



9th International Conference on **MANAGING PAVEMENT ASSETS (ICMPA9)**

Impact of Overweight Traffic on Pavement Life Using WIM Data and Mechanistic-Empirical Pavement Analysis

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Outline

- Background
- Objective
- Traffic Data
- Pavement Life Analysis
- Conclusions
- Ongoing Work

Background

- Traffic loading on road pavements is characterized by a number of different types of vehicles with variations in load magnitude, number of axles, and axle configuration
- The impact of overweight truck on pavement service life is affected by pavement structure, traffic characteristics, and overweight percentage
- Highway agencies seek reliable knowledge of the fraction of damage caused to pavement by heavy vehicles for establishing an efficient and equitable road user cost system

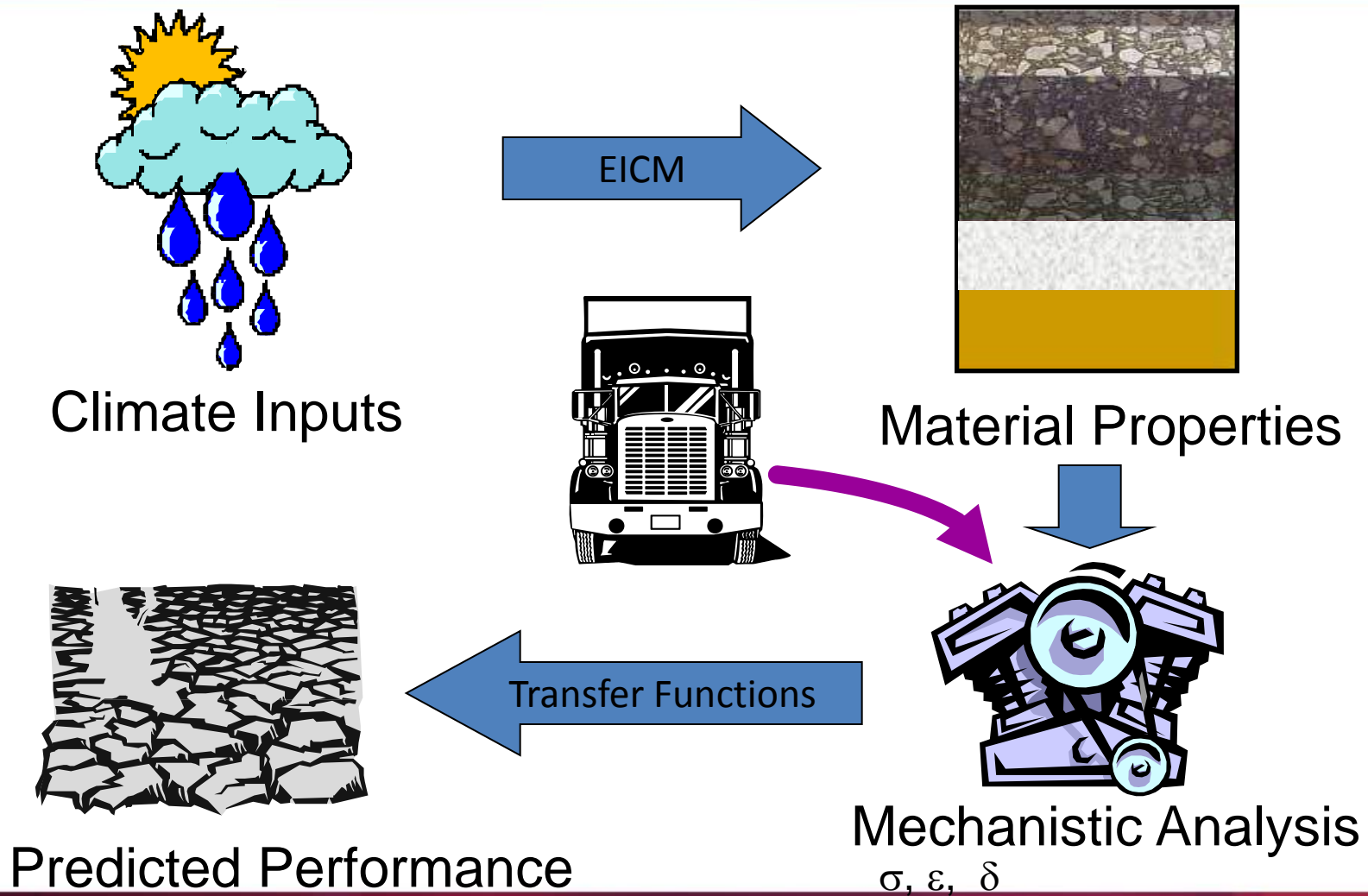
Relevant Previous Researches

- Roberts and Djakfar (2000) studied the impact of increasing the legal gross vehicle weight (GVW) limit as compared to the previous legal GVW
- Freeman et al. (2000) conducted a study to determine the effect of higher allowable weight limit provisions on pavement maintenance and rehabilitation cost in Virginia
- Sadeghi and Fathali (2007) conducted sensitivity analysis to find the significant parameters that influence the deterioration of pavement under truck loading
