

Asphalt Rubber Research and Testing Program Jackrabbit Forensic Evaluation

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CIVIL AND ENVIRONMENTAL
ENGINEERING



Projects

09/15/06 Work Plan - Asphalt Rubber Testing Program

Project	Due	Mix	Beam Fatigue Test		Flow Number				Flow Time				E* Dynamic Modulus				IDT		Triaxial Shear		Binder						
					Unconf		Conf		Unconf		Conf		Unconf		Conf						Tank	RTFO					
Two Guns Plant Mix	31-May-05	Conv	Done	Mohmo	Done	Yow Shi			Done	Yow Shi	Done	Krishna	Done	Javed			Done	Alex	Done	Alex	Done	Javed	Done	Javed			
		Open	Done	Andres & Kenny	Done	Krishna	Done	Andres & Krishna	Done	Krishna	Done	Krishna	Done	Javed	Done	Javed	Done	Alex	Done	Alex	Done	Javed					
		Gap	Done	Kenny & Alex	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Javed	Done	Javed	Done	Alex	Done	Alex	Done	Javed					
Jackrabbit	21-Dec-05	Conv	Done	Kenny	Done	Carolina	Done	Carolina	Done	Carolina	Done	Carolina	Done	Javed	Done	Krishna	Done	Alex	Done	Alex	Done						
		Open	Done	Kenny	Done	Carolina	Done	Carolina	Done	Carolina	Done	Carolina	Done	Javed	Done	Krishna	Done	Alex	Done	Alex	Done						
		Gap	Done	Kenny	Done	Carolina	Done	Carolina	Done	Carolina	Done	Carolina	Done	Javed	Done	Krishna	Done	Alex	Done	Alex	Done						
101-202 Project	1-Jun-06	101											Done	Krishna	Done	Krishna											
		202												Done	Carolina	Done	Carolina										
Silver Springs	31-Dec-05	Conv	Done	Kenny	Done	Carolina			Done	Carolina			Done	Krishna	Done	Krishna	Done	Alex	Done	Alex	Analysis only - Yin Tung						
		Open	Done	Kenny	Done	Carolina	Done	Krishna	Done	Carolina	Done	Krishna	Done	Krishna	Done	Krishna	Done	Alex	Done	Alex	Analysis only - Yin Tung						
Badger Springs	28-Feb-06	Conv	30	30	Kenny	Done	Krishna			Done	Krishna			Done	Krishna			Done	Alex	Done	Alex	Analysis only - Yin Tung					
		Open	Done	Kenny	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	9	0	Krishna	Done	Alex	Analysis only - Yin Tung			
		Gap	Done	Kenny	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	Done	Krishna	2	0	Krishna	Done	Alex	Analysis only - Yin Tung			
Kohl's Ranch	6/30/2006 delay	Conv1	4	0	Luiz	Done	Krishna			Done	Krishna			Done	Krishna								6	0	Alex		
		Conv2	10	0	Luiz	Done	Krishna			Done	Krishna			Done	Krishna								9	0	Krishna	6	0
Burrow Creek	31-Dec-06	Conv	30	20	Kenny	3	0	Carolina			3	0	Carolina			3	0	Krishna			9	9	Alex	6	0	Alex	
		Open	20	17	Kenny	3	0	Carolina	5	5	Carolina	3	0	Carolina	5	5	Carolina	3	3	Krishna	3	3	Krishna	9	9	Alex	6
Antelope Wash	31-Dec-07	Conv	30	30	Kenny	3	3	Carolina			3	3	Carolina			3	0	Krishna			9	9	Alex	6	6	Alex	
		Open	20	20	Kenny	3	3	Carolina	5	5	Carolina	3	3	Carolina	5	5	Carolina	3	3	Krishna	3	3	Krishna	9	9	Alex	6



Laboratory Tests

- Limited Binder Tests
- Triaxial Shear Strength
- Dynamic Modulus E^*
- Flow Number / Flow Time
- Fatigue
- IDT Creep and Strength



ARAC Problem

- ADOT experience in AR projects successful
 - Gap Graded Mixes (ARAC)

Total of 135 projects were constructed using the ARAC mix totaling 3521 lane miles

