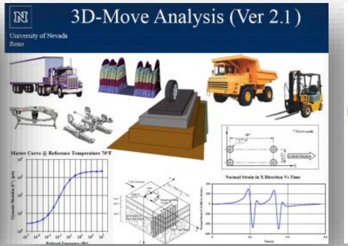






ARC Deliverables/Products Presentation and Workshop

http://www.arc.unr.edu/

Western Regional Superpave Center (WRSC)
University of Nevada, Reno

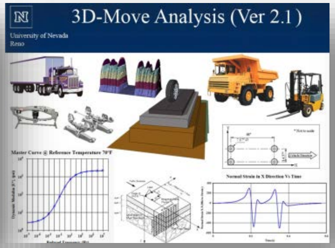
Washington, DC – January 15, 2015

ARC
Asphalt Research Consortium

WESTERN REGIONAL SUPERPAVE CENTER

11:05 – 11:30:	Pavement Engineering Software: Pavement Response Model to Dynamic Loads (3D-Move).
11:35 – 12:00:	Rutting Performance of Asphalt Mixtures Under Critical Conditions.
1:00 – 1:25:	Mix Design for Cold in-Place Recycling (CIR).
1:30 – 1:55:	Pavement Engineering Software: Thermal Cracking Analysis Package (TCAP).



ARC Deliverables/Products Presentation and Workshop

Rutting Performance of Asphalt Mixtures Under Critical Conditions

Standard Practice for

Determining Asphalt Mixture Critical Conditions for Rutting Evaluation by Means of Dynamic Repeated Load Triaxial (RLT) Test

AASHTO Designation: R XX-13

1. SCOPE

1.1. This standard practice describes the methodology for rutting susceptibility evaluation for hot mix asphalt (HMA) by means of dynamic Repeated Load Triaxial (RLT) test. This practice is intended for different types of asphalt mixtures having unmodified or modified asphalt binders.

1.2. This practice addresses the procedure to determine the RLT testing condi- regarding the loading pulse duration, rest period, and th- stresses. In addition, a mechanistic-based pro- susceptibility of HMA mixtures is de-

Western Regional Superpave Center

Critically Designed Asphalt Mixtures

Introduction[1]

- Every asphalt mixture has:
  - Critical temperature
  - Critical loading rate
  - Critical stress condition

Critical Conditions beyond which the mix will become highly unstable!