- Pais et al. (2013) studied the truck factor for the vehicles that travel with axle loads or the total vehicle weight above the maximum legal limits

Objective

- Impact of Overweight Traffic on Infrastructure in New Jersey (Research project sponsored by NJDOT)
- Quantify the effect of vehicular loading on pavement deterioration
 - Traffic data from weight-in-motion (WIM)
 - Mechanistic pavement analysis
 - Field performance data from PMS
- Evaluate pavement damage cost caused by overweight trucks as compared to revenue generated from permit fee (ongoing)

Mechanistic-Empirical Prediction of Pavement Performance



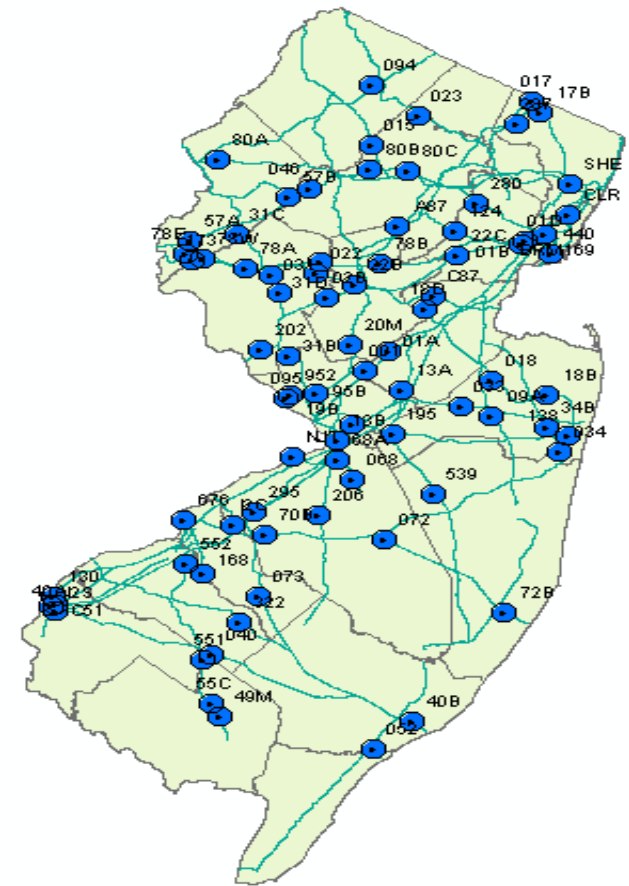
Definition of Overweight Vehicle

- Currently, the New Jersey Department of Transportation legislates 80,000 pound as the legal GVW. The legal axle weight on a single axle is 22,400lbs, and the legal tandem axle weight is 34,000lbs
 - Excess weigh fee \$5/ton in addition to \$10 base fee, \$12 transfer fee, and 5% service fee
- In this study, the WIM data is filtered into two traffic categories. The first category includes the vehicles within the legal weight limit and the second category includes the overloaded vehicles with the GVW or axle load exceeding the legal weight limit

