Field Performance of an Instrumented Pavement in Oklahoma

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Presentation Outline

- Objectives
- Pavement Design & Field Instrumentation
- Field Data Collection
- Development of Rut Prediction Models
- Future Work

Southeastern Asphalt User/Producer Group Meeting, December 6 – 9,

OBJECTIVES

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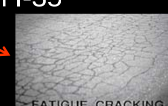
Objectives

- Develop transfer functions
  - Rut
  - Fatigue

- Study secondary roadway on I-35
  - Thinner Section
  - Accelerated Conditions



- Validate mechanistic pavement models
  - Actual vehicular traffic loading
  - Environmental conditions

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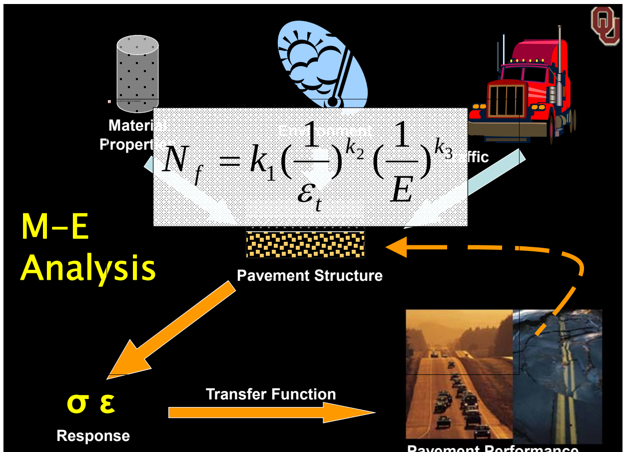

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PAVEMENT DESIGN & FIELD INSTRUMENTATION

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Site Location

- I-35 South Bound, McClain County (Oklahoma)
- 1000-ft. test section

Instrumented Site   WIM Site

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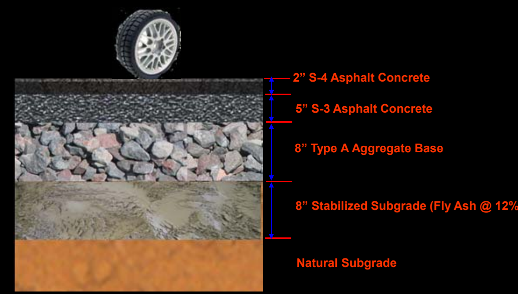
Pavement Section



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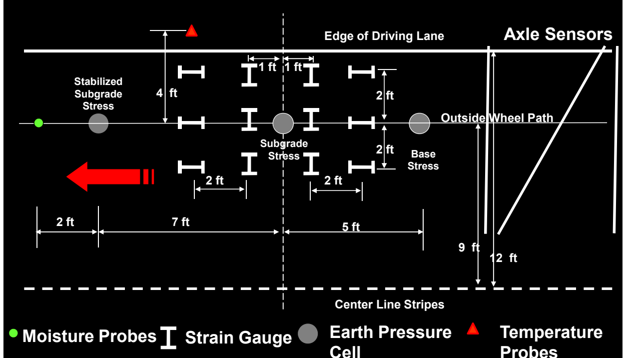
Instrumentation Array



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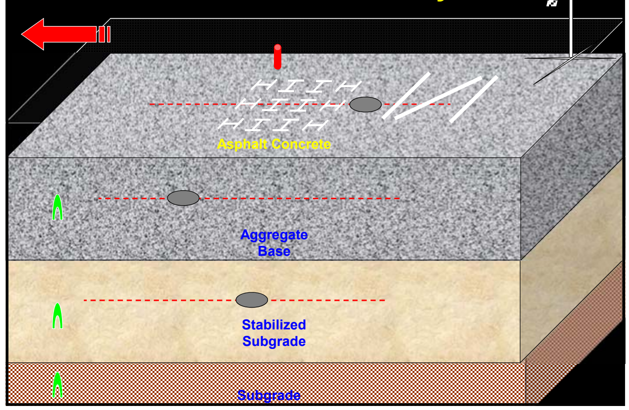
Instrumentation Layout



FIELD DATA COLLECTION

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Types of Data Collected

- Dynamic Data
  - Strain; Stress; Wheel wander (Offset)
- Environmental Data
  - Pavement temperature; Moisture under the pavement; Ambient temperature, Rainfall, Wind Speed, Humidity, Solar radiation
- Traffic Data
  - Weight/axle, Speed
- Performance Data
  - Falling weight deflectometer; Rut measurements; Crack mapping

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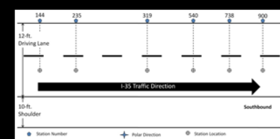
Traffic Data

- Vehicle Classification: WIM (Weigh-In-Motion) site

FWD Data

- Pavement Layer Moduli: FWD using Dynatest Model # 8000
- Plate diameter = 11.8-in.; Load = 6, 9, 12 and 15 kips; Sensor spacing = 0, 8, 12, 24, 36, 48, 72 in.
- Location: six identified stations