Mixture Rutting Susceptibility

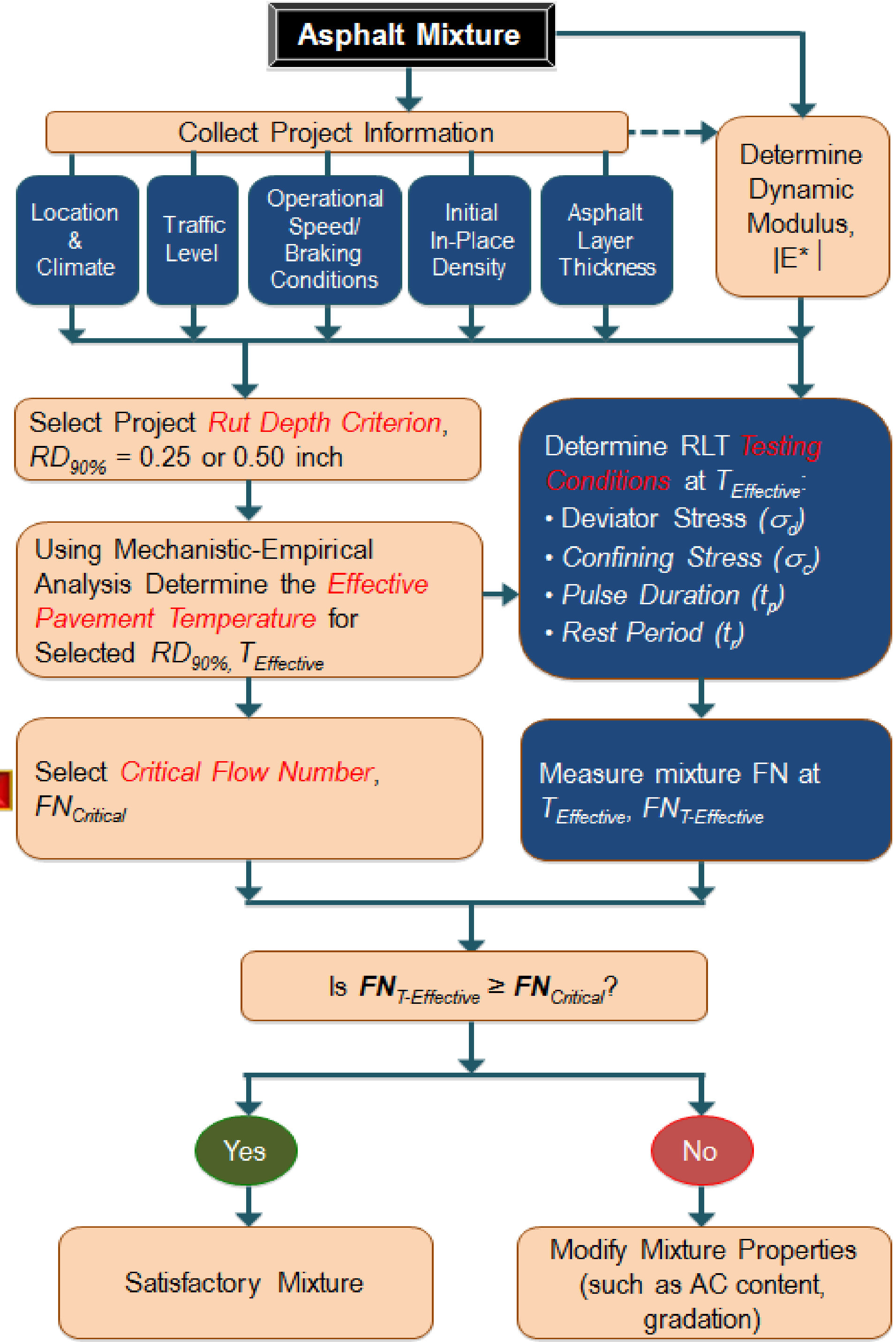
- Environmental Conditions/Location
- Traffic Loading Characteristics
- Material Properties
- Pavement Structure

Critically Designed Asphalt Mixtures
Introduction$_2$

- Critical conditions must be checked against expected field conditions where the mix will be placed.
- Optimization of Asphalt Mixture components in the design, production, and construction stage can lead to good performing HMA mixtures for highways and intersections.

Critically Designed Asphalt Mixtures

Mechanistic-Based Approach[1]



$T_{Critical}$ = Min temperature beyond which HMA becomes unstable

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Critically Designed Asphalt Mixtures

Mechanistic-Based Approach: Five Steps$_2$

Step 1

- Collect project information and select rut depth failure criteria.

Step 2

- Compute $T_{Effective}$ either using MEPDG analyses or the proposed predictive models.

Step 3

- Determine the RLT testing conditions based on HMA mixture dynamic modulus and other input parameters such as traffic speed, asphalt layer thickness, $T_{Effective}$, etc.

Step 4

- Select $FN_{Critical}$ based on designed traffic ESALs.

Step 5

- Conduct FN test and compare $FN_{T\text{-}Effective}$ to $FN_{Critical}$ for the appropriate design ESALs.