NJDOT Weigh-In-Motion (WIM) Data

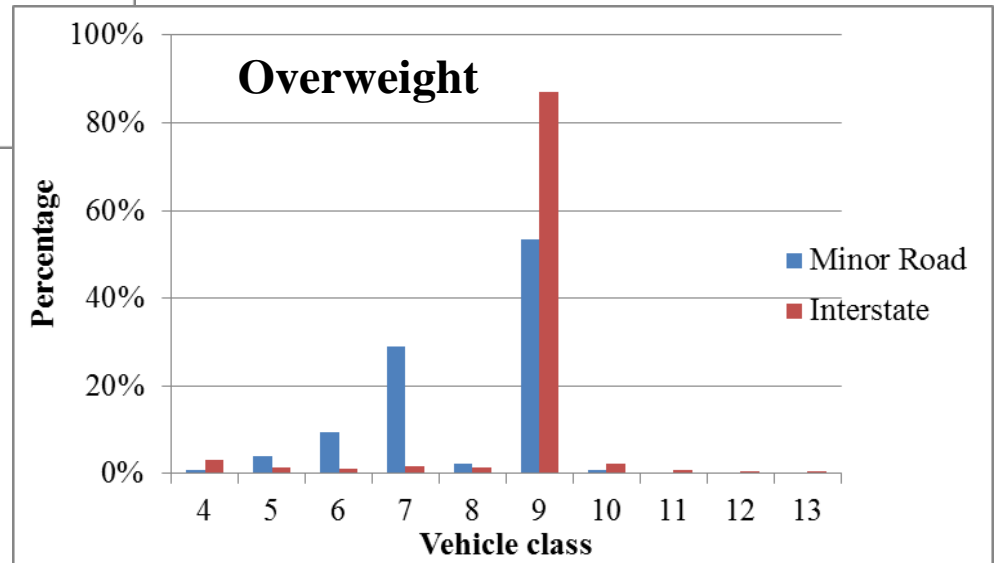
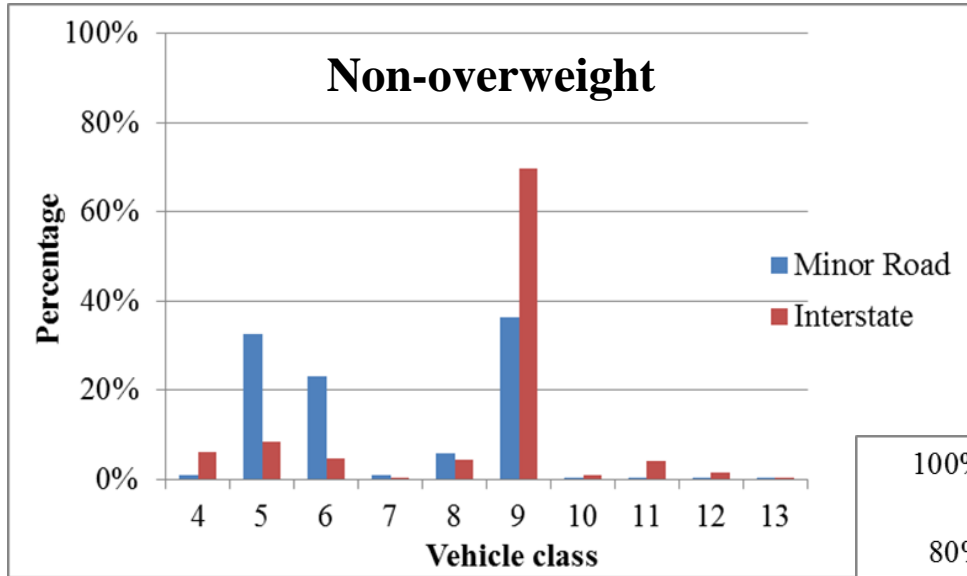
- Weigh-In-Motion or WIM data contain volume, classification, and weights for vehicles, and is collected on a continuous basis

Site	Route type	Average annual daily truck traffic (AADTT)		Percentage of overweight truck
		Total	Overweight	
1	Interstate	11739	1970	17%
2	Interstate	14131	1567	11%
3	Interstate	3572	686	19%
4	Major Highway	8337	558	7%
5	Interstate	10747	275	3%
6	Interstate	13607	899	7%
7	Minor road	928	230	25%
8	Minor road	2710	239	9%
9	Minor road	1348	143	11%
10	Minor road	485	26	5%

