EXPANDING THE REALM OF POSSIBILITY

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Structural Considerations in Moving Mega Loads on Idaho Highways

By:

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APPLIED RESEARCH ASSOCIATES, INC.

An Employee-Owned Company

Focus:

Overview ***mechanistic-empirical procedures*** used to determine the impact of oversize and overweight vehicles on flexible pavement performance in Idaho.

1. Examples for Using Mechanistic-Empirical Based Pavement Design-Analysis Procedures

Example: Analysis & design of designated routes for hauling overloads for pavement & rehabilitation design.

Photo: Courtesy of Jim Scherocman.

Example: Analysis of special loading configurations for pavement design.

Example: Determine impact from transporting overweight/oversize commodities on pavement deterioration and maintenance.

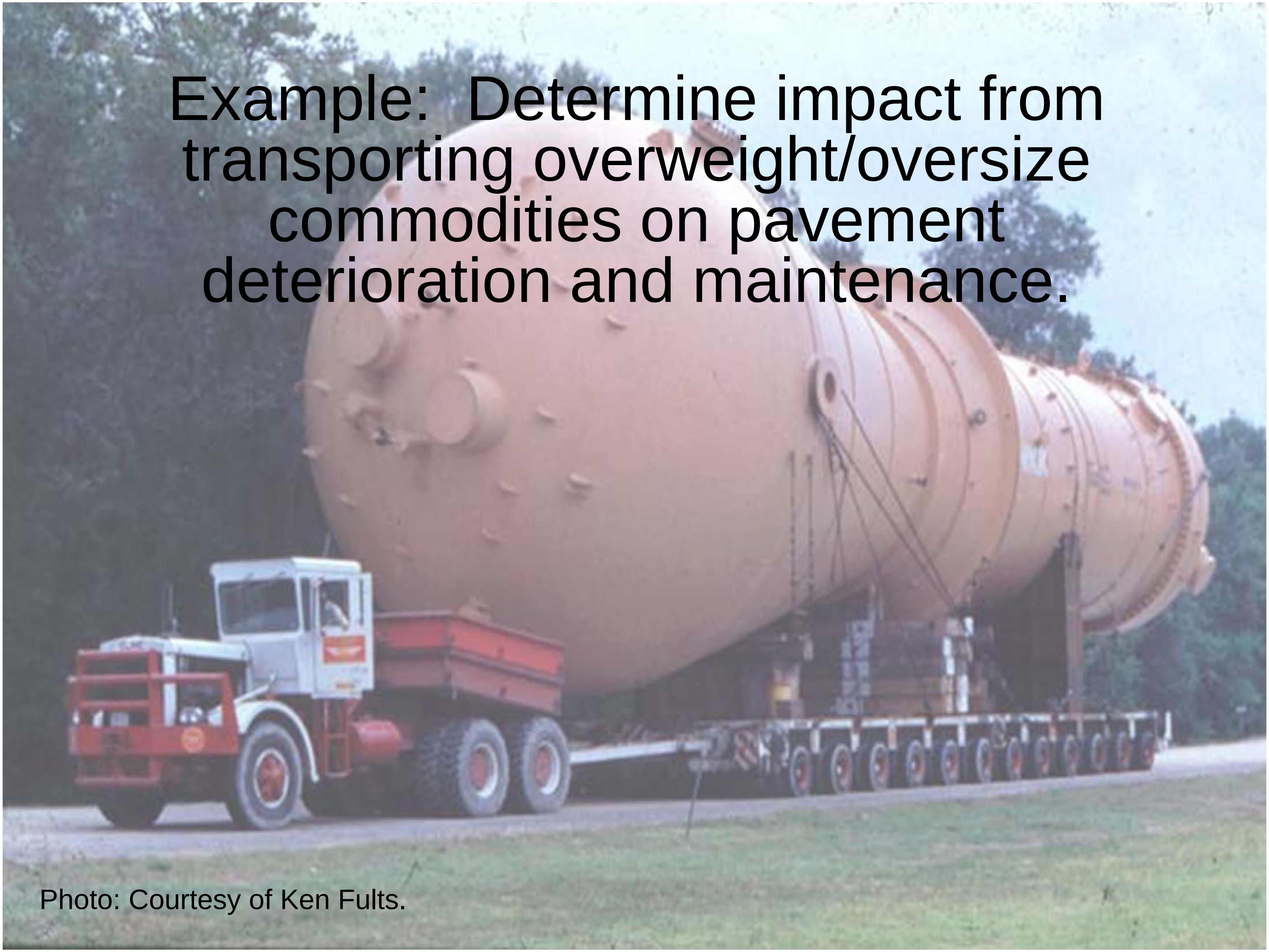
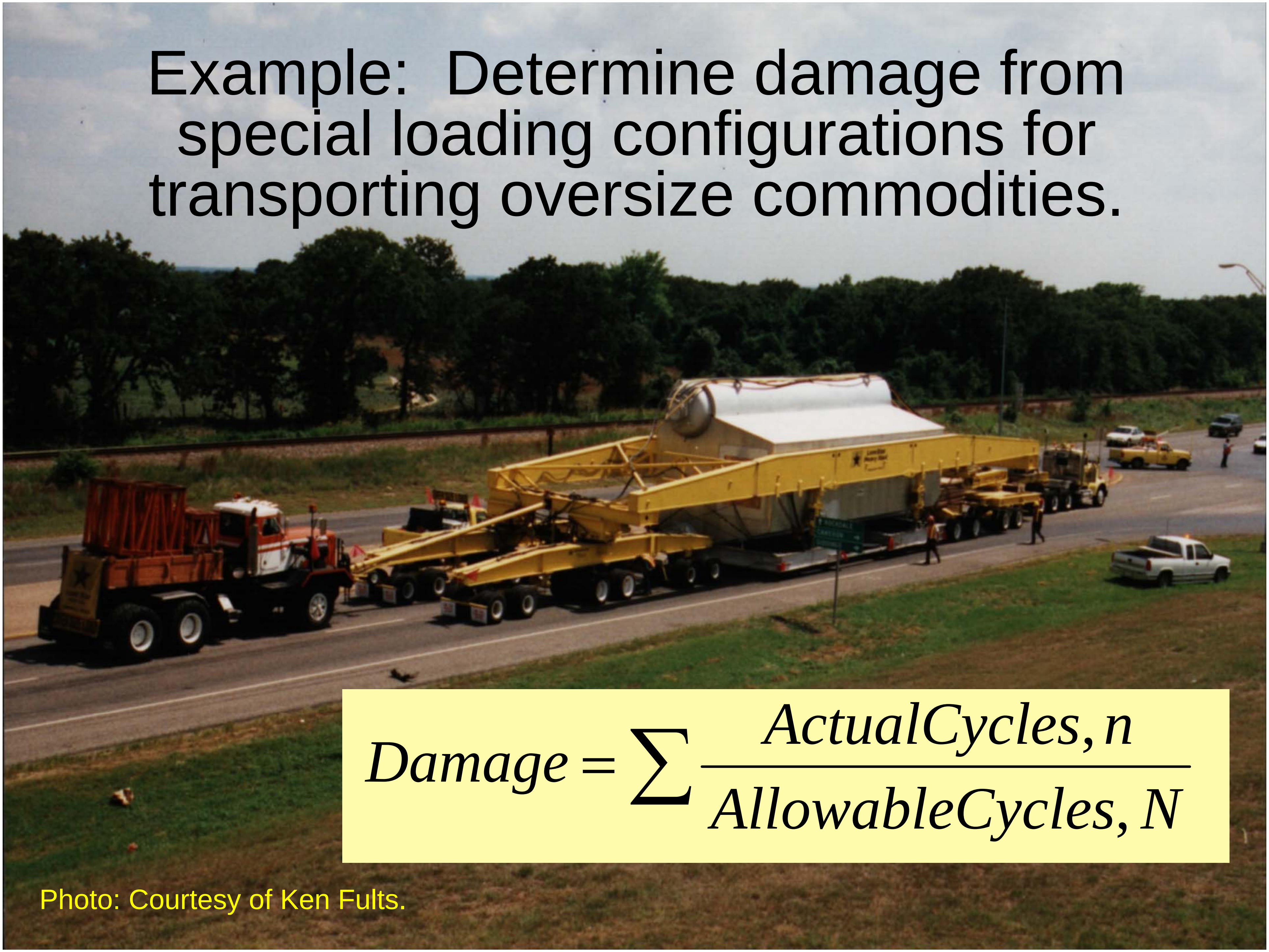


Photo: Courtesy of Ken Fults.

Example: Determine damage from special loading configurations for transporting oversize commodities.



$$Damage = \sum \frac{ActualCycles, n}{AllowableCycles, N}$$

Photo: Courtesy of Ken Fults.

- Higher loads, more axles, higher tire pressures:
- Result in higher bending or strains in the pavement:
- Causing increased pavement damage & shorter service life.

But, how much more damage?