Critically Designed Asphalt Mixtures

Established Predictive Equations for $T_{Effective}$

- $T_{Effective}$ for a RD ≤ 0.25 inches at 90% reliability

$$= 20.6099 + 0.8764(MAAT) + 1.5870(\sigma MAAT) - 2.0006(Wind) + 0.1079(Sunshine)$$
$$-0.0891(Rain) + 14.7893(\log(Freq)) - 3.5748(\log(ESALs)) + 0.1677(PG_{HT})$$

- $T_{Effective}$ for a RD ≤ 0.50 inches at 90% reliability

$$= 25.7540 + 0.8287(MAAT) + 1.4932(\sigma MAAT) - 2.1949(Wind) + 0.1101(Sunshine)$$
$$-0.0967(Rain) + 16.2478(log(Freq)) - 4.0479(log(ESALs)) + 0.1416(PG_{HT})$$

Critically Designed Asphalt Mixtures
Flow Number Criteria

No Braking Condition

Design 20-year ESALS (millions)	< 3	3 to 10	10 to 30
Critical Flow Number ($FN_{Critical}$)	5,000	7,000	13,000

Braking Condition

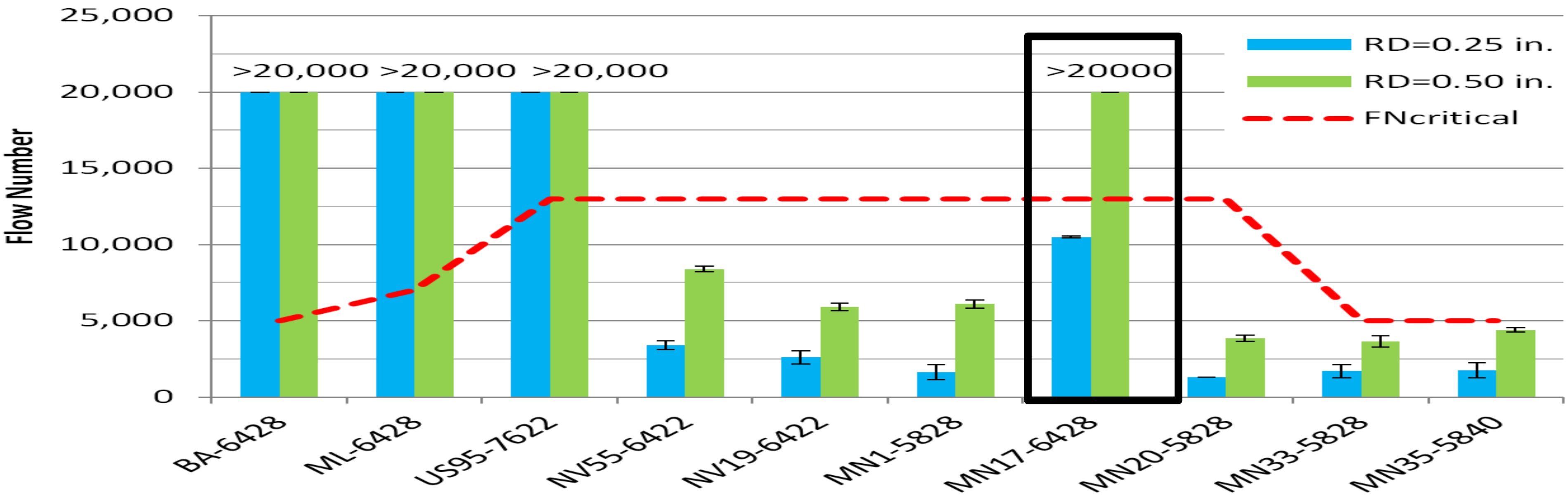
Critical FN criteria still need to be established

Critically Designed Asphalt Mixtures
Validation Mixes/Projects[1]