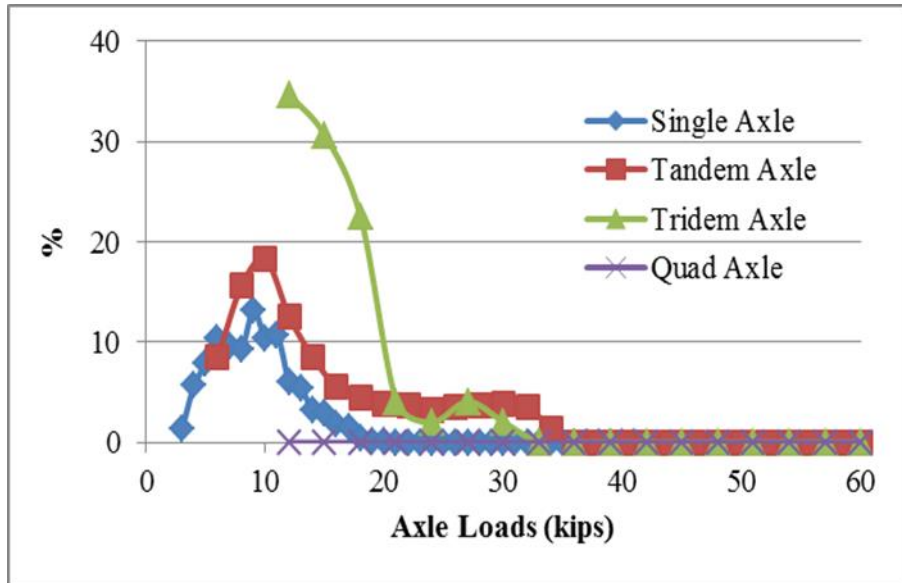


Distribution of New Jersey WIM Stations

Truck Class Distribution

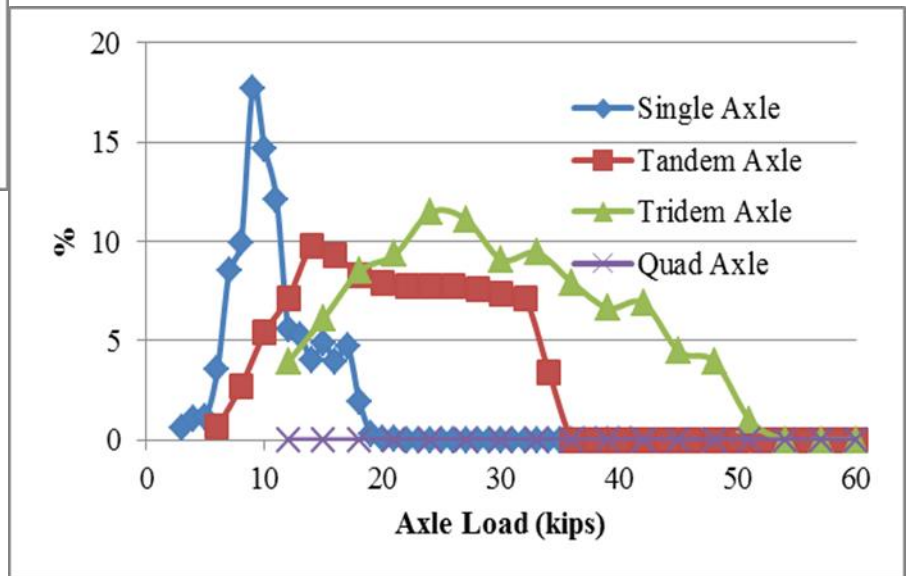


Non-Overweight Traffic (Class-9)