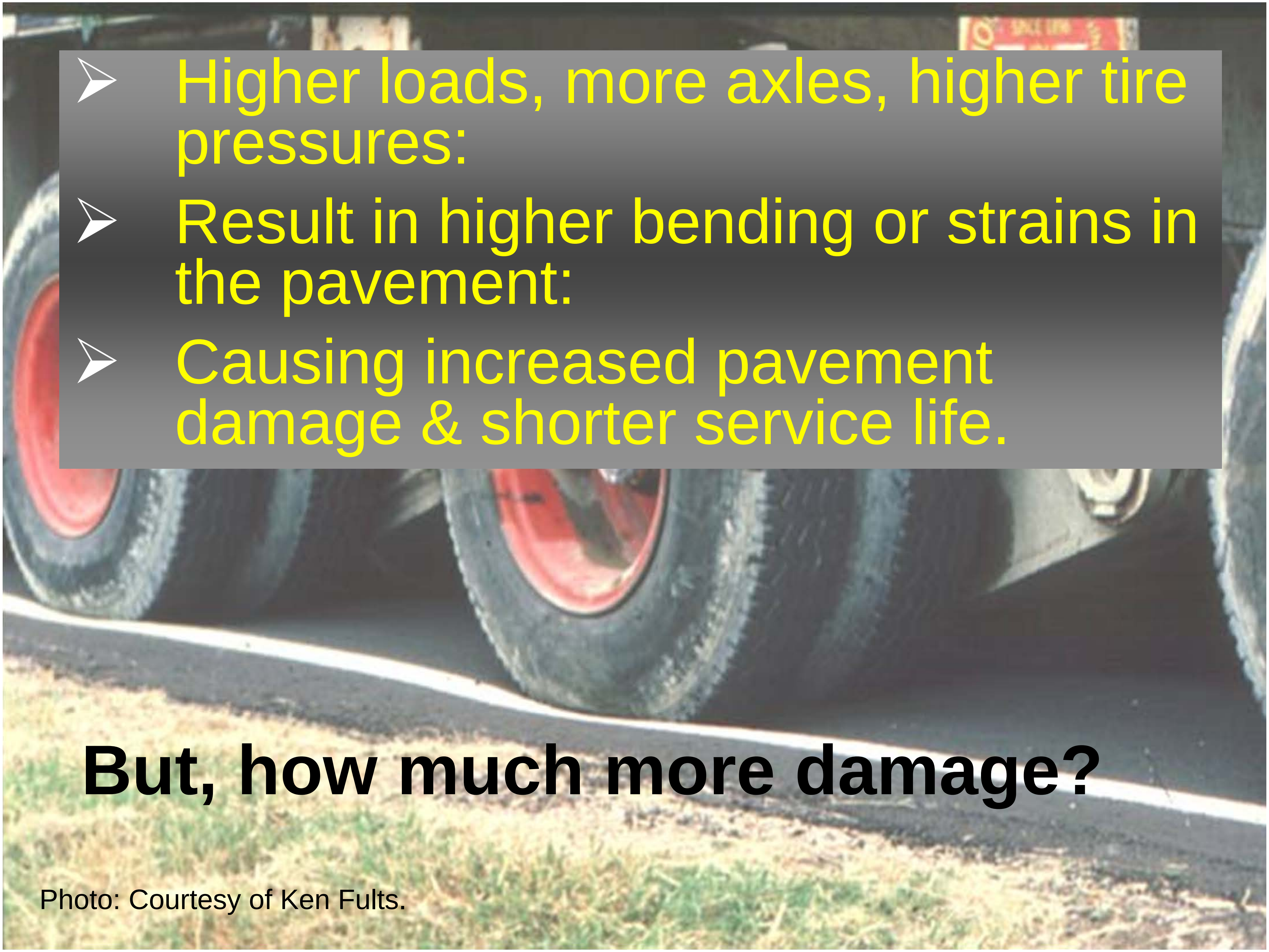


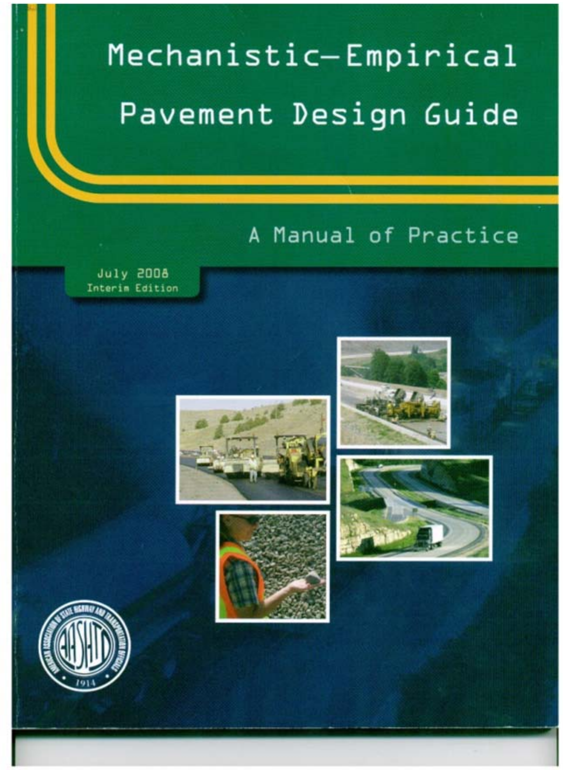
Photo: Courtesy of Ken Fults.

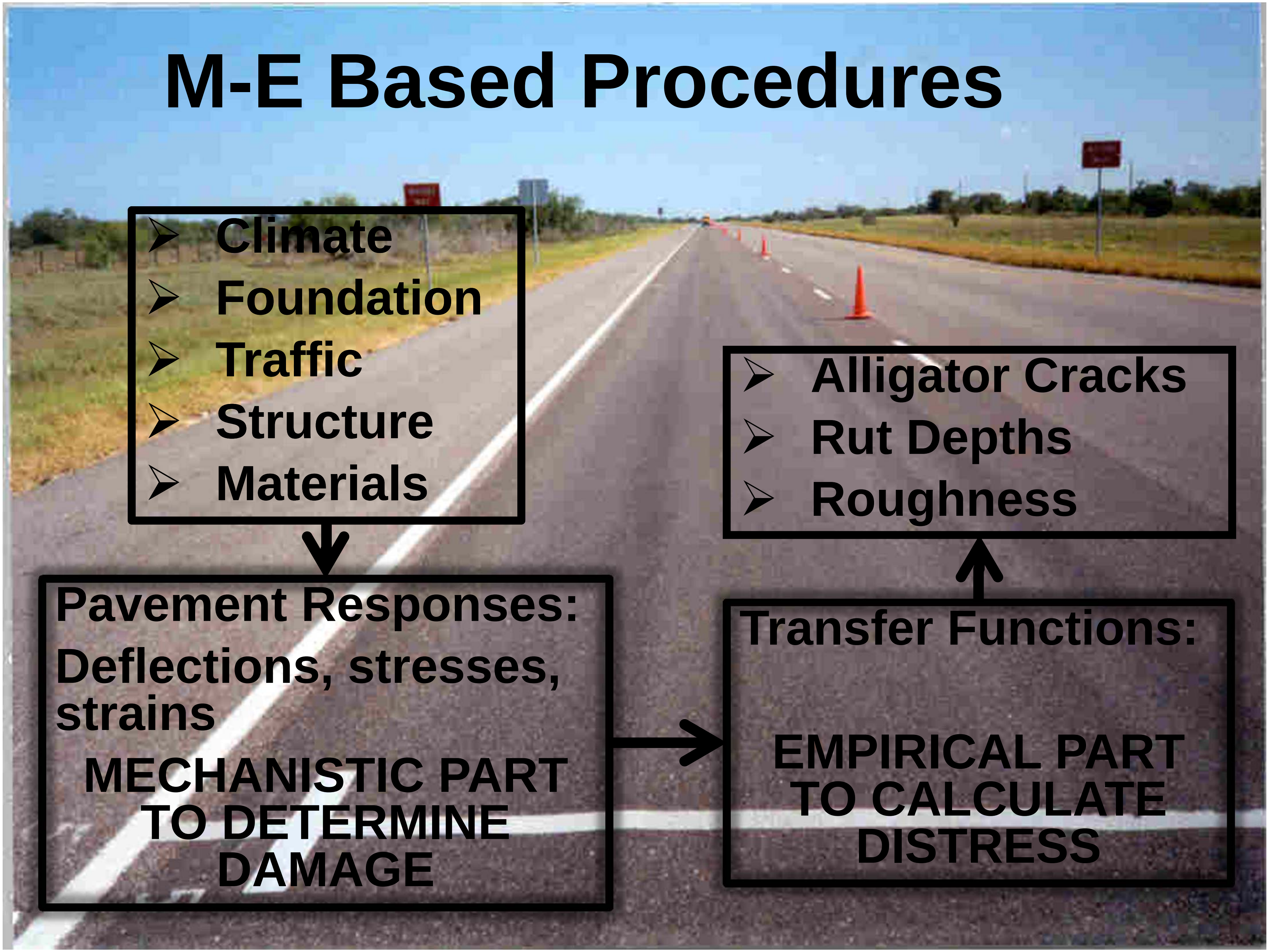
2. How Much More Damage?

Determined from Pavement Responses to Estimate Allowable Load Cycles, N

Pavement Evaluation Procedures.

- ✖ 1993 AASHTO Design Guide – Empirical Procedure
- ➡ Mechanistic-Empirical Equivalent Seasonal Modulus Values.
- ➡ Mechanistic-Empirical Pavement Design Guide.




