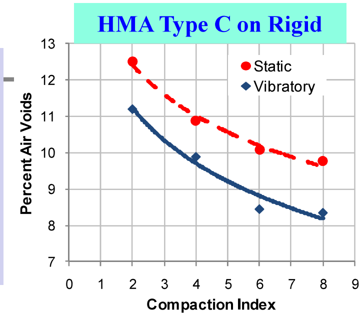


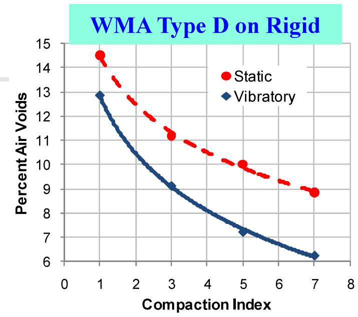
Examples of Correlations



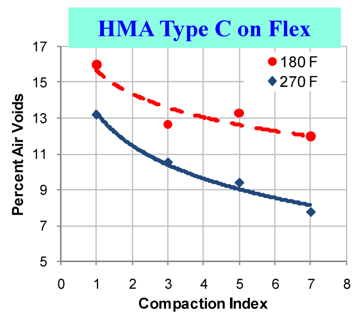
Influence Compaction Method and Temperature

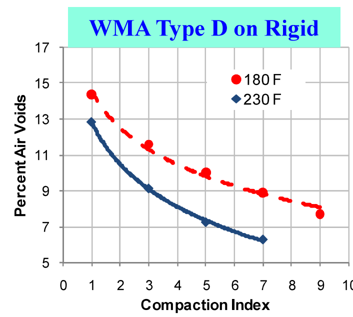
Vibratory rollers applied more compactive effort on the mat than the static rollers





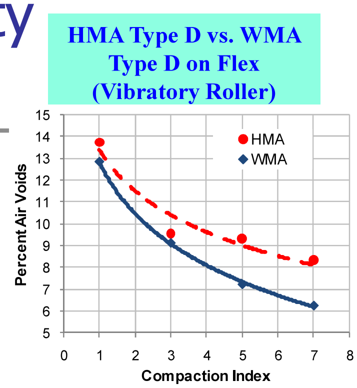
On average, there was 10% increase in the measured percent air voids per 30°F reduction in the compaction temperature

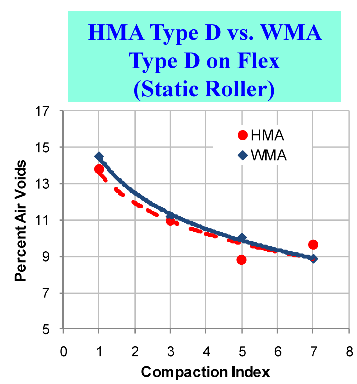




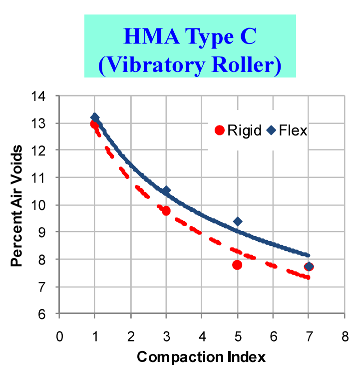
Influence of Mixture Design and Base Type on Density

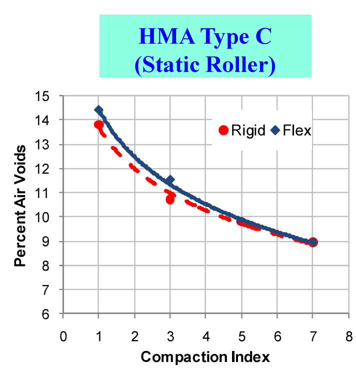
WMA is easier to compact than the HMA; vibratory rollers



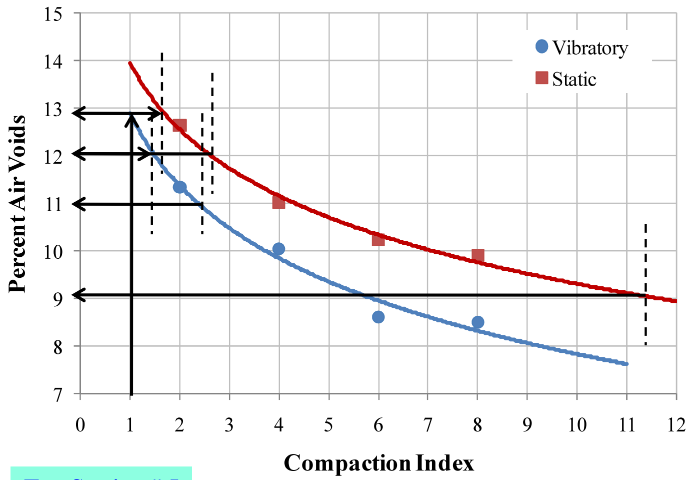


HMA over a rigid base, had slightly higher density than the corresponding mixtures on a flexible base