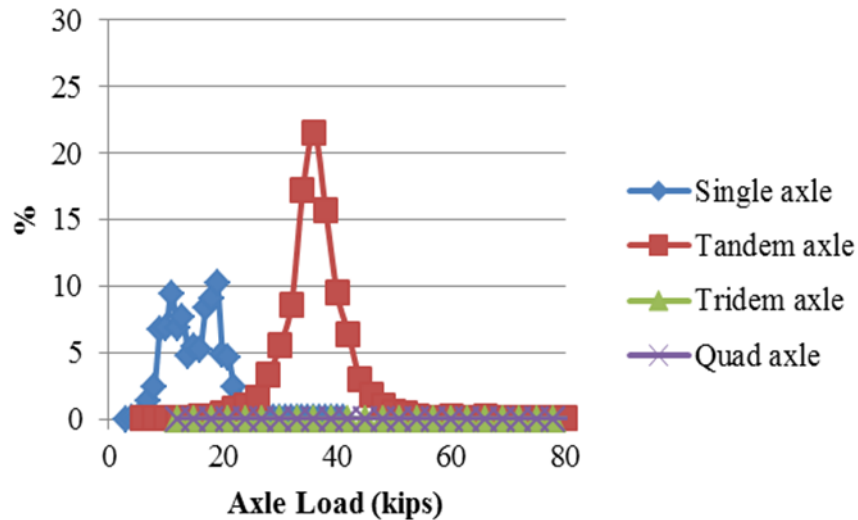


Minor Road

Interstate Highway

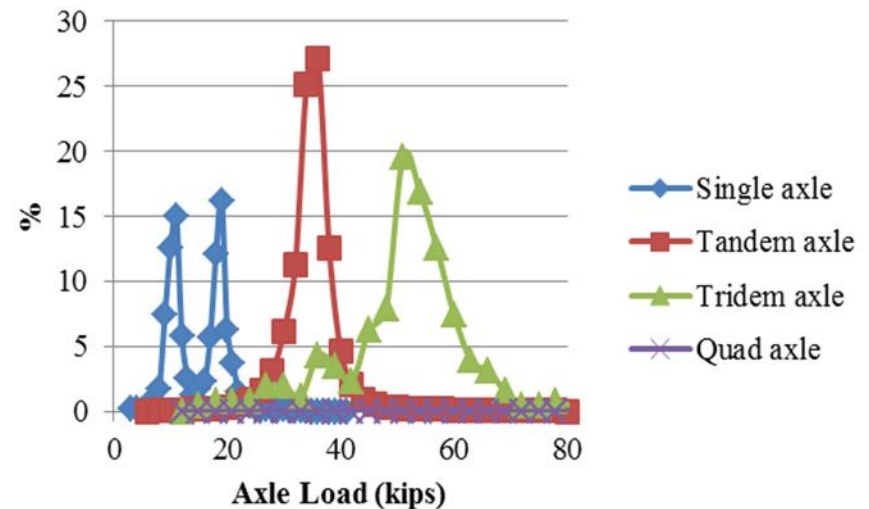


Overweight Traffic (Class-9)



Minor Road

Interstate Highway



Pavement Structures

Site	Pavement type	Layer Thickness (inch)		
		Asphalt	PCC	Base/ <u>Subbase</u>
1	Thick Flexible Pavement	11.5	/	20
2		16	/	20
3		12	/	10
4		10.5	/	10
5	Composite Pavement	4.5	10	12
6		3	9	12
7		3.5	7.5	12
8		3.5	7	12
9	Thin Flexible Pavement	4.5	/	20
10		2	/	18

Prediction of Pavement Life

- **Pavement Failure Criteria in Pavement-ME**

Performance criteria	Limit
Terminal IRI (in/mile)	172
AC top-down fatigue cracking (ft/mile)	2000
AC bottom-up fatigue cracking (%)	25
AC thermal fracture (ft/mile)	1000
Permanent deformation - total pavement (in)	0.75
Permanent deformation - AC only (in)	0.25

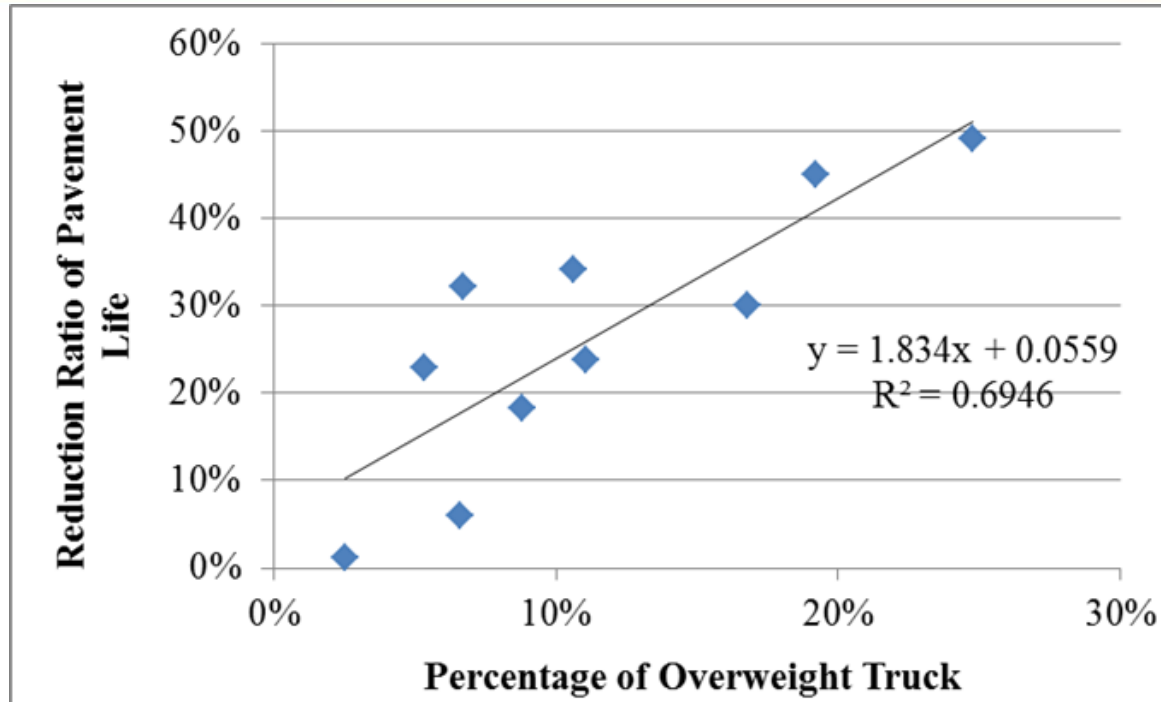
- **Thick Asphalt Pavement and Composite Pavement:**