M-E Based Procedures
Climate
Foundation
Traffic
Structure
Materials
Pavement Responses:
Deflections, stresses, strains
MECHANISTIC PART TO DETERMINE DAMAGE
Alligator Cracks
Rut Depths
Roughness
Transfer Functions:
EMPIRICAL PART TO CALCULATE DISTRESS

Effect of Mega Loads on Pavement Distress

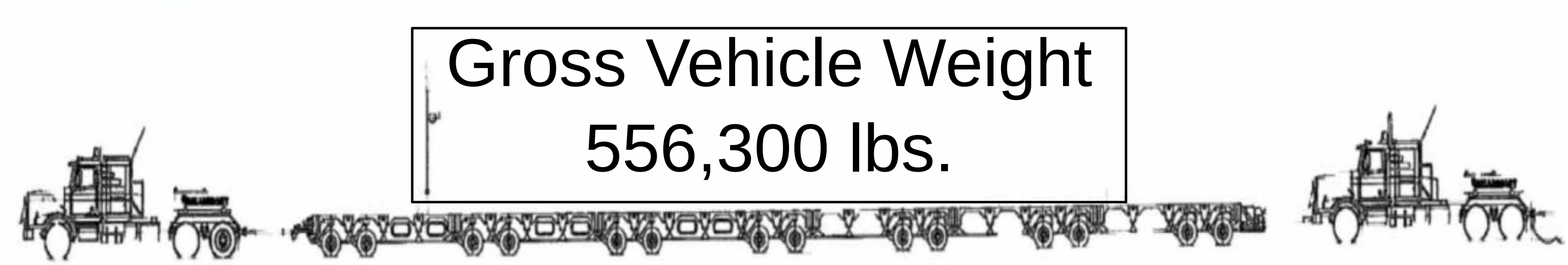
M-E Based Procedures to Determine Allowable Load Cycles (ESALs):

- Tensile strain bottom of HMA layer; ***FATIGUE CRACKING***.
- Vertical compressive strain in HMA; ***HMA RUTTING*****.**
- Subgrade vertical compressive strain; ***STRUCTURAL RUTTING***.

ESAL = Equivalent Single Axle Load.

3. How Much More Damage or Distress Specific to Idaho Mega Vehicles – Kearl Oil Sands Project?

Idaho Mega Vehicle Loading Details



Pull Vehicle:

- One Steering Axle
- One Tandem Axle

Push Vehicle:

- One Steering Axle
- One Tandem Axle

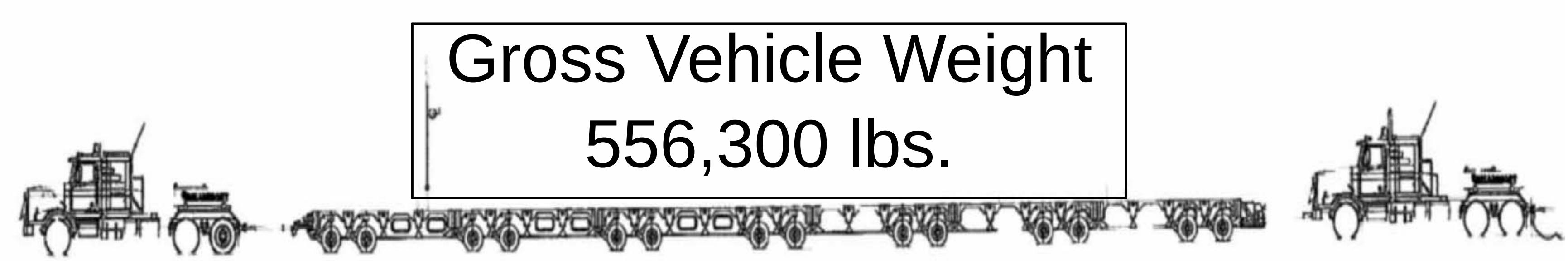
Trailer:

- Fourteen axles or seven tandem axles.

Frequency:

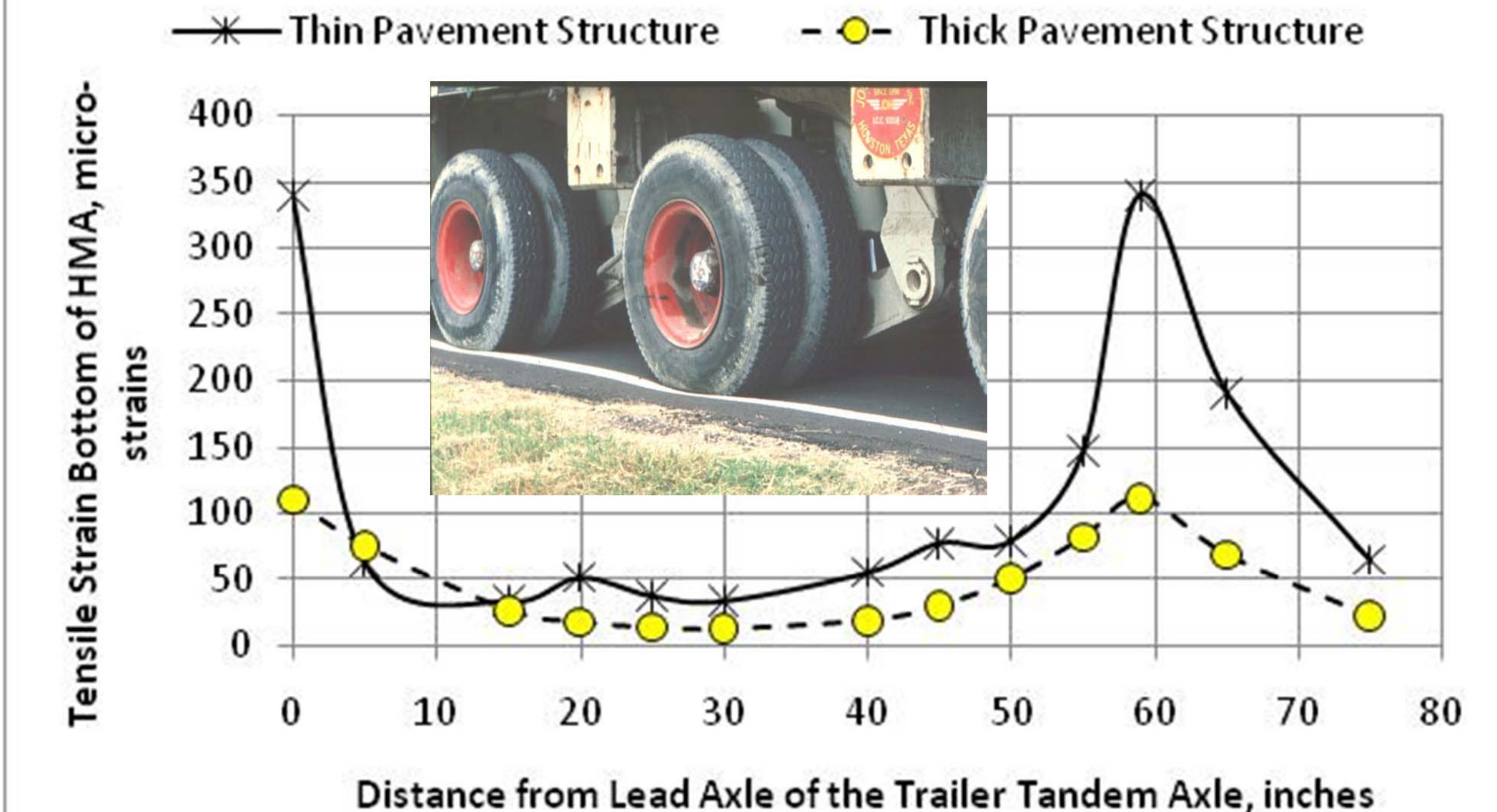
- 200 annual operations.