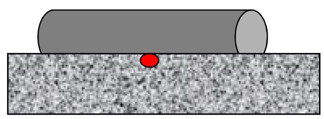


Proposed Method for Prediction of the Density Level in Real-Time

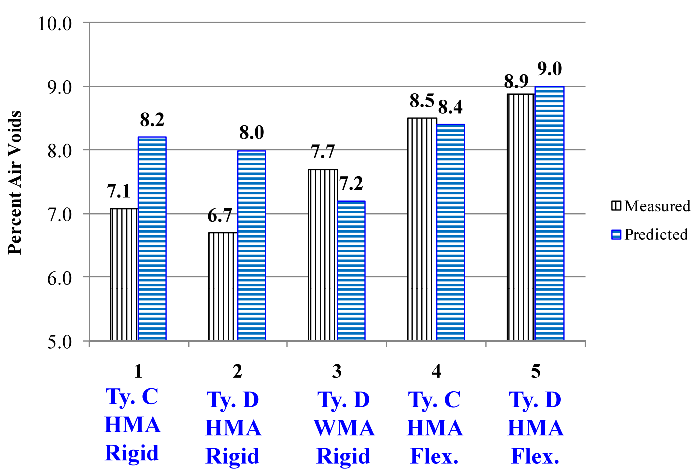


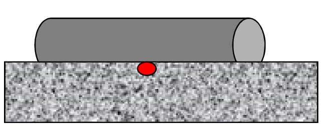
No. of Passes	Compaction Pattern	Predicted %AV	Measured % AV
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
4	Static	10.5	
5	Vibratory	9.8	
6	Static	9.6	
7	Vibratory	9.2	
[illegible]	[illegible]	[illegible]	8.9