- Rutting (permanent deformation) failure

- **Thin Asphalt Pavement:**

- Fatigue cracking failure

Effect of Overweight Traffic on Pavement Life



$$\text{Reduction ratio of pavement life} = \frac{L_0 - L_x}{L_0}$$

Where, L_0 : Pavement life caused by total traffic; and

L_x : Pavement life caused by the non-overweight traffic.

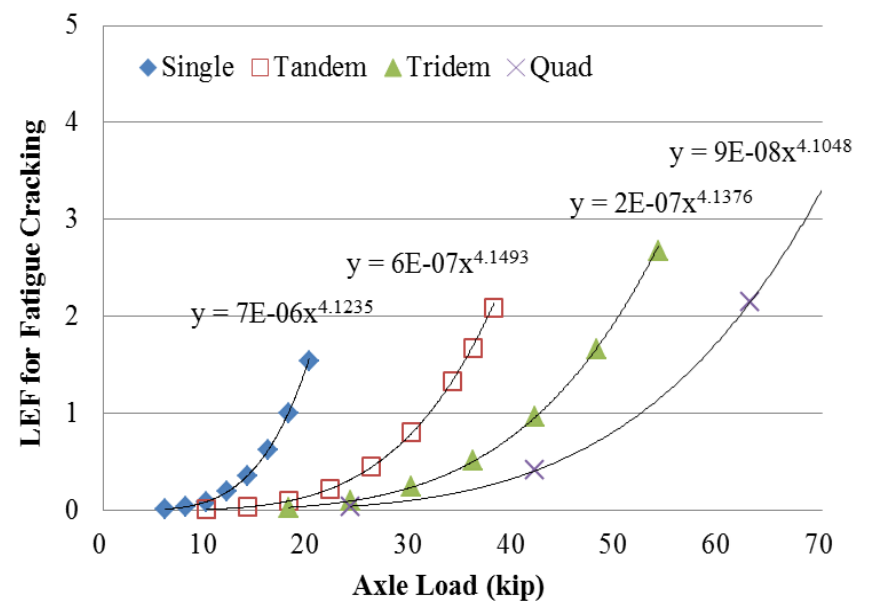
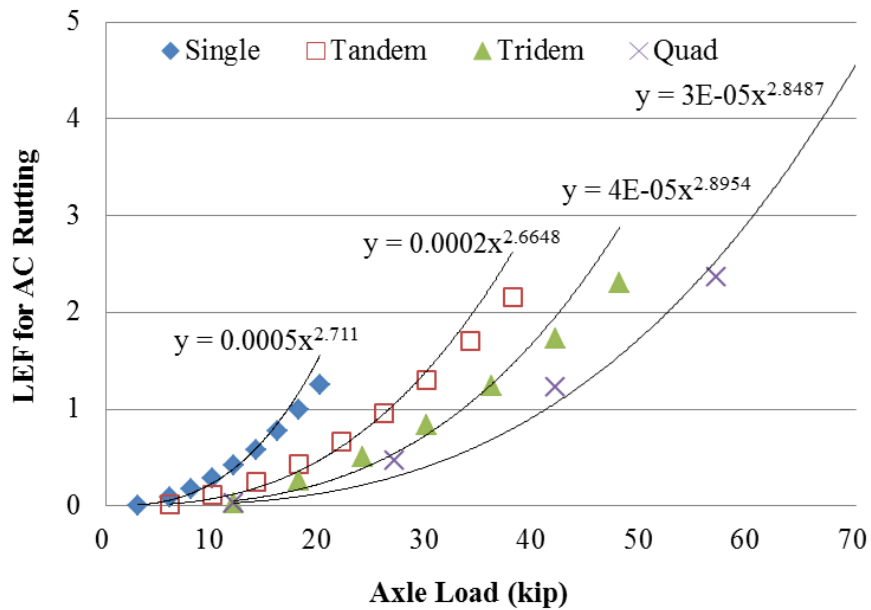
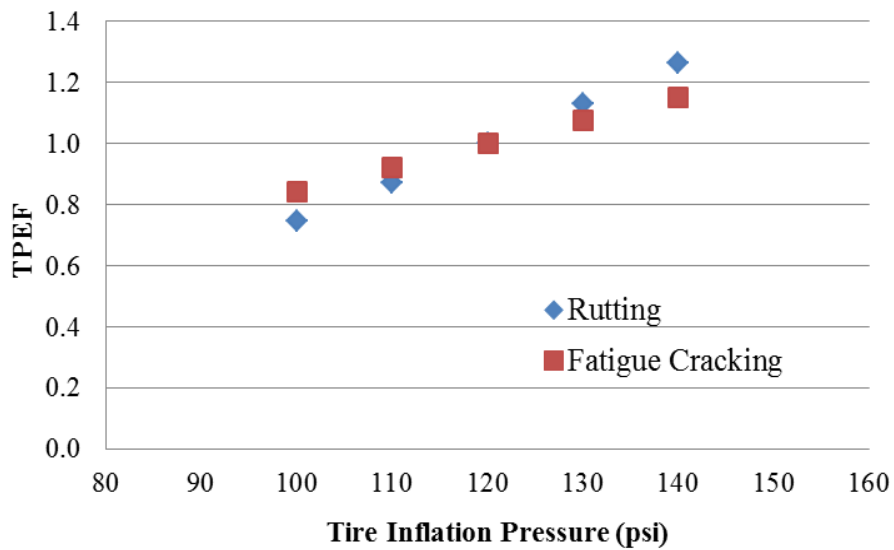
Load Equivalency Factor