Idaho Mega Vehicle Loading Details

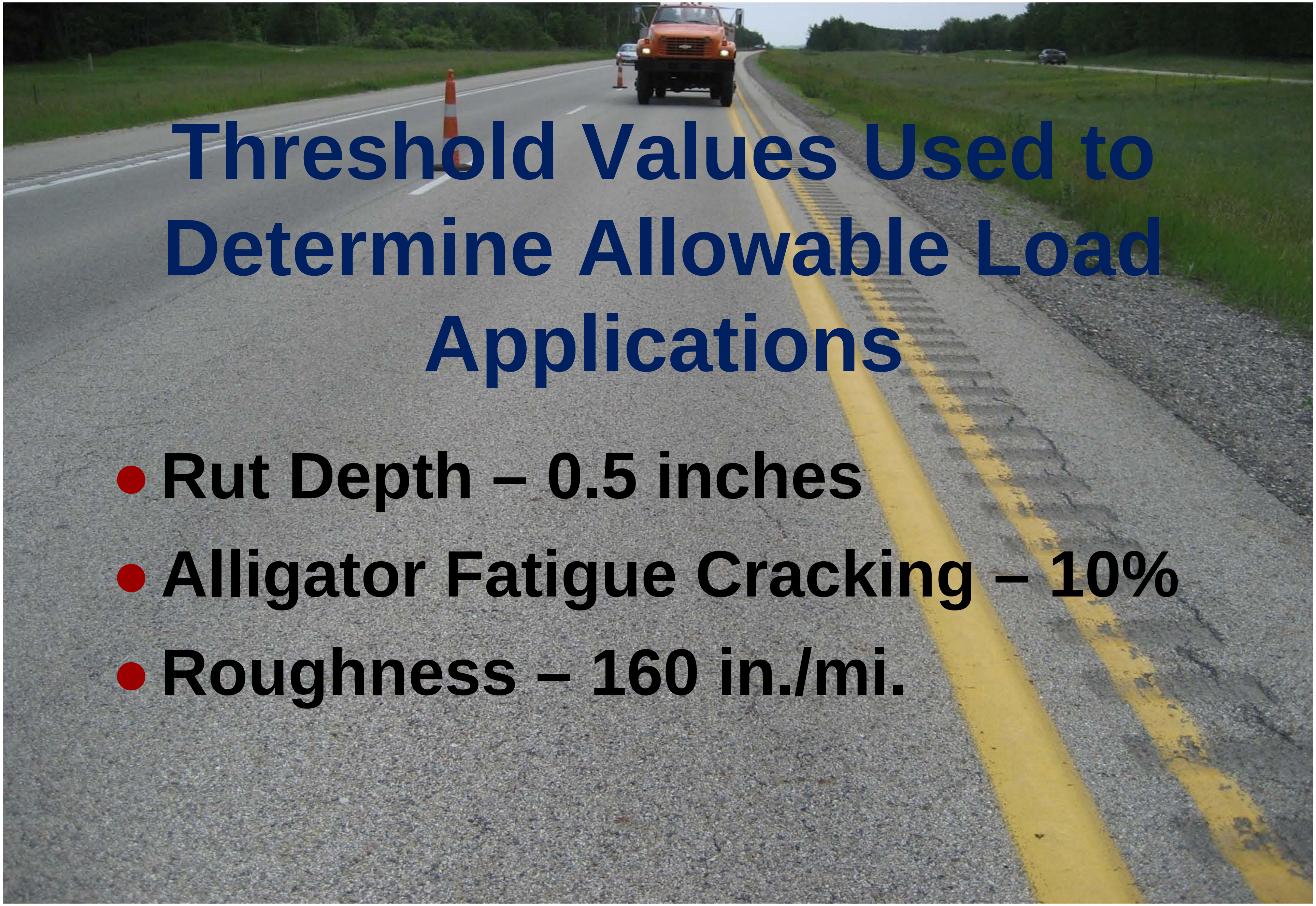


- Trailer Weight per Tire = 7,720 lbs.
- Tractor Steer Axle Weight per Tire = 8,050 lbs.
- Tractor Drive Axle Weight per Tire = 5,738 lbs.
- Dual Tire Spacing = 30 inches
- Tandem Axle Spacing = 59 inches
- Vehicle speed = 5 mph
- Tire pressure = 125 psi

Effect of Multiple Axles – Tensile Strain



Two strain applications for a tandem axle.



Threshold Values Used to Determine Allowable Load Applications

- **Rut Depth – 0.5 inches**
- **Alligator Fatigue Cracking – 10%**
- **Roughness – 160 in./mi.**

Allowable Number of Load Applications for Threshold Values

Pavement Structure	18-kip ESALs	Mega Vehicle/Loads	
		Steering Axle	Trailer Axles
Thin Pavement	1,661,000	949,000	999,000
Thick Pavement	41,129,000	24,205,000	24,463,000

Good subgrade support conditions assumed: A-1-b Soil; R-Value – 40 to 50

Equivalent Number of Single Axles Per Mega Vehicle

Pavement Structure	Number of ESALS		
	Tractor Steering Axle	Tractor Drive Axle	Trailer Axle
Thin Structure	1.75	1.58	1.66
Thick Structure	1.70	1.55	1.68