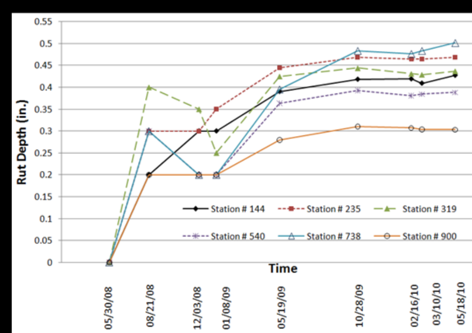
Rut Measurements

- Six Identified Stations (Station 144, 235, 319, 540, 738, 900-ft)
- Two Methods : (1) Straight Edge/ Rut Gauge
  (2) Face Dipstick®

(1)

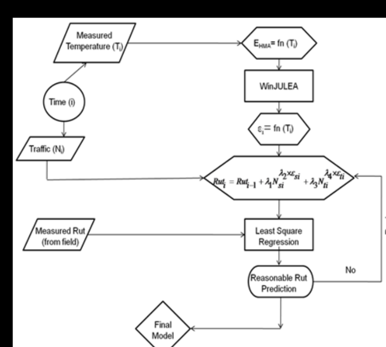
(2)

Rut Progression



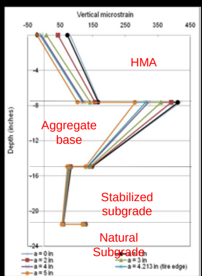
DEVELOPMENT OF RUT PREDICTION MODELS

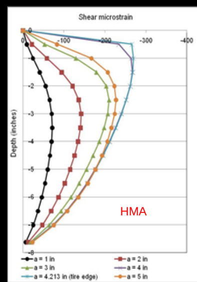
Rut Prediction Model Development



Rut Prediction Model Development (contd.)

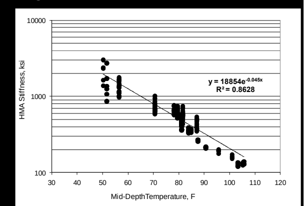
- Two models were developed: (1) Vertical Strain-based Model, and (2) Shear Strain-based Model



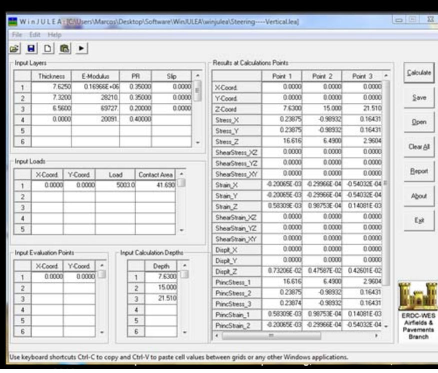


Vertical Strain-based Model Development

- Using WinJULEA
- Input data :
  - (a) HMA modulus (Back-calculated from FWD testing).
  - (b) Layer thickness
  - (c) Traffic data: axle type and weight



Vertical Strain-based Model Development (contd.)



Vertical Strain-based Model Development (contd.)

- Pick all steering and tandem axles of that hour
- Use WinJULEA to predict vertical strains. For example :

For Steering Axles:

$$\varepsilon_s = \frac{\varepsilon_{s1} + \varepsilon_{s2} + \varepsilon_{s3} + \dots\dots + \varepsilon_{sn}}{W_{s1} + W_{s2} + W_{s3} + \dots\dots + W_{sn}}$$

For Tandem Axles:

$$\varepsilon_t = \frac{\varepsilon_{t11} + \varepsilon_{t12} + \varepsilon_{t13} + \varepsilon_{t14} + \varepsilon_{t21} + \dots\dots + \varepsilon_{tnn}}{W_{t11} + W_{t12} + W_{t13} + W_{t14} + W_{t21} \dots\dots + W_{tnn}}$$

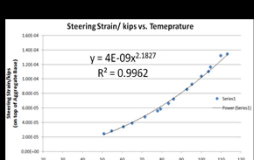
where, ε_s= Vertical Steering Strain; ε_t= Vertical Tandem Strain; W_s= Steering Axle Weight; W_t= Tandem Axle Weight

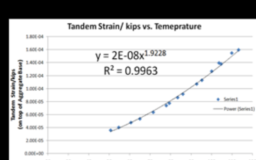
Vertical Strain-based Model Development (contd.)

- Run WinJULEA for a wide range of temperature to get vertical strain-temperature correlations:

For Steering Axles: $\varepsilon_s = 4 * 10^{-09}\, T^{2.1827}$

For Tandem Axles: $\varepsilon_t = 2 * 10^{-08}\, T^{1.9228}$





Vertical Strain-based Model Development (contd.)