Test Section # 5

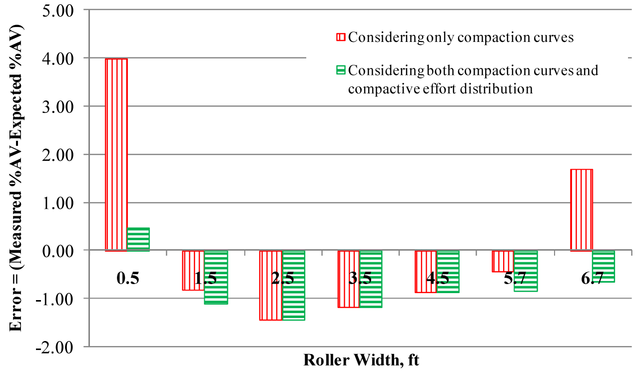


Proposed Method for Prediction of the Density Level in Real-Time

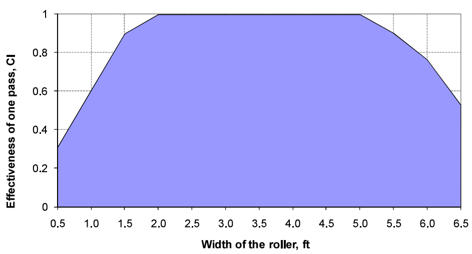




Predicted and Measured Percent Air in the middle of the mat

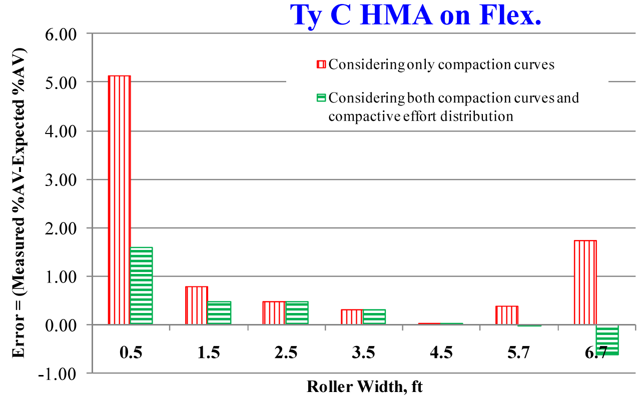


Error in Predicting Density Level for Test Section 1; Ty C HMA on Rigid



Efficiency Distribution

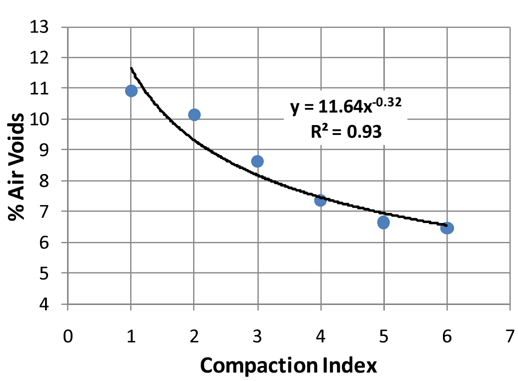
Error in Predicting Density Level for Test Section 4 Ty C HMA on Flex.



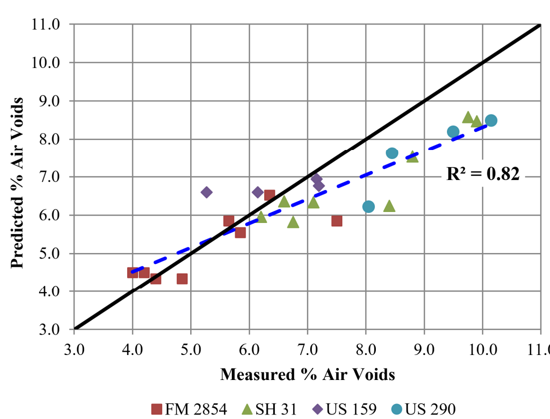
Field Validation

- 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

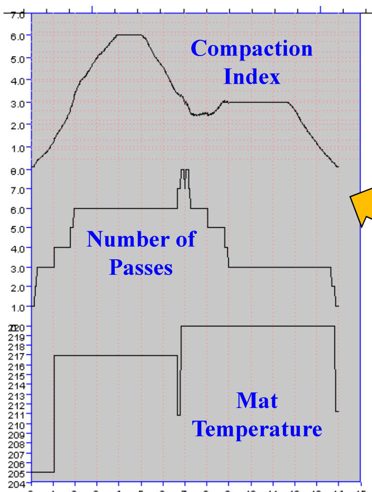
Correlation between predicted and measured % air voids for some field projects



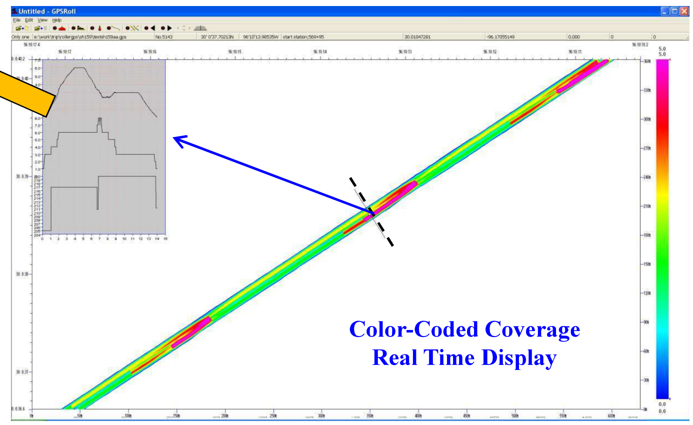
An example of Compaction Curve for BD Roller; SH 31