Year	HMA		
	Ton	Wt. Avg Price	Total Price
1989	45,334	\$27.38	\$1,241,320.00
1990	22,178	\$16.64	\$369,038.00
1991	19,667	\$25.44	\$500,420.50
1992	23,530	\$28.24	\$664,477.50
1993	57,117	\$19.43	\$1,109,561.75
1994	51,545	\$24.17	\$1,245,951.20
1995	144,359	\$18.33	\$2,646,373.25
1996	124,290	\$21.94	\$2,726,824.00
1997	219,491	\$23.34	\$5,122,184.44
1998	396,601	\$18.56	\$7,361,132.90
1999	421,781	\$21.97	\$9,264,552.78
2000	271,863	\$21.30	\$5,789,444.56
2001	269,356	\$25.41	\$6,844,416.00
2002	105,486	\$24.12	\$2,544,242.25
2003	215,802	\$23.97	\$5,173,042.50
2004	325,809	\$20.63	\$6,721,831.90
2005			
2006			
ALL	2,714,209	\$21.86	\$59,324,813.53



Recent ADOT Problems with Gap Graded AR Mixes (2004)

- Few Projects (4-5) that showed early Failure:
- One project of interest: I-40 Jackrabbit
 - Constructed in August 2004
 - 2005 serious Rutting Problems in Gap Graded mix
 - Stripping may be the cause