Number of ESALs for Mega Vehicle = 30

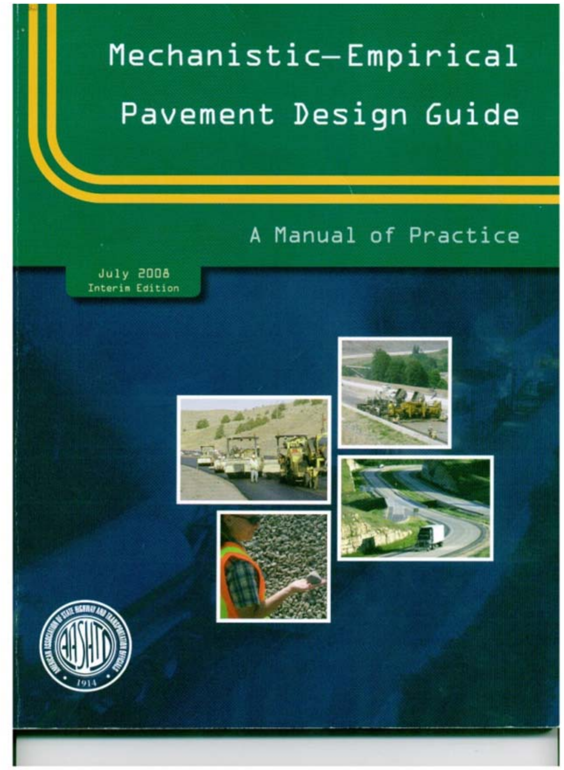
Annual ESALs = 6,000

4. What does this mean in terms of pavement distress or performance?

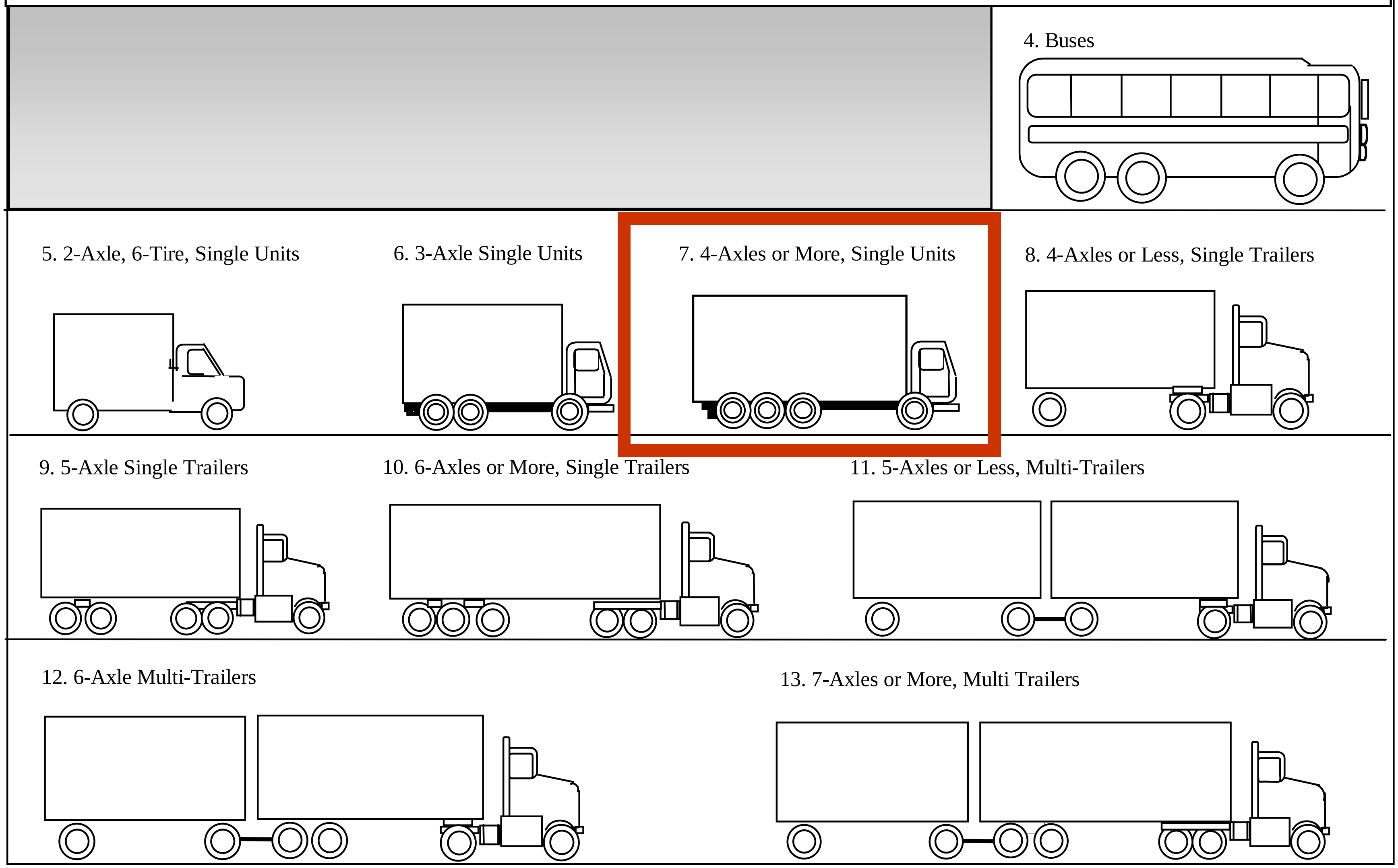
MEPDG Design Process

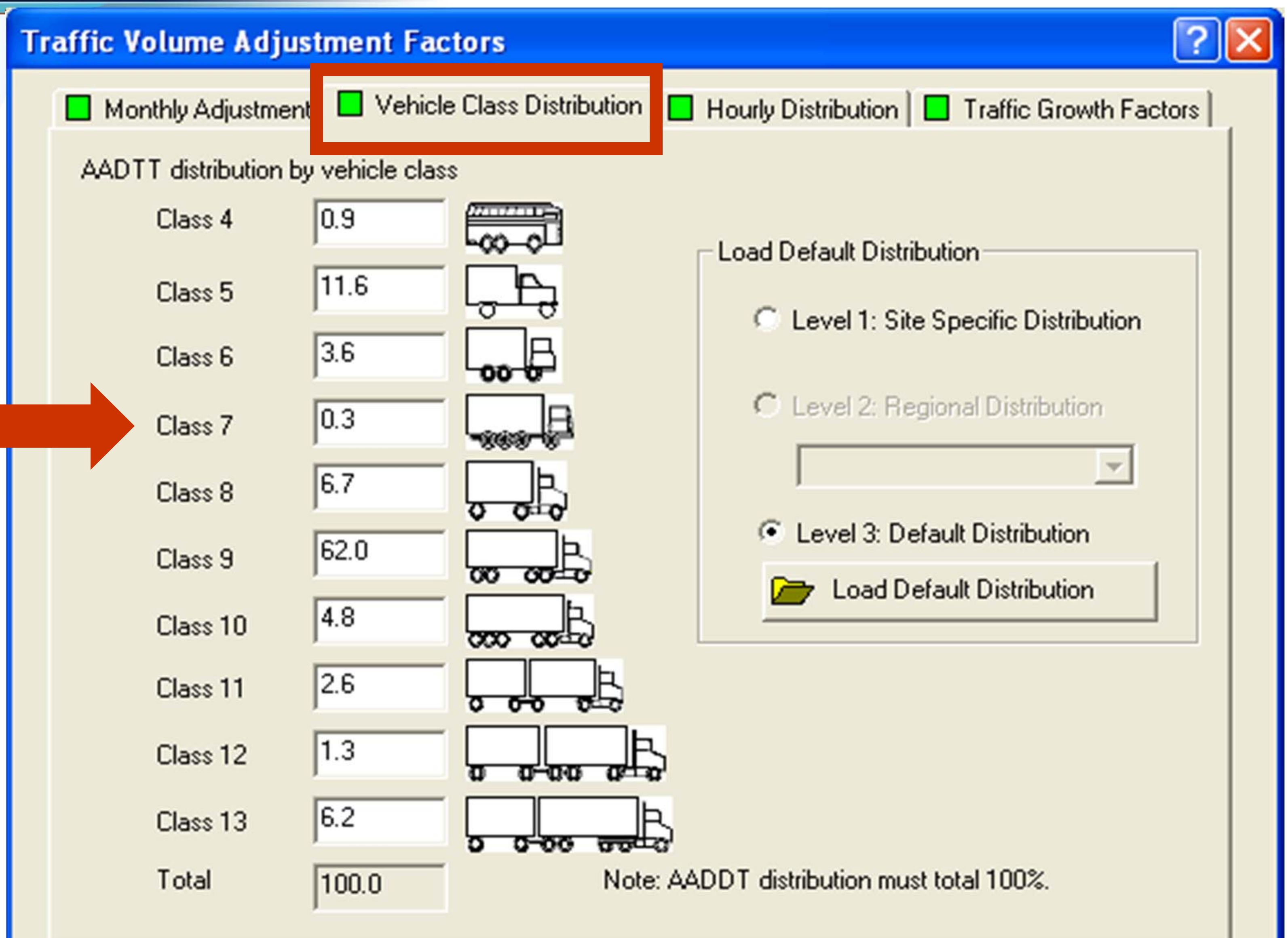
Distresses Predicted for the Idaho Mega Vehicles Versus Roadway without Mega Vehicles:

1. Bottom-Up Alligator Cracking
2. Total Rut Depth
3. Roughness



FHWA Vehicle Classifications





Truck Class Distribution:

Truck Class #7 used to represent the mega vehicles.

Monthly/Seasonal Adjustment Factors

Traffic Volume Adjustment Factors

Monthly Adjustment | Vehicle Class Distribution | Hourly Distribution | Traffic Growth Factors

Load Monthly Adjustment Factors (MAF)

- Level 1: Site Specific - MAF
- Level 3: Default MAF

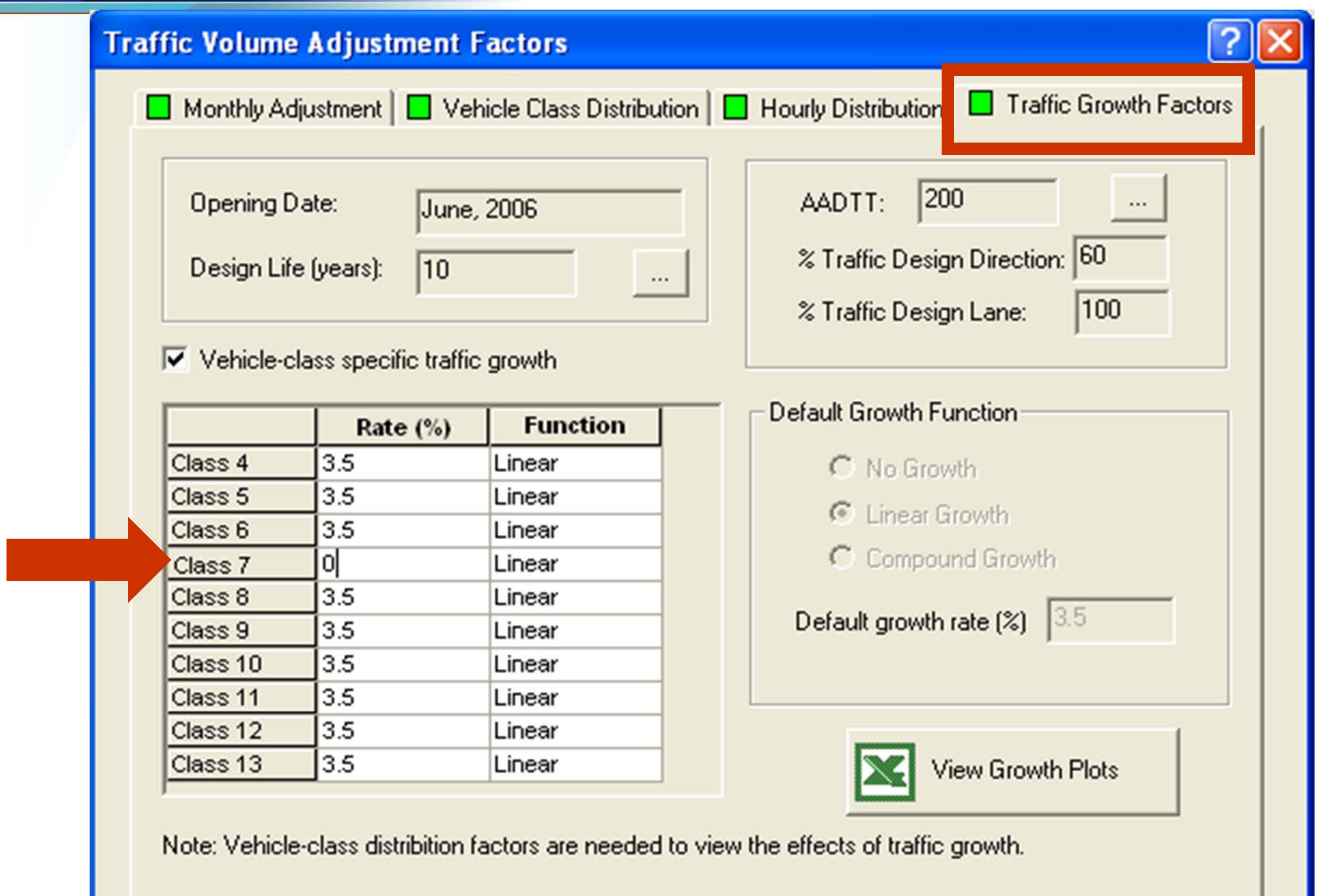
Load MAF From File

Export MAF to File

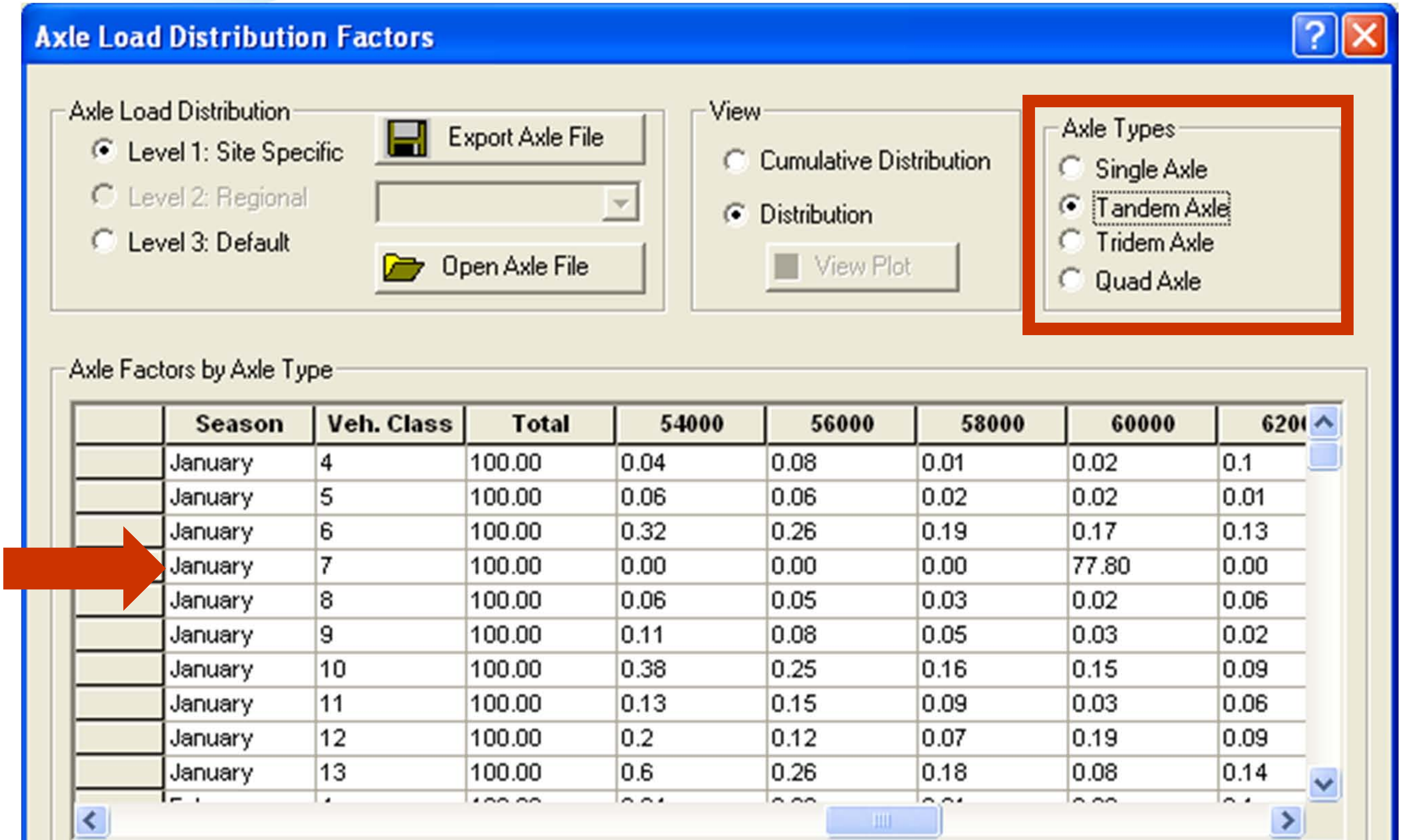
Monthly Adjustment Factors

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
February	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
March	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
April	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
May	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
June	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
July	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
August	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
September	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
October	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
November	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
December	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