Mix ID	Location	Const. Date / Initial in-place air voids	Traffic Speed	20-year MESAL	Rut Depth
B. Ave_(6428)	Bravo Ave., Reno, NV.	August 2008 / 6%	Stopped to 25 mph	1	≤ 0.05 in. after 4 years of service
M. Lane_(6428)	Moana Lane Ext., Reno, NV.	November 2006 / 6%	40 mph	6	≤ 0.09 in. after 6 years of service
US95_(7622)	US95, Las Vegas, NV.	September 2007 / 7%	50 mph	18	No visible rutting
NV55_(6422)	WesTrack Cell 55	June 1997 / 4%	40 mph	30 (0.58[1])	0.87 in. after 5 months of service
NV19_(6422)	WesTrack Cell 19	March 1996 / 8%	40 mph	30 (4.8[1])	0.52 in. after 2.5 years of service
MN01_(5828)	MnRoad, I-94,Cell 1	September 1992 / 6.5%	65 mph	12.0 (8.5[1])	0.46 in. after 13 years of service
MN17_(6428)	MnRoad, I-94, Cell 17	July 1993 / 7%	65 mph	12.1 (10[1])	0.34 in. after 15 years of service
MN20_(5828)	MnRoad, I-94, Cell 20	July 1993 / 7%	65 mph	12.1 (5.1[1])	0.48 in. after 9 years of service
MN33_(5828)	MnRoad, Low Volume Closed Loop, Cell 33	August 1999 / 6%	35 mph	0.4 (0.13[1])	0.65 in. after 8 years of service
MN35_(5840)	MnRoad, Low Volume Closed Loop, Cell 35	August 1999 / 5.5%	35 mph	0.4 (0.13[1])	0.73 in. after 8 years of service

Critically Designed Asphalt Mixtures
Validation Mixes/Projects[2]

Mix ID	***Target RD90% = 0.25 inch***	***Target RD90% = 0.50 inch***	***$FN_{Critical}$***	***Predicted Performance at 90% Reliability (inch)***	***Field Performance - Measured RD (inch)***
	Average $FN_{T\text{-}Effective}$	**Average $FN_{T\text{-}Effective}$**			
B. Ave_(6428)	No Flow	No Flow	5,000	≤ **0.25**	≤ 0.05 (4 yrs)
MN33_(5828)	1,695	3,645	5,000	> 0.50	0.65 (8 yrs)
MN35_(5840)	1,745	4,395	5,000	> 0.50	0.73 (8 yrs)
M. Lane_(6428)	No Flow	No Flow	7,000	≤ **0.25**	≤ 0.09 (6 yrs)
US95_(7622)	No Flow	No Flow	13,000	≤ **0.25**	0.00 (5 yrs)
NV55_(6422)	3,395	8,395	13,000	> 0.50	0.87 (0.4 yrs)
NV19_(6422)	2,595	5,895	13,000	> 0.50	0.52 (2.5 yrs)
MN01_(5828)	1,645	6,095	13,000	> 0.50	0.46 (13 yrs)
MN17_(6428)	10,495	No Flow	13,000	≤ **0.50**	0.34 (15 yrs)
MN20_(5828)	1,296	3,845	13,000	> 0.50	0.48 (9 yrs)



Critically Designed Asphalt Mixtures
Critical Review of Proposed Approach

Consider traffic level?	Yes (ESALs)
Consider operational speed?	Yes
braking/non-braking conditions?	Yes / Requires further validation for braking condition
Approach relies on mechanistic analysis?	Yes (MEPDG Predictions using calibrated rutting models)
Consider climate conditions?	Yes ($T_{Effective}$ function of MAAT, Wind, Sunshine, Rain, etc.)
Confined test?	Yes (Predictive equations)
Consider HMA stiffness?	Yes (E*)
Consider pavement structure?	Yes (Affect deviator and confining stress)
Consider Initial In-place air voids?	Yes
Criteria based on rut depth level?	Yes (0.25 or 0.50" at 90% reliability level)
Requires additional processing data?	No (Traditional analysis of FN data)
Can be implemented in AMPT?	*Not yet / Requires equipment modification to be able to handle the proposed stress levels and pulse durations. Work on equivalent testing conditions.*

Critically Designed Asphalt Mixtures

Draft AASHTO Standard

(http://www.arc.unr.edu/Outreach.html#TechDevelopmentProducts)

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1.1. This standard practice describes the methodology for rutting susceptibility evaluation for hot mix asphalt (HMA) by means of dynamic Repeated Load Triaxial (RLT) test. This practice is intended for different types of asphalt mixtures having unmodified or modified asphalt binders.