I-40 West Bound
Mile Post 277.0 – 277.1
06/01/2005





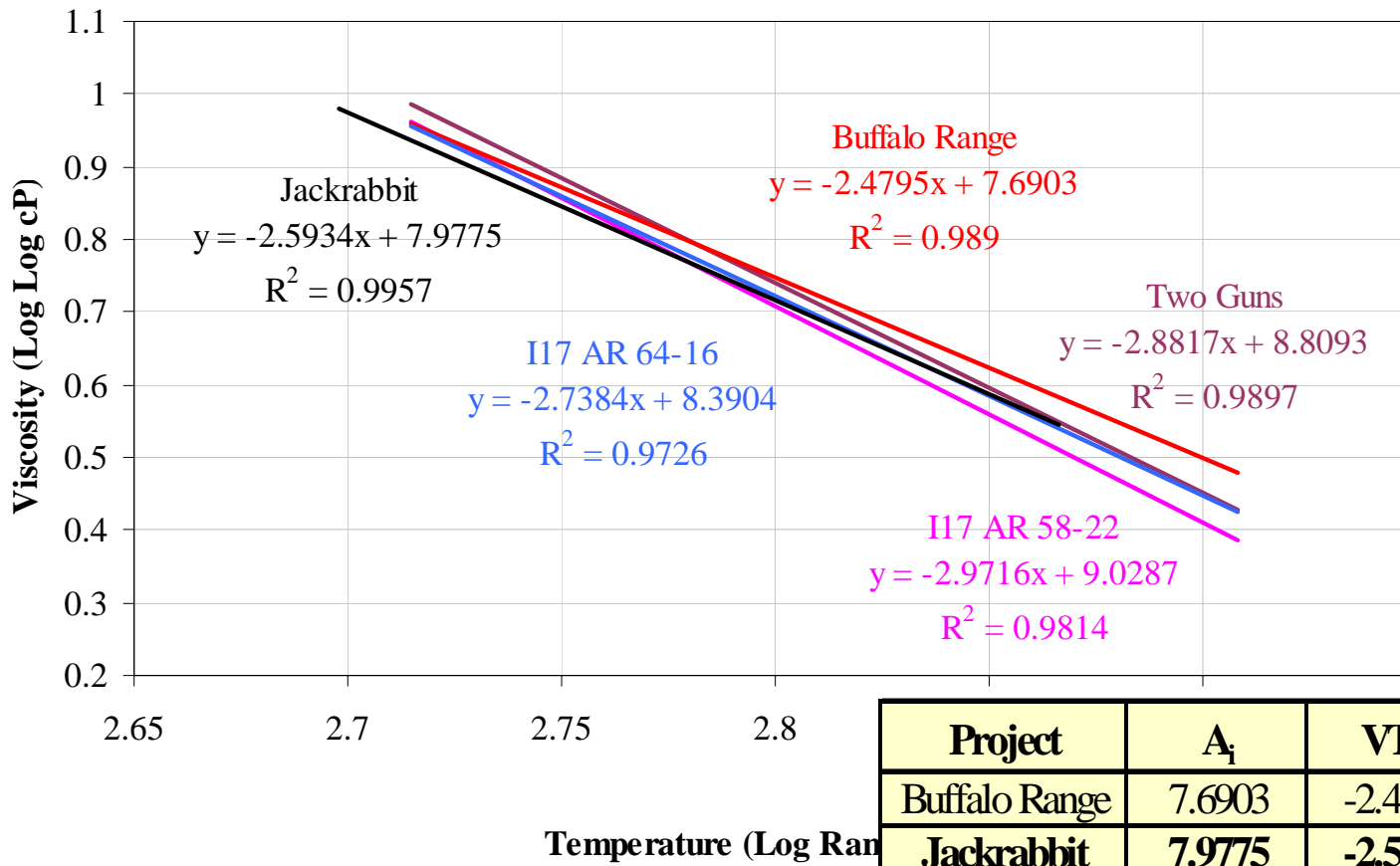
Action

- Evaluate ASU mixtures' test results
- Compare test properties among successful and failed projects
- Conduct AASHTO T 283 (Lottman Test) Standard Test Procedure
- Assess the way distresses are predicted using the MEPDG (2002 Pavement Design Guide)
 - Rutting and Fatigue Cracking
- Focus: identify possible causes of early failure.



Binder Tests

Summary of Binder Temperature and Viscosity relationship of AR mixes for different projects, Aging: Original



Project	A_i	VIS_i	R^2	Rank
Buffalo Range	7.6903	-2.4795	0.9890	1
Jackrabbit	7.9775	-2.5934	0.9957	2
I17 AR 64-16	8.3904	-2.7384	0.9726	3
Two Guns	8.8093	-2.8817	0.9897	4
I17 AR 58-22	9.0287	-2.9716	0.9814	5