- Field rut measurements every three months and interpolation gives a rut value for each hour of each day
- Final rut prediction model using non-linear regression:

$$Rut_i = Rut_{i-1} + \lambda_1 (N_{si}^{\lambda_2 * \varepsilon_{si}} + N_{ti}^{\lambda_3 * \varepsilon_{ti}})$$

where,

$$\varepsilon_{si} = \varepsilon_s * \frac{W_{s1} + W_{s2} + W_{s3} + \dots\dots + W_{sn}}{N_{si}}$$

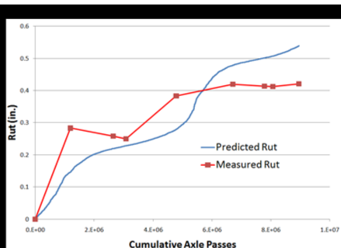
$$\varepsilon_{ti} = \varepsilon_t * \frac{W_{t11} + W_{t12} + W_{t13} + W_{t14} + W_{t21} \dots\dots + W_{tnn}}{N_{ti}}$$

where, N_{si}= Total no. of steering axles at i[th] hour; N_{ti}= Total no. of tandem axles at i[th] hour; ε_{si}= Normalized Vertical Steering Strain; ε_{ti}= Normalized Vertical Tandem Strain

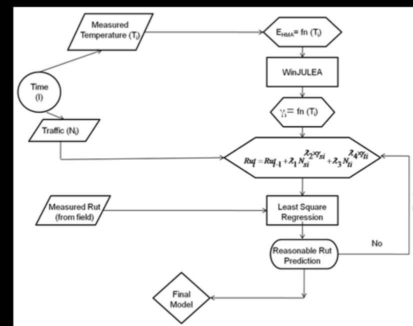
Final Vertical Strain-based Model

- Final vertical strain-based rut prediction model:

$$Rut_i = Rut_{i-1} + 3.26 * 10^{-06}(N_{si}^{1.54*10^2*\varepsilon_{si}} + N_{ti}^{3.48*10^2*\varepsilon_{ti}})$$



Shear Strain-based Model Development



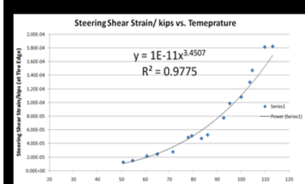
Shear Strain-based Model Development

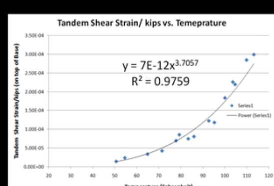
(contd.)

- Run WinJULEA for a wide range of temperature to get shear strain-temperature correlations:

For Steering Axles $\gamma_s = 1 * 10^{-11}\, T^{3.4507}$

For Tandem Axles: $\gamma_t = 7 * 10^{-12}\, T^{3.7057}$





Shear Strain-based Model Development

(contd.)

- Field rut measurements every three months and interpolation gives a rut value for each hour of each day
- Final rut prediction model using non-linear regression:

$$Rut_i = Rut_{i-1} + \lambda_1'(N_{si}^{\lambda_2'*\gamma_{si}} + N_{ti}^{\lambda_3'*\gamma_{ti}})$$

where,

$$\gamma_{si} = \gamma_s * \frac{W_{s1} + W_{s2} + W_{s3} + \dots\dots\dots + W_{sn}}{N_{si}}$$

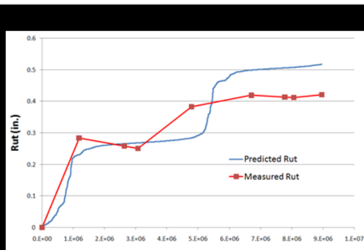
$$\gamma_{ti} = \gamma_t * \frac{W_{t11} + W_{t12} + W_{t13} + W_{t14} + W_{t21} \dots\dots\dots + W_{tnn}}{N_{ti}}$$

where, γ_s= Steering Shear Strain; γ_{si}= Normalized Steering Shear Strain; γ_t= Tandem Shear Strain; γ_{ti}= Normalized Tandem Shear Strain

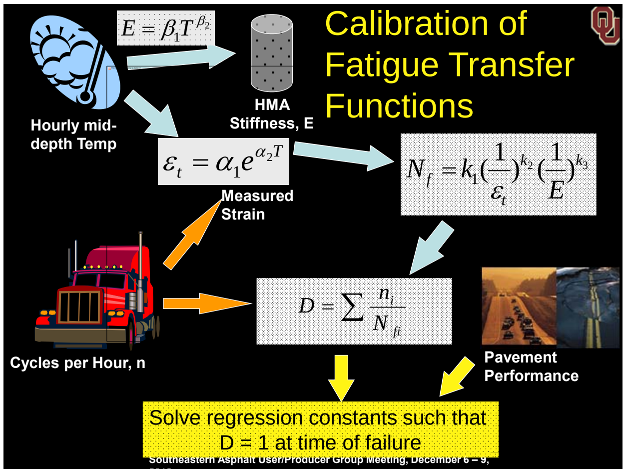
Final Shear Strain-based Model

- Final shear strain-based rut prediction model:

$$Rut_i = Rut_{i-1} + 1.38 * 10^{-06}(N_{si}^{1.58*10^2*\gamma_{si}} + N_{ti}^{3.37*10^2*\gamma_{ti}})$$



FUTURE WORK



Outcome…

- M-E performance model calibration or development
- Laboratory data to field performance
- Pavement response for dynamic effects on pavement deterioration from mechanistic viewpoint
- Develop seasonal trends in pavement response
- Correlate response to pavement damage

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