- Load equivalency factors (LEFs) can be used to quantify the impact of overweight truck (truck class, axle load, pressure, tire type etc.) on pavements
- LEF represents the equivalency of any axle load compared to ESAL

$$\text{LEF} = \frac{1/N}{1/N_{ESAL}} = \frac{N_{ESAL}}{N}$$

Where, LEF = Load Equivalency Factor; N_{ESAL} = allowable number of load repetitions to failure under the loading of ESAL; and N = allowable number of load repetitions to failure under the loading of the axle with different axle and tire configurations.

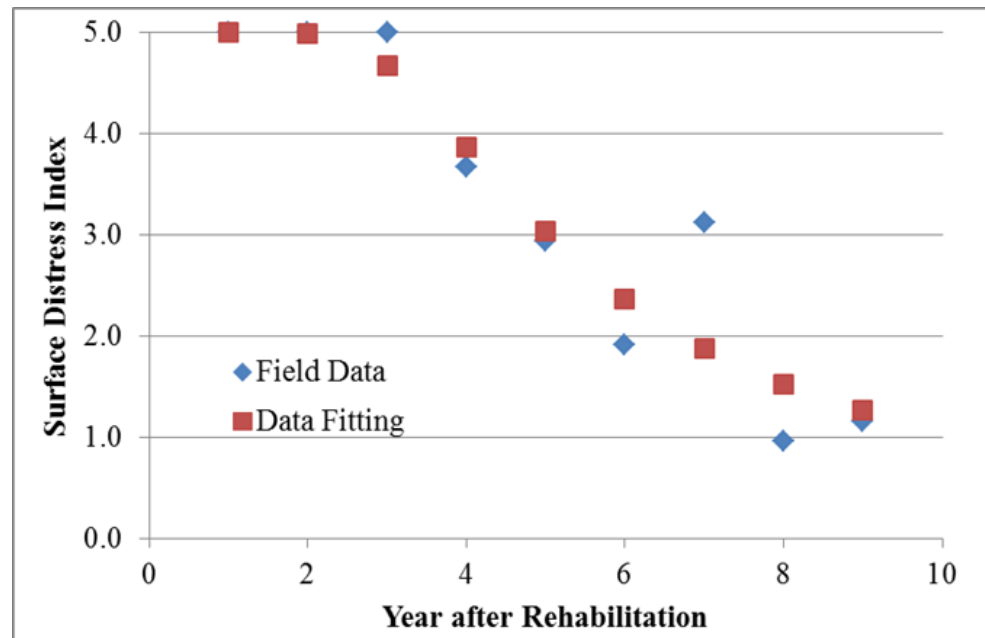
Results on LEF



Pavement Field Performance Data

- Surface Distress Index (SDI) and International Roughness Index (IRI) from 2000 to 2012
- It was found that the IRI usually does not reach the failure criteria or the rehabilitation threshold after 10 years
- SDI is selected to be a better index reflecting pavement deterioration.
 - Include non-load related distresses outside the wheel paths (NDI) and load related distress index (LDI)
 - Good: $SDI > 3.5$ and $IRI < 95\text{in/mile}$
 - Poor: $SDI < 2.4$ or $IRI > 170\text{in/mile}$