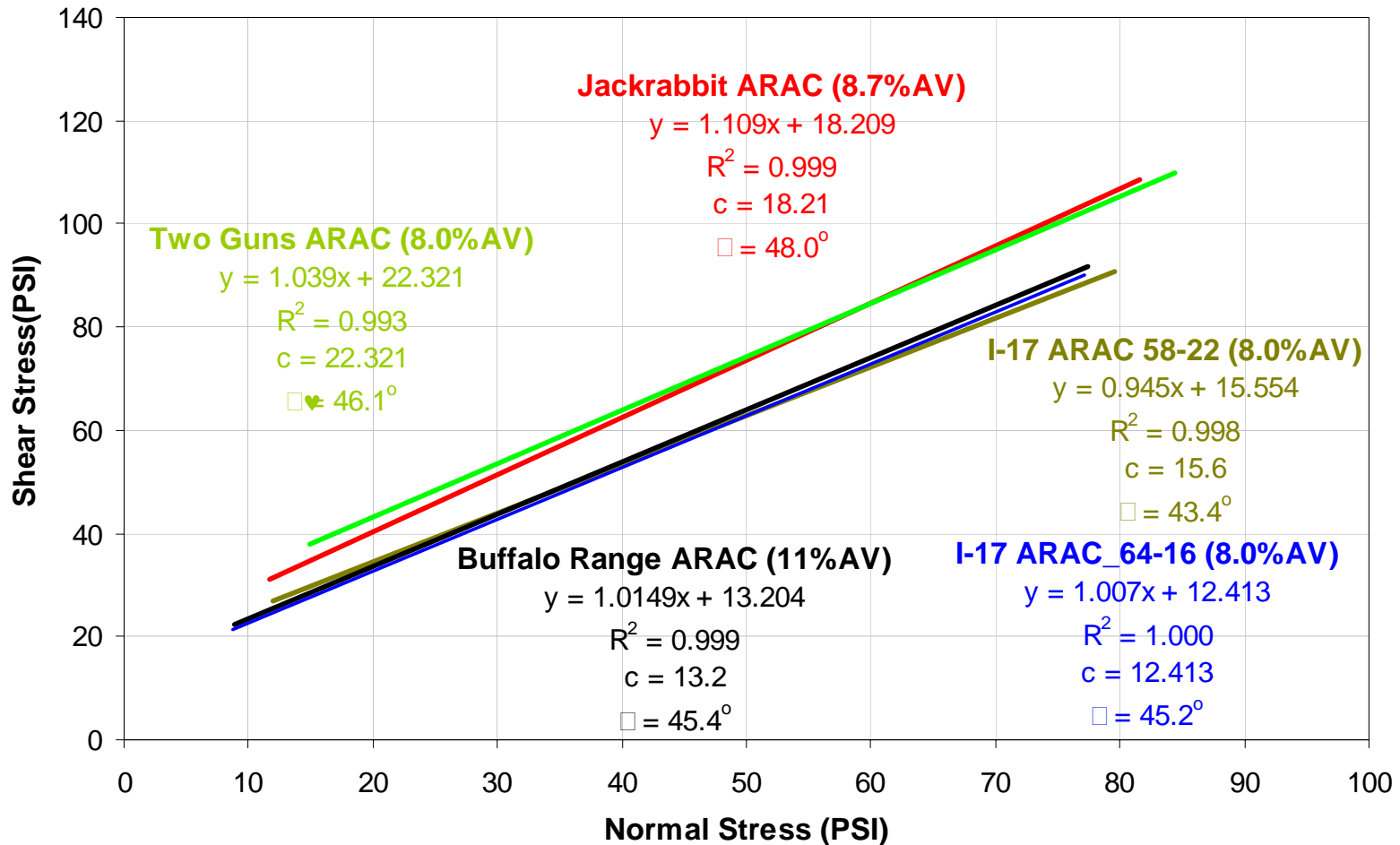
TRIAXIAL SHEAR STRENGTH TEST

- Specimen: cylindrical, gyratory compacted, 4 inches in diameter and 6 inches in height
- Strain rate: 0.05 in/in/min
- Test temperature: 100oF
- Three confinement levels: 0, 20, and 40 psi



Triaxial Shear Strength Tests

Mohr-Coulomb Failure Envelope





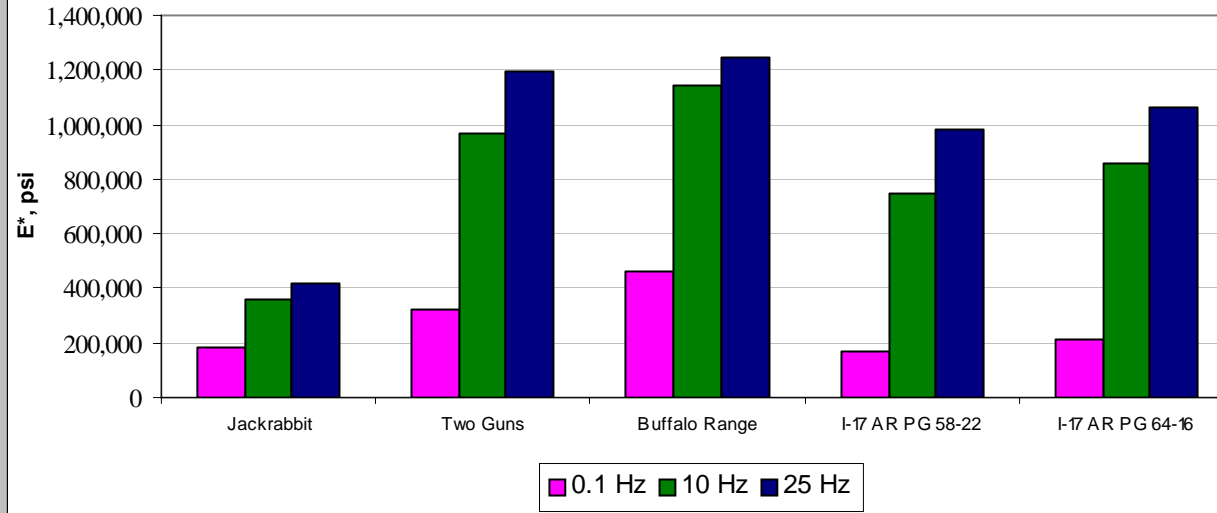
DYNAMIC MODULUS TEST

- Compare results of the Unconfined and Confined E^* Dynamic Modulus tests of Asphalt mixes of ADOT projects tested at Arizona State University.
- Particular emphasis on ARAC mixes.
- Comparison done owing to the following test conditions: Two Temperatures: 100 and 130 °F, three frequencies: 0.1, 10 and 25 Hz, and 20 psi confinement level.