1.2. This practice addresses the procedure to determine t… regarding the loading pulse duration, rest period, an… stresses. In addition, a mechanistic-based proc… susceptibility of HMA mixtures is de…

DETERMINING EFFECTIVE PAVEMENT TEMPERATURE

The effective pavement temperature ($T_{Effective}$) is obtained as the equivalent annual asphalt pavement temperature (T_{EAAPT}) that will result in the same level of rutting at the end of the 20-year design period at 90% reliability rut depth of 6.4 mm (0.25 in.) or 12.7 mm (0.50 in.).

Determine $T_{Effective}$ as the testing temperature to be used in the RLT using Equation 1 or Equation 2:

For rut depth criterion of 6.4 mm (0.25 in.):

$$T_{Effective} = 20.6099 + 0.8764(MAAT) + 1.5870(\sigma MMAT) - 2.0006(Wind) + \ldots .1079(Sunshine) - 0.0891(Rain) + 14.7893(\log(Freq)) - 3.5748(\log(ESALs)) + \ldots .1677(PG_{HT}) \quad \text{if} \quad \text{rut depth criterion} < 6.4 \text{ mm (0.25 in.)} \qquad (1)$$

…r rut depth criterion of 12.7 mm (0.50 in):

$$\ldots_{ective} = 25.7540 + 0.8287(MAAT) + 1.4932(\sigma MAAT) - 2.10\ldots \; \ldots 101(Sunshine) - 0.0967(Rain) + 16.2478(\log(F\ldots \; \ldots 16(PG_{HT}) \ldots$$

12. DETERMINING THE RLT TESTING CONDITIONS

12.1. The selected testing conditions shall ensure that the testing state of stresses and loading pulse characteristics are appropriate and best simulate the stress and loading pulse conditions encountered in the pavement under traffic loads.

12.2. Compute the deviator stress pulse duration (t_p) using Equation 3:

$$\log(t_p) = -0.00353\,(T_{Effective}) - 0.0236(S) + 0.00015(S)^2 - 0.6654 \qquad (3)$$

where:

t_p = deviator stress pulse duration, seconds;

$T_{Effective}$ = effective pavement temperature, °C;

S = vehicle operational speed, mph.

12.3. Compute the deviator stress rest period (t_r) using Equation 4:

$$t_r = \frac{L}{S}$$

Critically Designed Asphalt Mixtures
Impact of Mixture Characteristics

Mixture Characteristics

Air voids and Asphalt PG_{HT}

Lockwood Mixes
- PG64-22
- PG58-22
- PG52-22

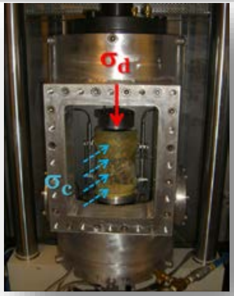
Aggregate morphology

Asphalt binder non-recoverable properties

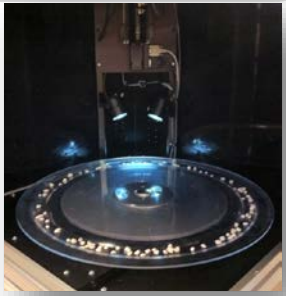
HMA Internal structure

Nine Mixtures (ETG FN Task Force)

RLT Testing
- Flow Number
- Air voids = 2, 4 and 7%

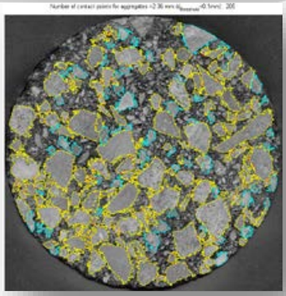


AIMS
- Particle Shape
- Coarse Angularity
- Fine Angularity
- CAAT



MSCR
- Non-recoverable creep compliance
- Percent recovery

2D-Imaging
- Aggregate contact points
- Aggregate gradation



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Thank You!