OK | Cancel



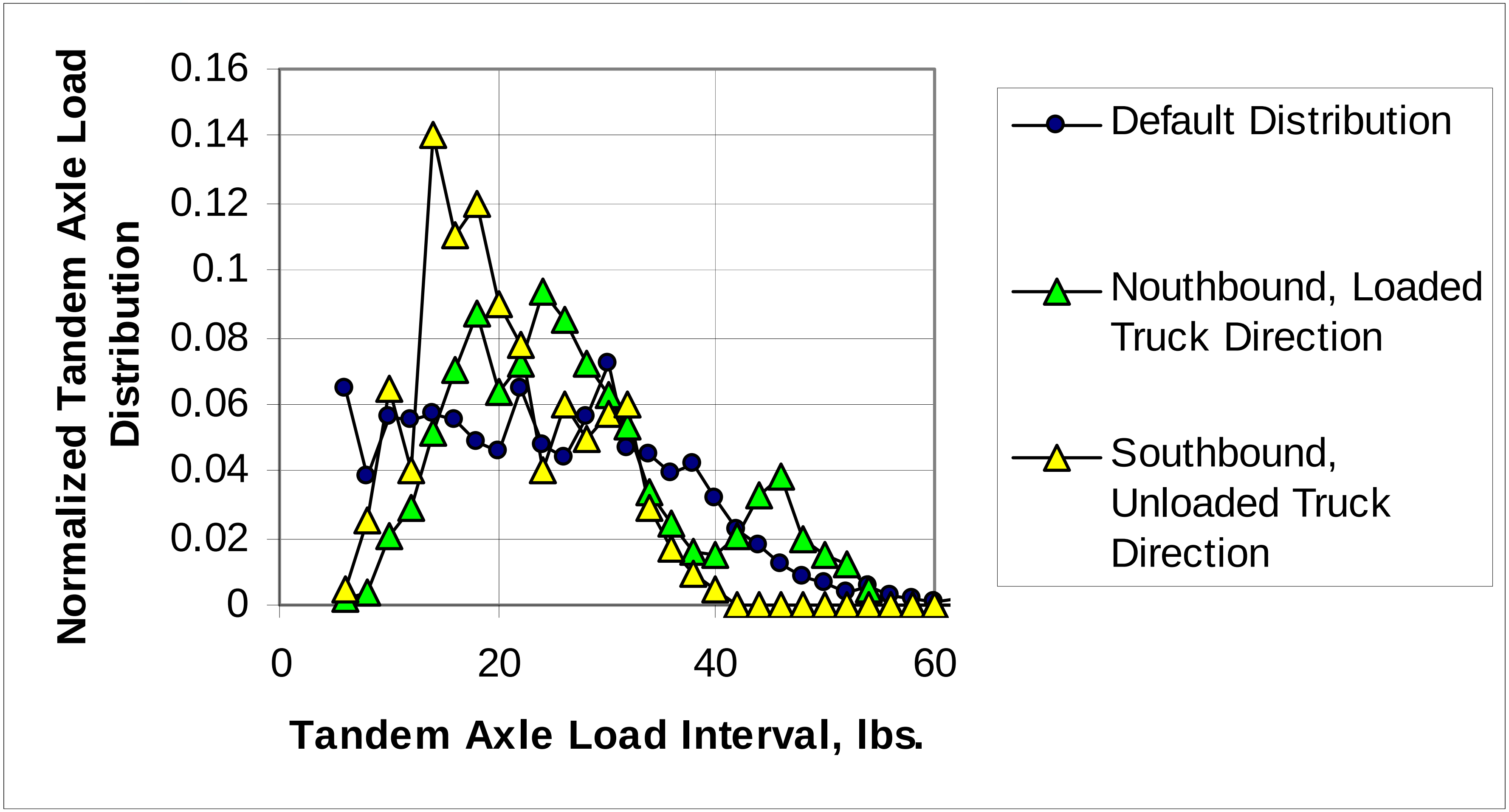
Truck Growth:
No growth used for mega vehicle.



	Season	Veh. Class	Total	54000	56000	58000	60000	620(
	January	4	100.00	0.04	0.08	0.01	0.02	0.1
	January	5	100.00	0.06	0.06	0.02	0.02	0.01
	January	6	100.00	0.32	0.26	0.19	0.17	0.13
	January	7	100.00	0.00	0.00	0.00	77.80	0.00
	January	8	100.00	0.06	0.05	0.03	0.02	0.06
	January	9	100.00	0.11	0.08	0.05	0.03	0.02
	January	10	100.00	0.38	0.25	0.16	0.15	0.09
	January	11	100.00	0.13	0.15	0.09	0.03	0.06
	January	12	100.00	0.2	0.12	0.07	0.19	0.09
	January	13	100.00	0.6	0.26	0.18	0.08	0.14

Axle Load Distribution

Truck Tandem Axle Load Distributions



General Traffic Inputs

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Lateral Traffic Wander

Mean wheel location (inches from the lane marking): 18

Traffic wander standard deviation (in): 10

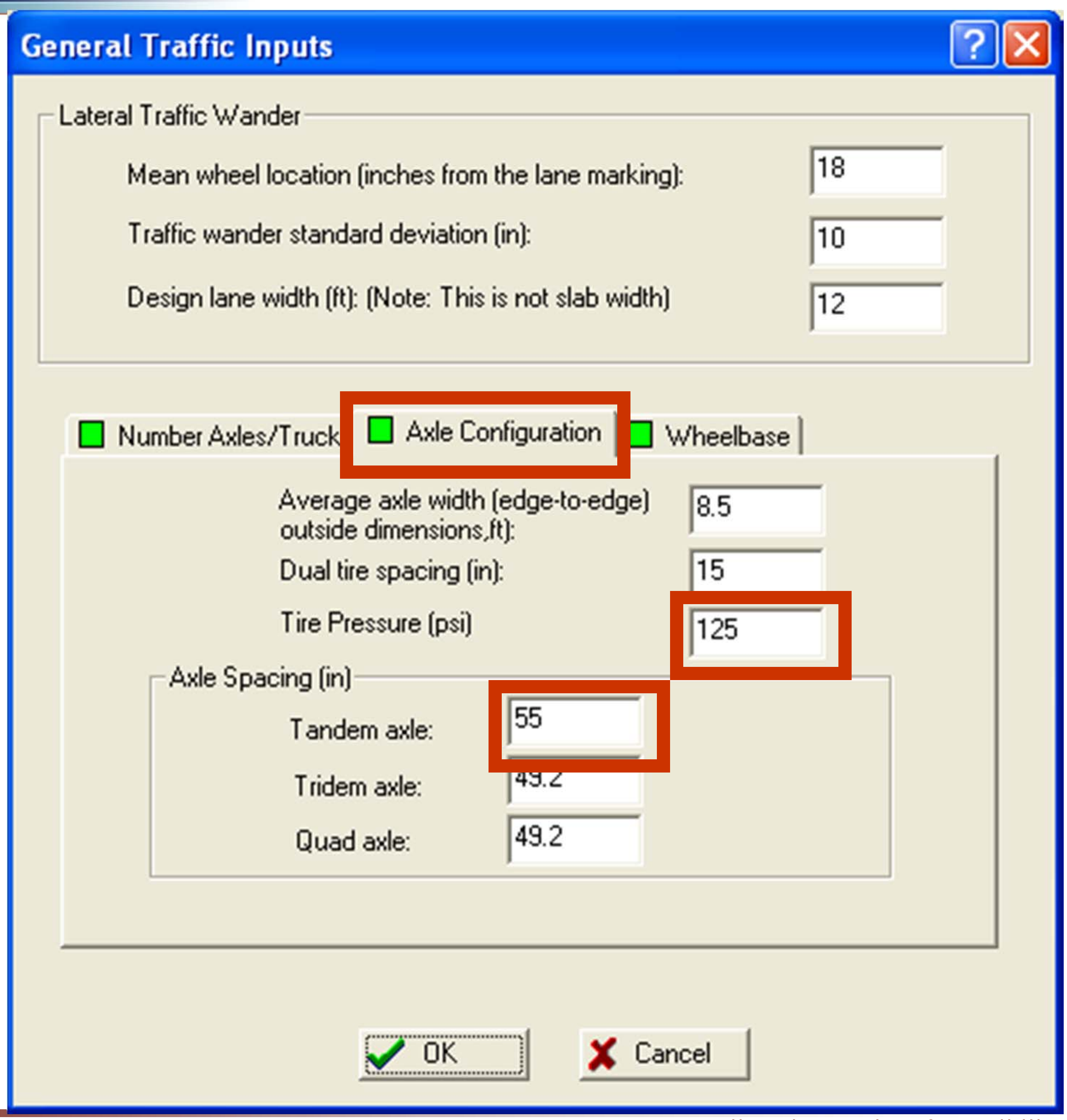
Design lane width (ft): (Note: This is not slab width) 12