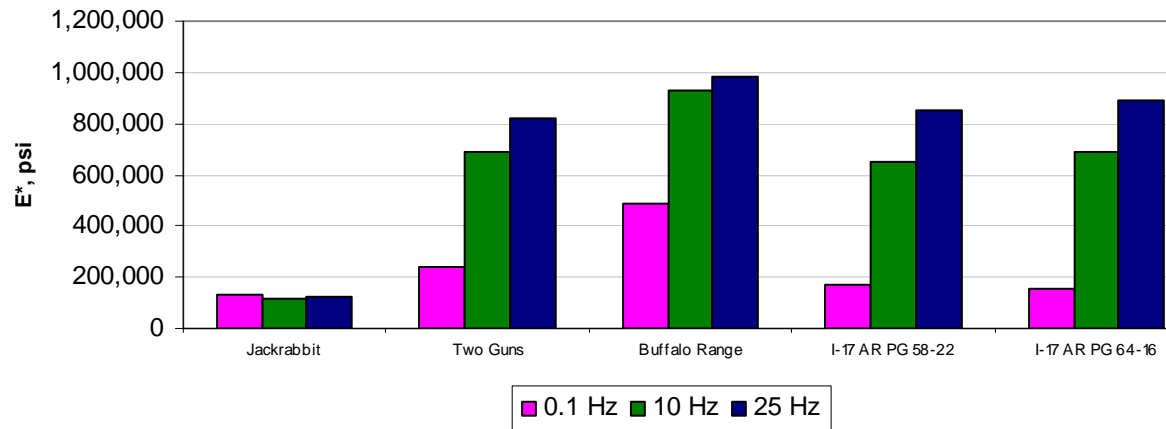


E* Test Results

Comparison Study of Measured Dynamic Modulus E* values of Confined Gap Graded mixtures at 0.1, 10 and 25 Hz and Temp 100 °F at 20 psi Confinement



Comparison Study of Measured Dynamic Modulus E* values of Confined Gap Graded mixtures at 0.1, 10 and 25 Hz and Temp 130 °F at 20 psi Confinement



