Developing Permanent Deformation Model for Hot Mix Asphalt

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Introduction

• Various Failures in Flexible Pavements,
• Why Rutting is the One Selected for this Study?
• Rutting Classification,
• Gap,
• Laboratory Experiments &
• Design Approach.
Introduction

Longitudinal

Transverse

Potholes

Raveling
Introduction

Rutting-1.1,

Fatigue cracking-1.8, and

Thermal cracking-2.2
Background

Rutting Definition;

*Rutting in Flexible Pavement*
Background

One dimensional densification or vertical compression;

Lateral flow or plastic movement;

Mechanical deformation.

Excessive Air Voids
Lack of Compaction

Primary Type
Purely Shear
Low Air Voids
Asphalt Layer

Least Common Type
Unbound Layers
Background

Critical stresses transmitted in flexible pavement  (Druta,2006)
Background

One dimensional densification or vertical compression;

Lateral flow or plastic movement;

Mechanical deformation.

1. Least Common Type
2. Severity Level; low to moderate
New Design Procedure

Strategic Highway Research Program (SHRP)

Superpave, short for Superior Performing Asphalt Pavements
New Design Procedure

Dynamic Modulus, $E^*$, determined by the uniaxial and triaxial compression test;

Flow Number, $F_N$, determined from the repeated load test; and

Flow Time, $F_T$, determined from the static creep test.
New Design Procedure

Dynamic Modulus Master Curve
New Design Procedure

Repeated Creep Test
New Design Procedure

Specifying tertiary point (Witczak, 2005).
Modeling

Rutting Prediction Methodology and Models:

1) *The Empirical Modeling*,

2) *Mechanistic-Empirical Models*,

   *Simple Performance Test*,

   (These, we will look at)

3) *Advanced Constitutive Model*:  
   *Linear Viscoelasticity (LVE)*
## Experimental Stage

**Dynamic & resilient modulus variables**

<table>
<thead>
<tr>
<th>Binder 60/70</th>
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<th>Binder 80/100</th>
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<tbody>
<tr>
<td>AC 14</td>
<td>AC 20</td>
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<td>AC 20</td>
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<tr>
<td>$V_a = 4.0%$</td>
<td>$V_a = 7.0%$</td>
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## Experimental Stage

Repeated and static load creep test variables

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<tr>
<td><strong>Temp.1 = 40,^\circ C</strong></td>
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<tr>
<td>$(\sigma_d)_1$</td>
<td>600kPa</td>
<td>600kPa</td>
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<tr>
<td>$(\sigma_d)_2$</td>
<td>690kPa</td>
<td>690kPa</td>
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<tr>
<td>$(\sigma_3)_1$</td>
<td>0 kPa</td>
<td>0 kPa</td>
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<tr>
<td>$(\sigma_3)_2$</td>
<td>275 kPa</td>
<td>0 kPa</td>
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<tr>
<td></td>
<td>$\sigma_3 = 275$ kPa</td>
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<tr>
<td><strong>Temp.2 = 60,^\circ C</strong></td>
<td></td>
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</tr>
<tr>
<td>$(\sigma_d)_1$</td>
<td>600kPa</td>
<td>600kPa</td>
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<tr>
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Aim and Objectives

For designing purpose;

1) Based on mechanistic-empirical modeling: \( RD = a \left( F_{Nr} \right)^b \)

2) Deduce from viscoelastic theory:

   **Generalized Burgers Model:**

   \[
   \varepsilon = \frac{\sigma}{E_0} \left( 1 + \frac{t}{T_0} \right) + \sum_{i=1}^{n} \frac{\sigma}{E_i} \left[ 1 - \exp\left( -\frac{t}{T_i} \right) \right] \text{ or,}
   \]

   **Generalized Maxwell Model:**

   \[
   E(t) = \sum_{i=1}^{m} E_i e^{-t/\tau_i}
   \]
Thanks