Pavement Life Estimated from Field Performance Data



$$SDI = SDI_0 - \exp(a - b * c^{\ln(\frac{1}{Age})})$$

Where,

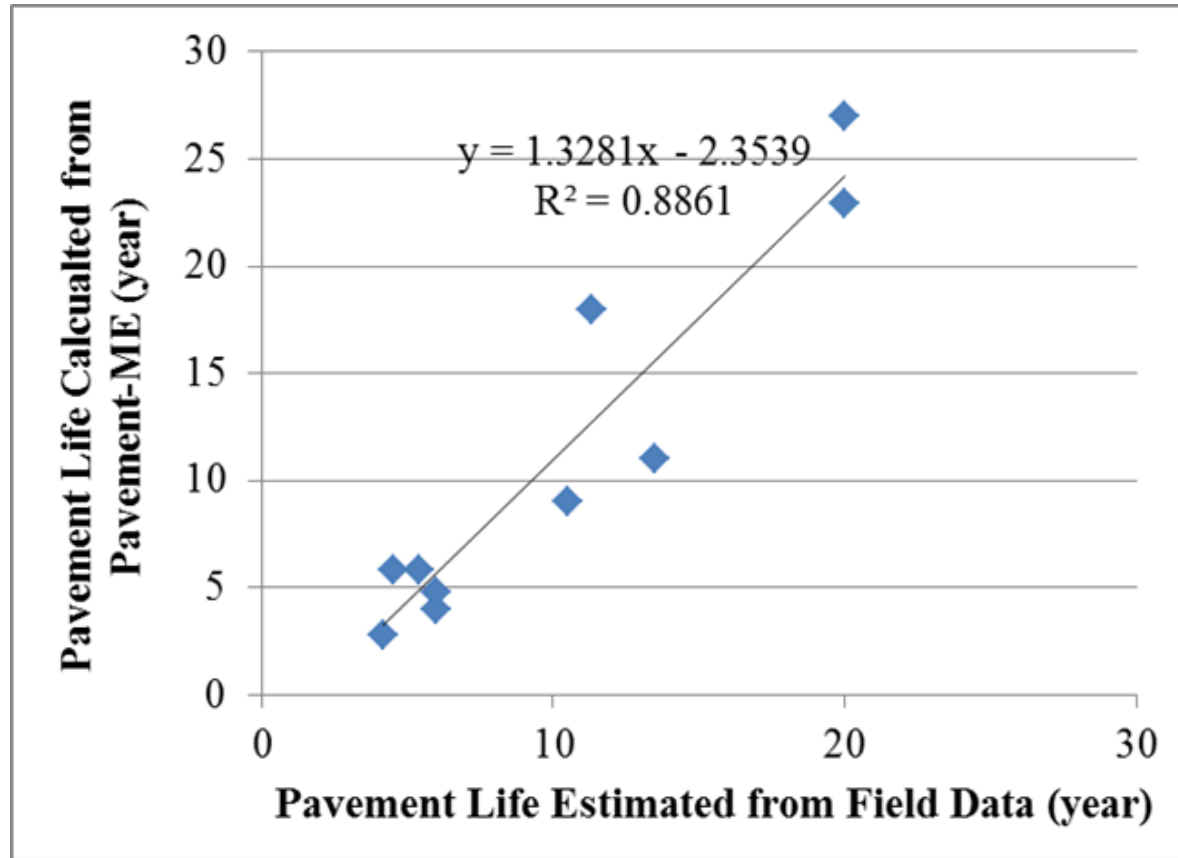
SDI = Surface distress index;

SDI₀ = Surface distress index at year zero (usually 5);

Age = the year since the initial construction of the last rehabilitation treatment; and

a,b,c = model coefficients with $a = \ln(SDI_0)$ and $SDI_{terminal}=0$.

Pavement Life from M-E Analysis and Field Data



Ongoing Work

- Quantify relationship between pavement life and traffic parameters and pavement structure using a big set of data
- Develop marginal pavement damage cost function
- Compare pavement damage cost caused by overweight trucks to revenue generated from permit fees

Conclusions

- Different distribution patterns were observed between the overweight and non-weight traffic in terms of truck classes and axle load spectra
- The reduction ratio of pavement life was used to normalize effect of overweight truck at different conditions
 - In general, 1% increase of overweight truck may cause 1.8% reduction of pavement life
- M-E analysis was proved to be a valid approach to quantify the impact of overweight truck on pavement damage with WIM data input

Acknowledgement

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