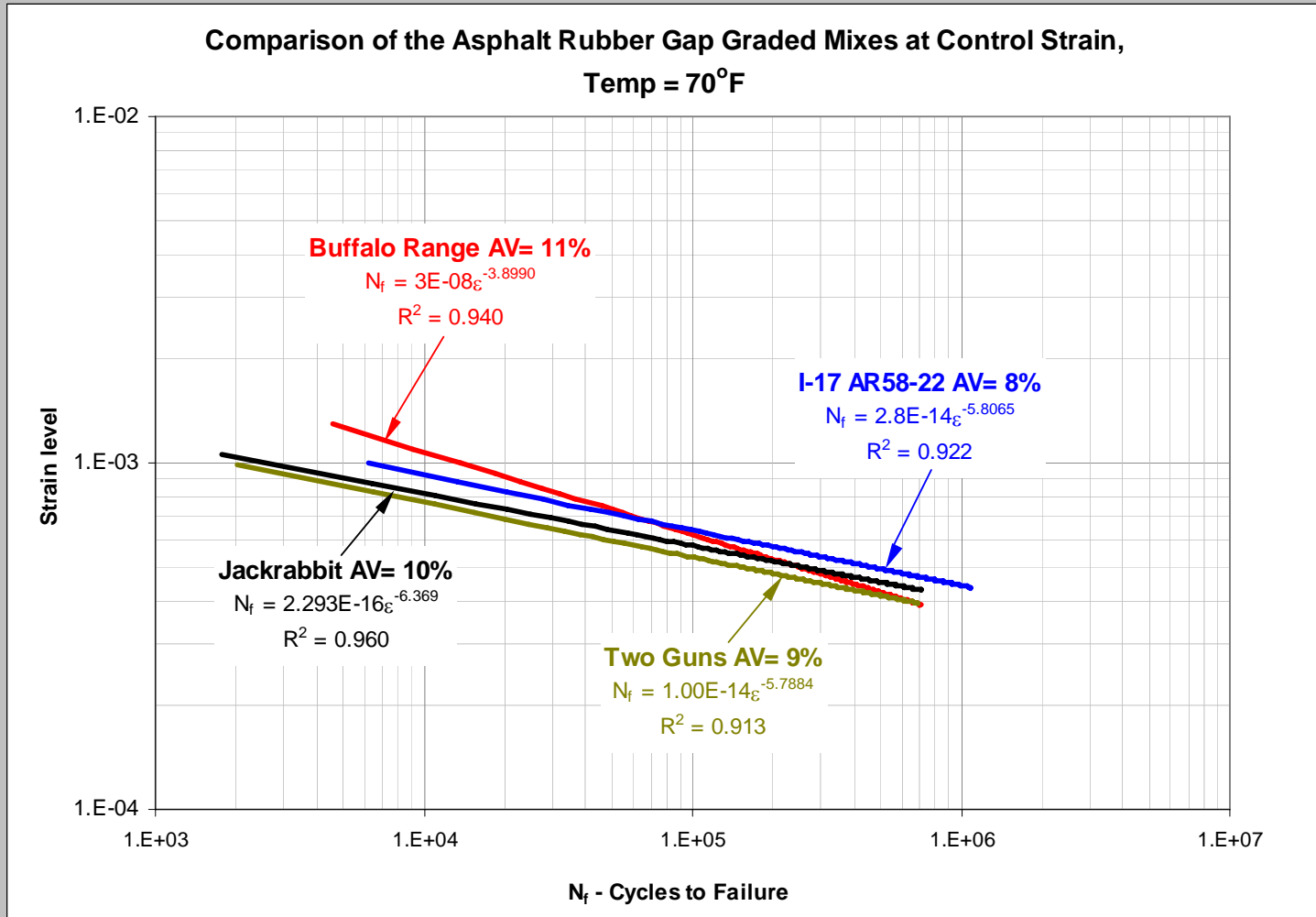


FLEXURAL BEAM FATIGUE TEST

- Specimen: beam 2.5 inches wide, 2.0 inches high, and 15 inches long
- Load condition: Constant strain level, 6-8 levels of the range (300-1750 $\mu\epsilon$)
- Load frequency: 10 Hz
- Test temperature: 100, 70, and 40°F for gap graded mixtures and 70 and 40°F for open graded mixtures