Number Axles/Truck | Axle Configuration | Wheelbase

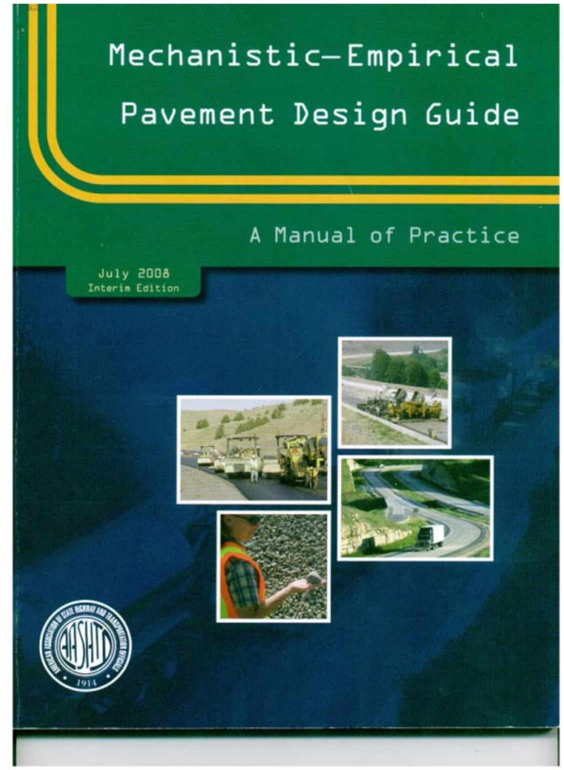
	Single	Tandem	Tridem	Quad
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	2	5	0	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

OK | Cancel

General Traffic Inputs

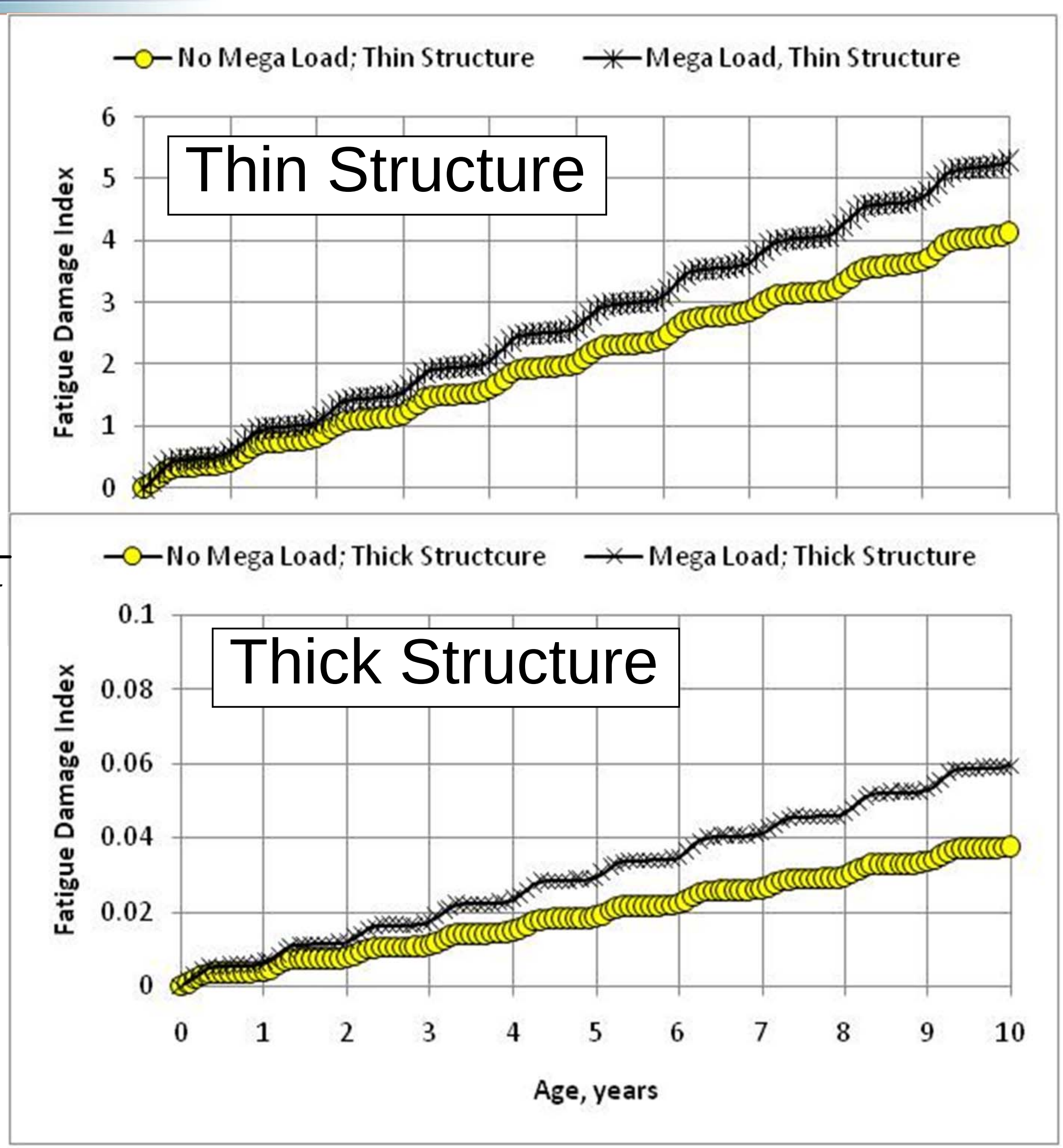


Distresses or Performance Indicators Predicted with the MEPDG:

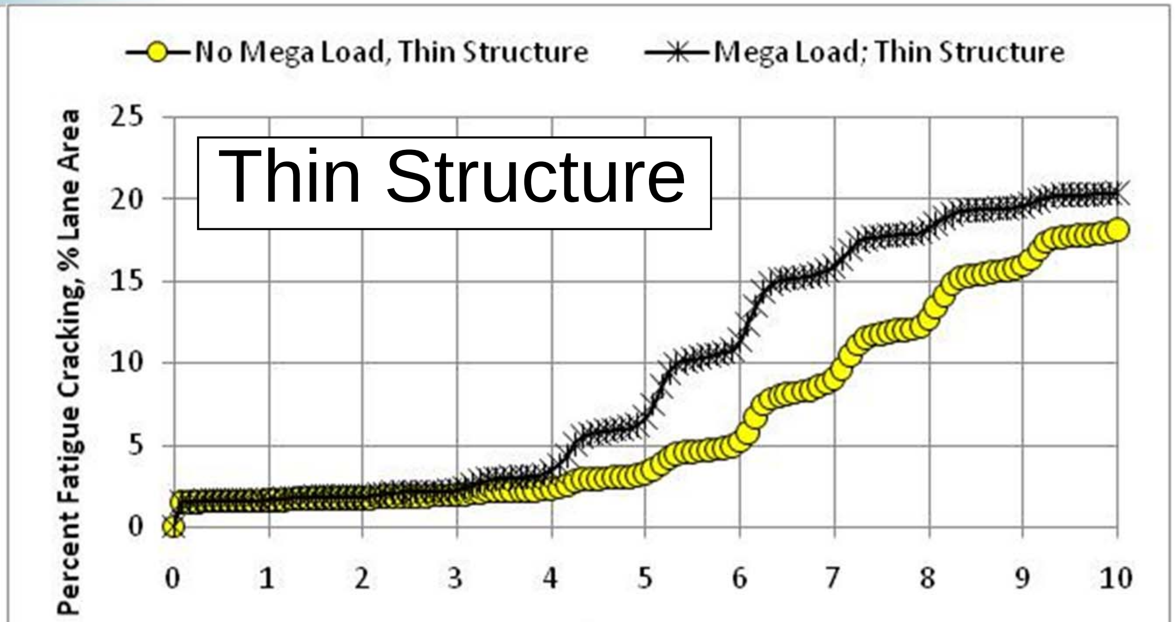


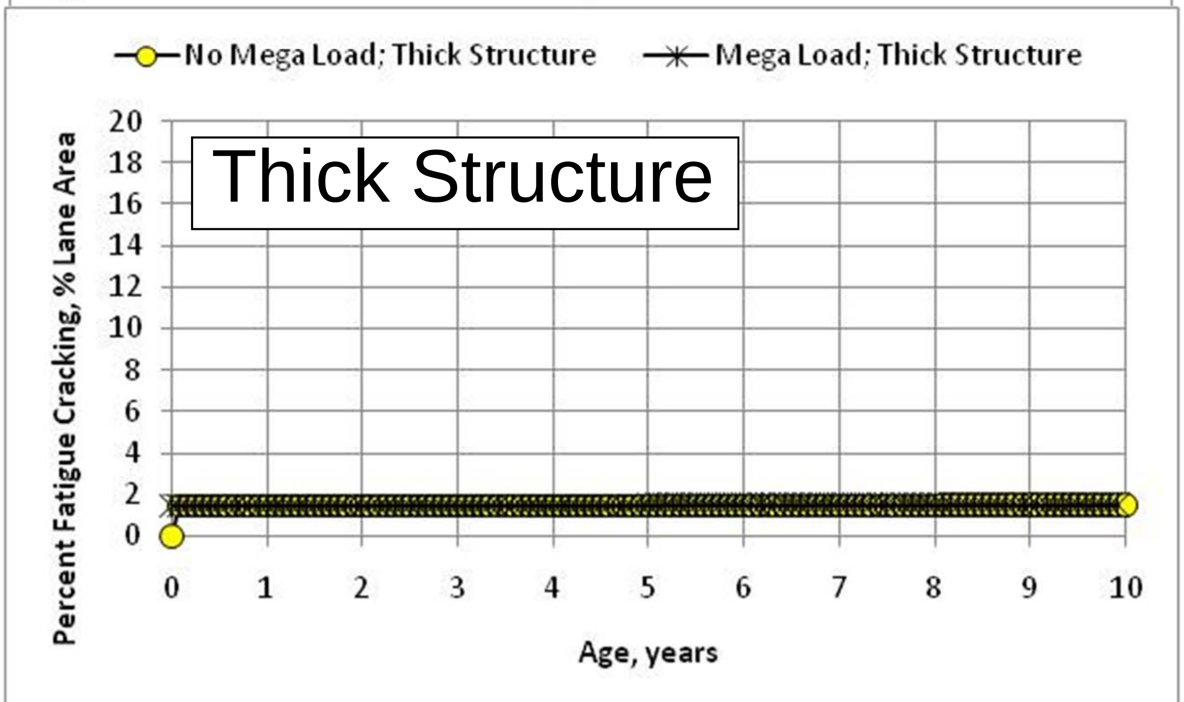
Increased Fatigue Damage

$$Damage = \sum \frac{n}{N}$$

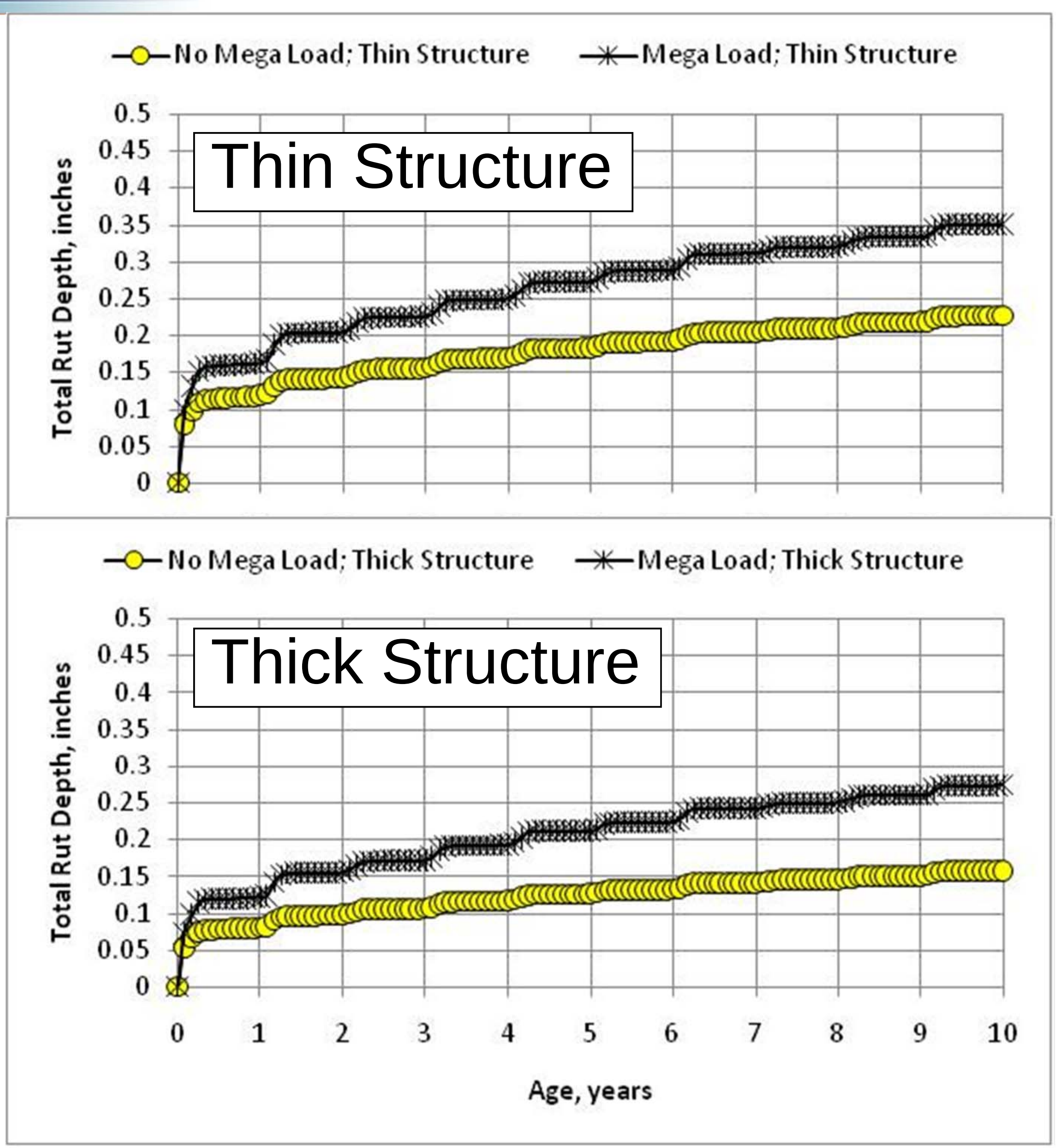


Increased Fatigue Cracking

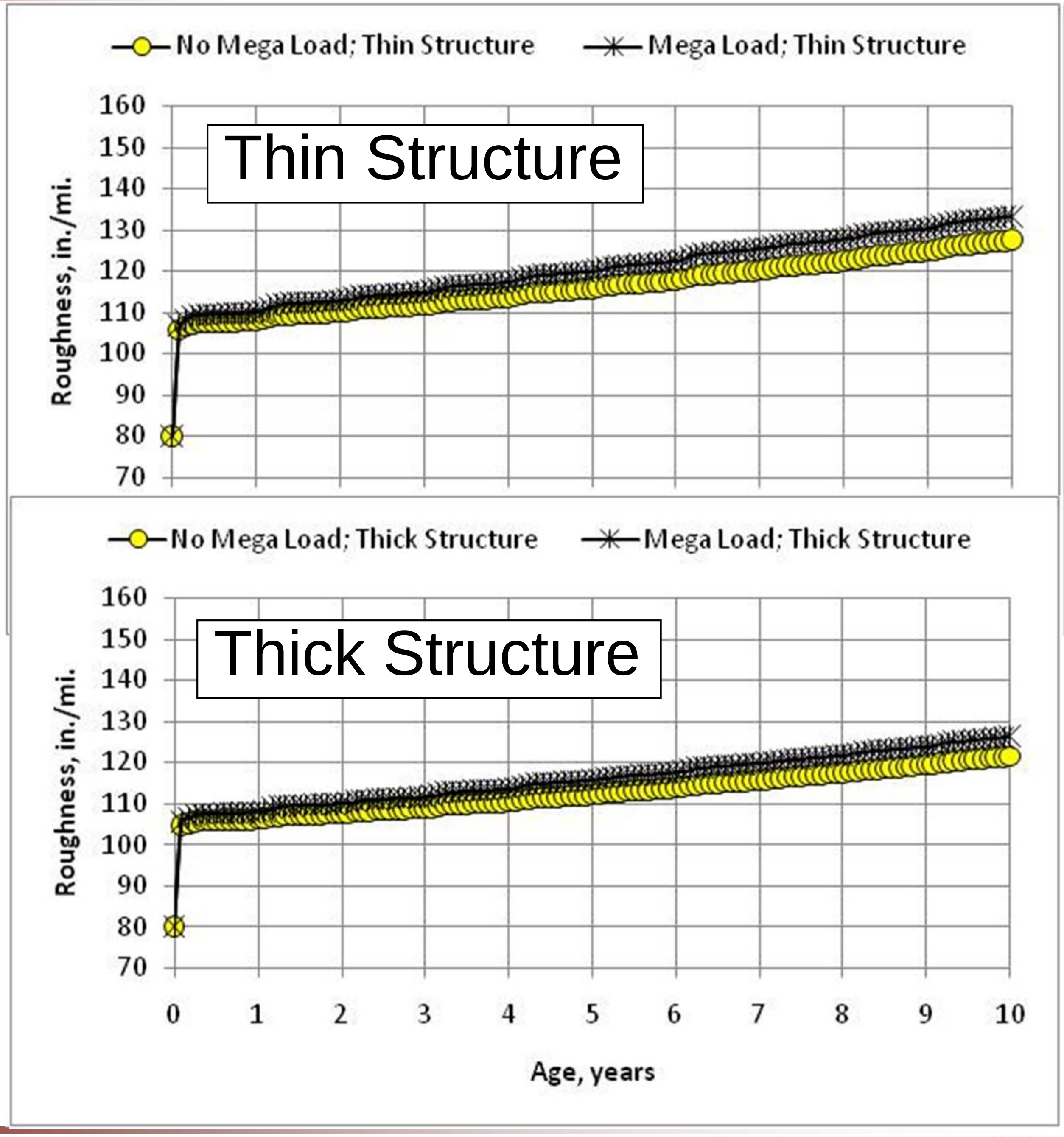




Increased Rutting



Increased Roughness



5. Summary or Findings

M-E Based Analysis:

1. Each mega vehicle applies about 30 ESALs per operation.
2. Pavement will exhibit slightly higher levels of alligator cracking, rutting, and roughness.
3. Mega vehicle more damaging over weaker soils.

5. Summary or Findings

4. Expect service lives to decrease no more than about 2 years in comparison to pavements without these mega vehicles ***that were properly designed***.
5. New designs or rehabilitation strategies will require no more than about 0.5 inch of HMA.

QUESTIONS?

Photo: Courtesy of Ken Fults.