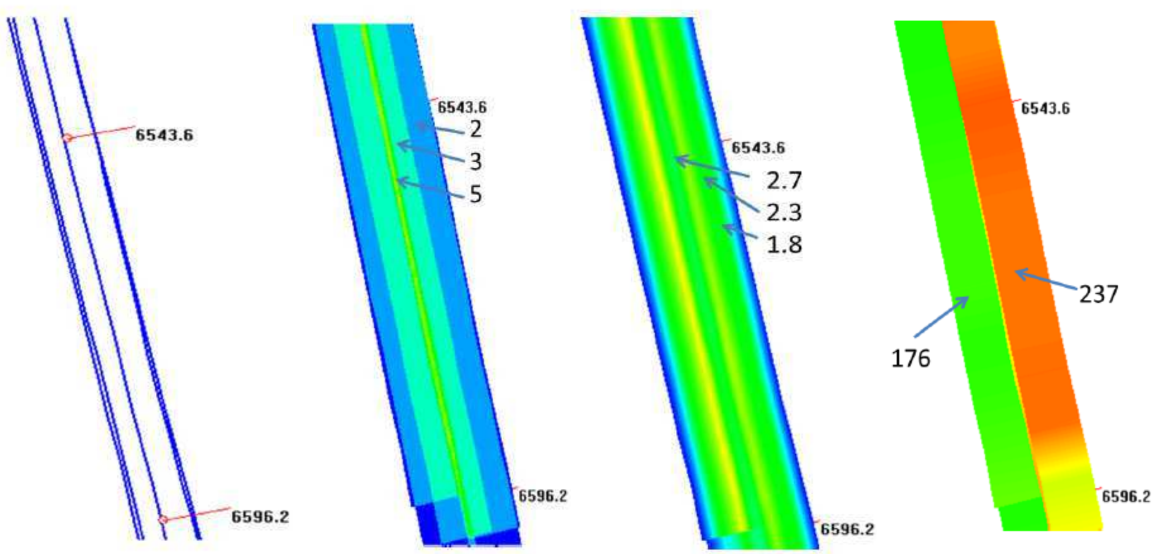
Phase II: Compaction Monitoring System



X-axis is the width in feet



Phase II: Compaction Monitoring System



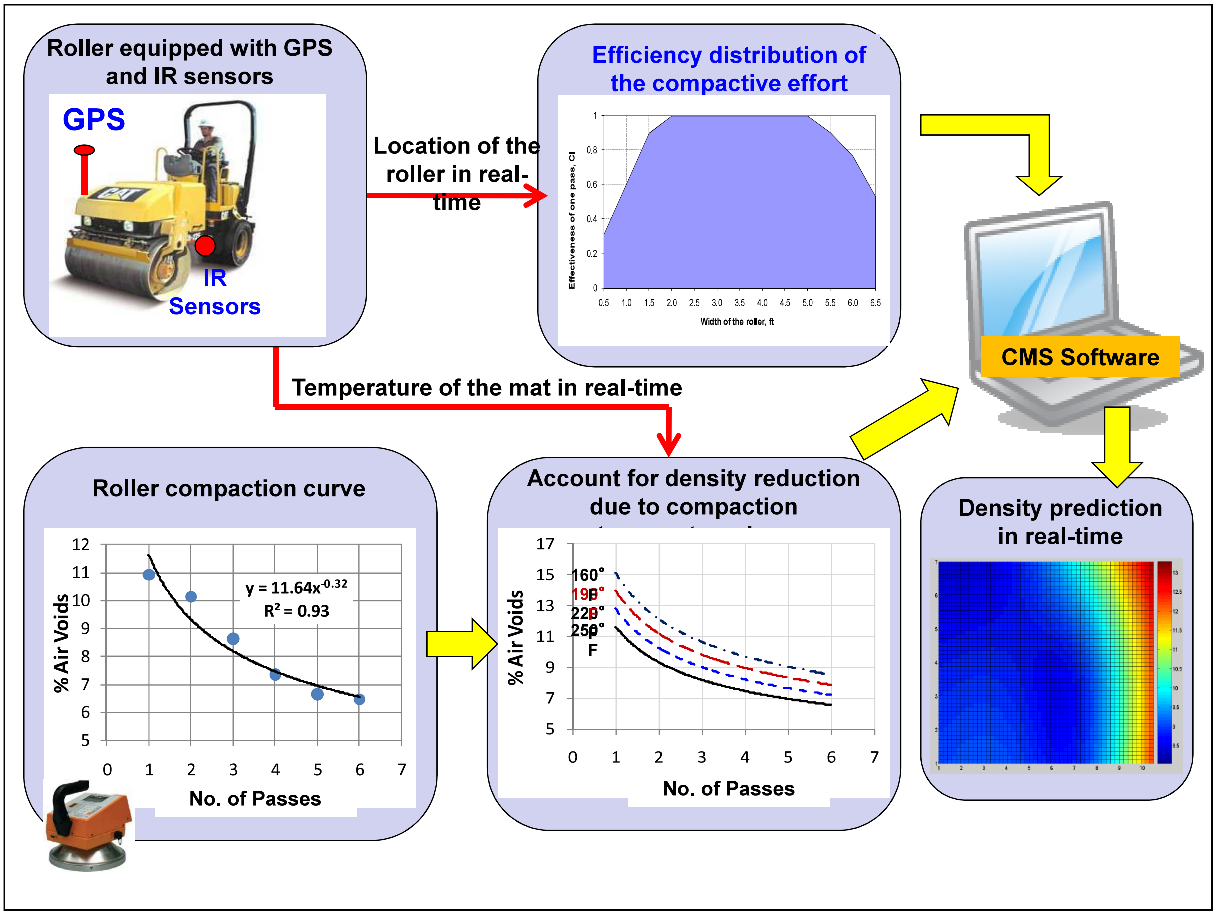
Roller Paths

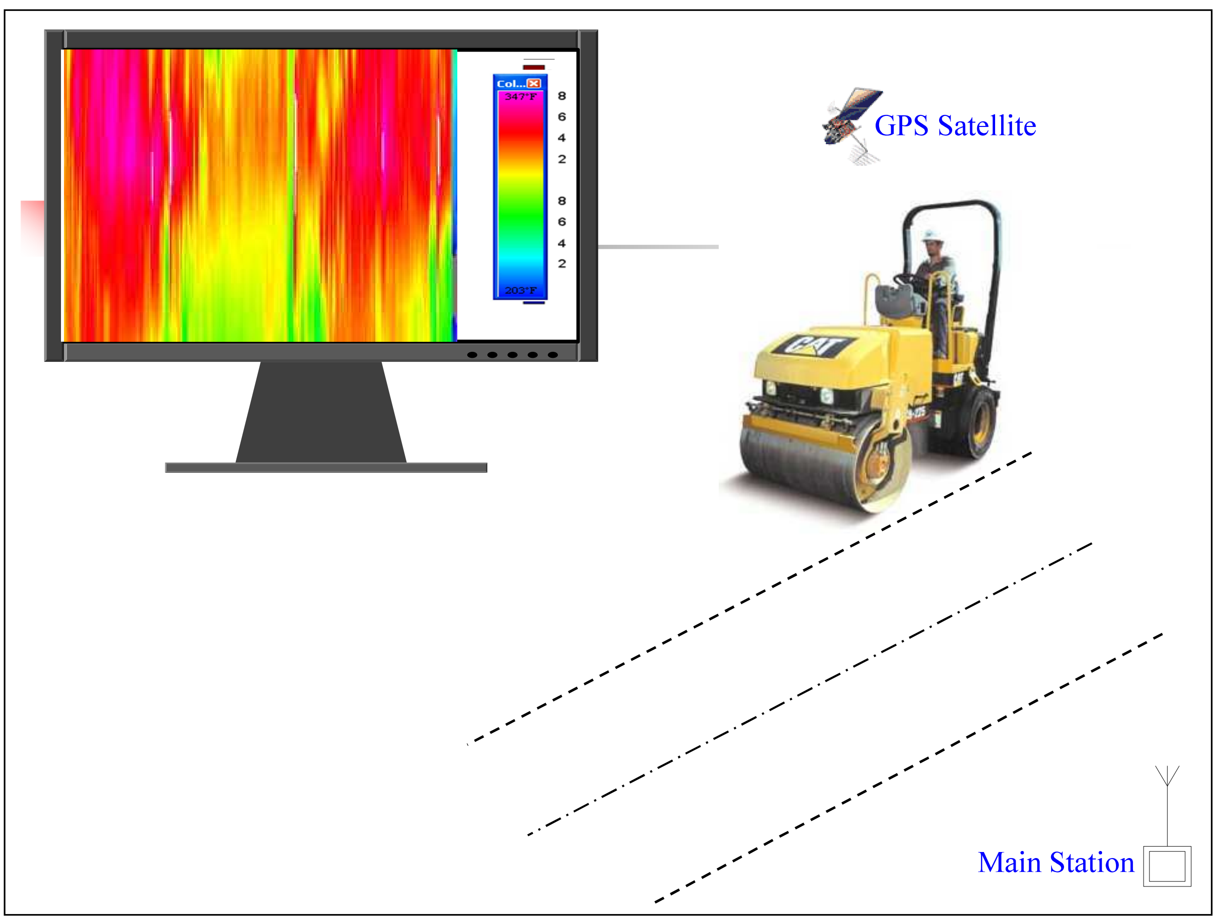
Number of Passes

Compaction Index

Mat Temperatures

Compaction Data from US 87 recorded using CMS


Roller equipped with GPS and IR sensors
GPS
IR Sensors
Location of the roller in real-time
Efficiency distribution of the compactive effort
Effectiveness of one pass, CI
Width of the roller, ft
CMS Software
Temperature of the mat in real-time
Roller compaction curve
% Air Voids
y = 11.64x^-0.32
R² = 0.93
No. of Passes
Account for density reduction due to compaction
% Air Voids
160°F
190°F
220°F
250°F
No. of Passes
Density prediction in real-time


347°F
203°F
GPS Satellite
Main Station

Questions