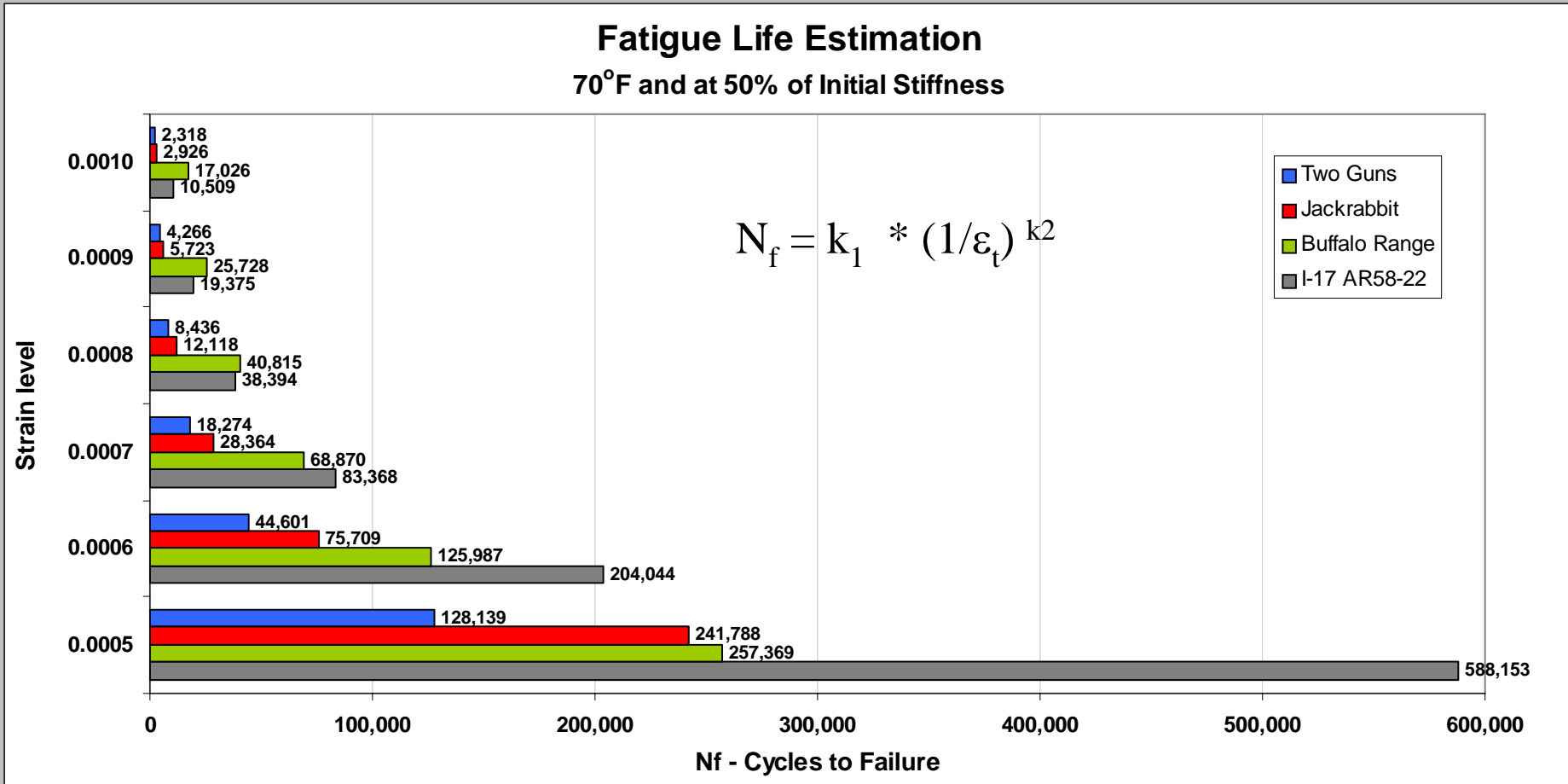


Comparison of ARAC Mixtures at 70°F





Fatigue Life Estimation





Two Guns ARAC Mixes, Modified Lottman Test Results

Condition Type	Sample ID	Design AC (%)	Actual Va (%)	Thickness (mm)	Load Max (N)	Diameter (mm)	Tensile Strength (N/mm ²)	TSR (%)	Average TSR (%)
C*	41315 T	7.00	9.28	72.57	1175.75	100	103.15		
D**	41315 B	7.00	8.90	72.11	1820.95	100	160.76	64.16	
C*	41339 B	7.00	6.78	71.91	1953.59	100	172.96		
D**	41339 T	7.00	7.44	71.76	2670.73	100	236.95	72.99	
C*	41344T	7.00	7.30	75.40	6200.00	100	523.48		
D**	41344B	7.00	7.04	75.20	9900.00	100	838.10	62.46	66.54

C - Wet Conditioned Samples*

*D** - Dry Samples*



Jackrabbit ARAC Mixes, Modified Lottman Test Results

Condition Type	Sample ID	Design AC (%)	Actual Va (%)	Thickness (mm)	Load Max (N)	Diameter (mm)	Tensile Strength (N/mm ²)	TSR (%)	Average TSR (%)
C*	JR342T	7.30	9.05	74.27	4790	100	410.61		
D**	JR342B	7.30	7.21	74.36	11770	100	1007.67	40.75	
C*	JR343B	7.30	7.31	74.45	6350	100	542.99		
D**	JR343T	7.30	7.68	73.17	10950	100	952.71	56.99	
C*	JR340B	7.30	12.98	75.31	2940	100	248.53		
D**	JR340T	7.30	14.33	75.60	6960	100	586.09	42.40	46.72

C - Wet Conditioned Samples*

*D** - Dry Samples*



MEPDG Input Data

- Construction history for all the projects
- Initial AADT
- For Pavement Structure:
 - Overlay: Asphalt Materials
Properties from laboratory testing for AR mixes (Level 1)
 - Existing Structure (Level 3)
- Subgrade modulus



