

Estimation of Stress Conditions for the Flow Number Simple Performance Test – TRB 10-2652

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Objectives

Asphalt Layer Behavior

Stress State Loading Rate Temperature

1. Define **loading conditions** in the asphalt layer created by moving truck load.
2. Recommendations for equivalent triaxial loading characteristics, deviator (σ_d) & confining (σ_c) stresses, in the **FLOW NUMBER (FN)** test.

Flow number test

Stress state in the pavement/triaxial condition

2" below surface

Permanent responses histories

$\sigma_d = \frac{1}{\sqrt{3}} |f_{axial}|$

$\sigma_c = \frac{1}{\sqrt{3}} (\sigma_1 + \sigma_2 + \sigma_3)$

$f_{axial} = \frac{1}{\sqrt{3}} \sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}$

Database of pavement stresses

- 50 mph without braking
- 40 mph without braking
- 20 mph without braking
- 20 mph with braking
- 2 mph with braking

HMA layer temp: 40 °C, 50 °C, 60 °C, and 70 °C

3D-Move model overview

Complex surface loadings in all three directions.

Moving loads of any shape (braking & turning forces)

Visco-elastic properties

Load distribution on 18-wheel Truck

Load redistribution due to braking

Braking	Steering axle	Driving axle	Trailer axle
Braking - Horizontal	2,081	2,968	2,968
Braking - Vertical	6,459	5,152	5,151
No Braking - Horizontal	0	0	0
No Braking - Vertical	4,000	4,200	4,200

Material properties characterization – AMPT E*

3D-Move based triaxial conditions at 2" below pavement surface

Max σ_d & σ_c for 4", 6", & 8" asphalt layer

Predictive equations for 4", 6", & 8" asphalt layer

4-inch HMA layer (without braking):

$$\sigma_d = -0.0844(T) + 0.06[E'] + 83.708$$

$$\sigma_c = 0.0232(T) - 0.0169[E'] + 32.495$$

6-inch HMA layer (without braking):

$$\sigma_d = -0.804(T) + 0.0066(T^2) + 0.076(S) - 0.000922(T)(S) - 7.045 \times \log(E') + 114.37$$

$$\sigma_c = -0.000967(T^2) - 0.1107(S) + 0.00171(T)(S) + 0.00139(T)[E'] + 31.41$$

8-inch HMA layer (without braking):

$$\sigma_d = 0.000576(T^2) + 0.000316(S^2) + 0.0463(E') - 0.00199(T)[E'] + 79.01$$

$$\sigma_c = -0.000826(T^2) - 0.11284(S) + 0.00168(T)(S) + 0.00139(T)[E'] + 30.26$$

Case of study: WestTrack

ENTRANCE RAMP EXIT RAMP

No FN

Critical Temperature (T_{cr})

Overall conclusions

- Amplitude of the equivalent triaxial σ_d & σ_c are highly affected by:
 - mixture $[E']$
 - pavement effective temperature
 - vehicle speed
- Prediction equations for estimating σ_d & σ_c as a function of pavement thickness.
- Lab determined T_{cr} for the WestTrack mix showed consistency with field-observed critical rutting temperature.
- The combination of elevated temperatures for an extended period of time & the traffic-induced loading contributes to the increased rate of rutting.

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