Traffic information

<i>PROJECT</i>	<i>INITIAL AADTT</i>
Buffalo Range	14500
Two Guns	15530
Jack Rabbit	16200
Riordan	12350
Walnut Canyon	13400

- Principal Arterial-Interstate Load Distribution (Default Load Distribution)



Project Mixtures Properties

<i>Project</i>	<i>Mix</i>	<i>Binder</i>	<i>Target AC (%)</i>	<i>Target Va (%)</i>
<i>Buffalo Range</i>	AR-ACFC	AR 58-22	8.8	18
	ARAC	AR 58-22	6.8	11
<i>Two Guns</i>	Conv	PG 64-22	4.6	7
	AR-ACFC	AR 58-22	9.4	18
	ARAC	AR 58-22	7.0	9
<i>Jackrabbit</i>	Conv	PG 64-22	4.8	7
	AR-ACFC	AR 58-22	9.3	18
	ARAC	AR 58-22	7.3	9



Subgrade Resilient Modulus

<i>PROJECT</i>	<i>AVERAGE SUBGRADE MODULUS(Psi)</i>
Buffalo Range	25300
Two Guns	25100
Jack Rabbit	12500
Riordan	11300
Walnut Canyon	17750

- Subgrade resilient modulus by milepost were provided by ADOT for the different projects



Design Guide was not calibrated for Asphalt Rubber Mixes, but....

Distress Assessment of Conventional HMA and Asphalt Rubber Overlays on PCC Pavement Using the Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures

Session 701, Components Effects on Hot-mix Asphalt Pavement Structures
84th Annual Meeting Transportation Research Board
Washington D.C. –January 12th 2005

Maria Carolina Rodezno
Graduate Research Assistant



TRB, Jan 2005



CONCLUSIONS

- The rutting in conventional HMA and AR mixes is one of the distresses that the Design Guide can predict more accurately, despite the fact that no further calibration efforts were made on the rutting performance model.
- For the fatigue cracking level 3 analysis, the prediction was not accurate as expected. Future fatigue analysis should consider calibrated fatigue models for the different mixtures.
- The predicted IRI results differ significantly. One possible explanation is the inaccurate results for the distress performance output.

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MEPDG RESULTS-RUTTING

MEPDG Prediction- AC Rutting (in)					
<i>Project</i>	<i>BR</i>	<i>TG 1</i>	<i>TG2</i>	<i>JR1</i>	<i>JR2</i>
2001	0.04	-	-	-	-
2002	0.08	-	-	-	-
2003	0.11	0.02	0.01		
2004	0.13	0.05	0.03	0.04	0.04
2005	0.16	0.06	0.03	0.09	0.09
2006	0.17	0.07	0.04	0.12	0.12
2008	0.19	0.09	0.05	0.14	0.14
2009	0.20	0.10	0.06	0.17	0.18
2010	0.21	0.11	0.06	0.20	0.20
2011	0.23	0.12	0.07	0.21	0.22
2012	-	0.12	0.07	0.23	0.23
2013	-	0.13	0.08	0.24	0.25
2014	-	-	-	0.26	0.27



RESULTS - JACKRABBIT REDUCING E* FOR ARAC LAYER

- Attempt to simulate stripping of ARAC mixture.

	AC Rutting (in)		
Year	100 %E*	75% E*	50% E*
2004	0.04	0.13	0.62
2005	0.09	0.29	0.76
2006	0.12	0.39	0.84
2007	0.14	0.46	0.91
2008	0.17	0.56	0.99
2009	0.20	0.65	1.06
2010	0.21	0.70	1.11
2011	0.23	0.75	1.15
2012	0.24	0.80	1.19
2013	0.26	0.87	1.25



CONCLUSIONS

- Most of the laboratory tests indicated that there is no major difference in properties between Jackrabbit and other projects
- The E^* test results for Jackrabbit $<$ E^* other projects
- Positive Results from AASHTO T 283, more in progress.
- The attempt to simulate stripping problem in the field by reducing E^* values for Gap Graded mix may be indicative of possible failure.

THANK YOU

Questions?