Asphalt Rubber Research and Testing Program
Jackrabbit Forensic Evaluation

October 16, 2006

Kamil E. Kaloush, Ph.D., P.E.

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				
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				
		Gap	Done		Kenny	Done		Carolina	Done		Carolina	Done		Carolina	Done		Carolina	Done		Javed	Done		Krishna	Done		Alex	Done	Alex				
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				
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	9	0	Krishna	Done	Alex				
		Gap	Done		Kenny	Done		Krishna	Done		Krishna	Done		Krishna	Done		Krishna	Done		Krishna	Done		Krishna	2	0	Krishna	Done	Alex				
Kohl's Ranch	6/30/2006 delay	Conv1	4	0	Luiz	Done		Krishna				Done		Krishna				Done		Krishna							6	0	Alex	Analysis only - Yin Tung		
		Conv2	10	0	Luiz	Done		Krishna				Done		Krishna				Done		Krishna				9	0	Krishna	6	0	Alex			
Burrow Creek	31-Dec-06	Conv	30	20	Kenny	3	0	Carolina				3	0	Carolina				3	0	Krishna				9	0	Alex	6	0	Alex			
		Open	20	17	Kenny	3	0	Carolina	5	5	Carolina	3	0	Carolina	5	5	Carolina	3	0	Krishna	3	3	Krishna	9	9	Alex	6	6	Alex			
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	6	Alex			

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)

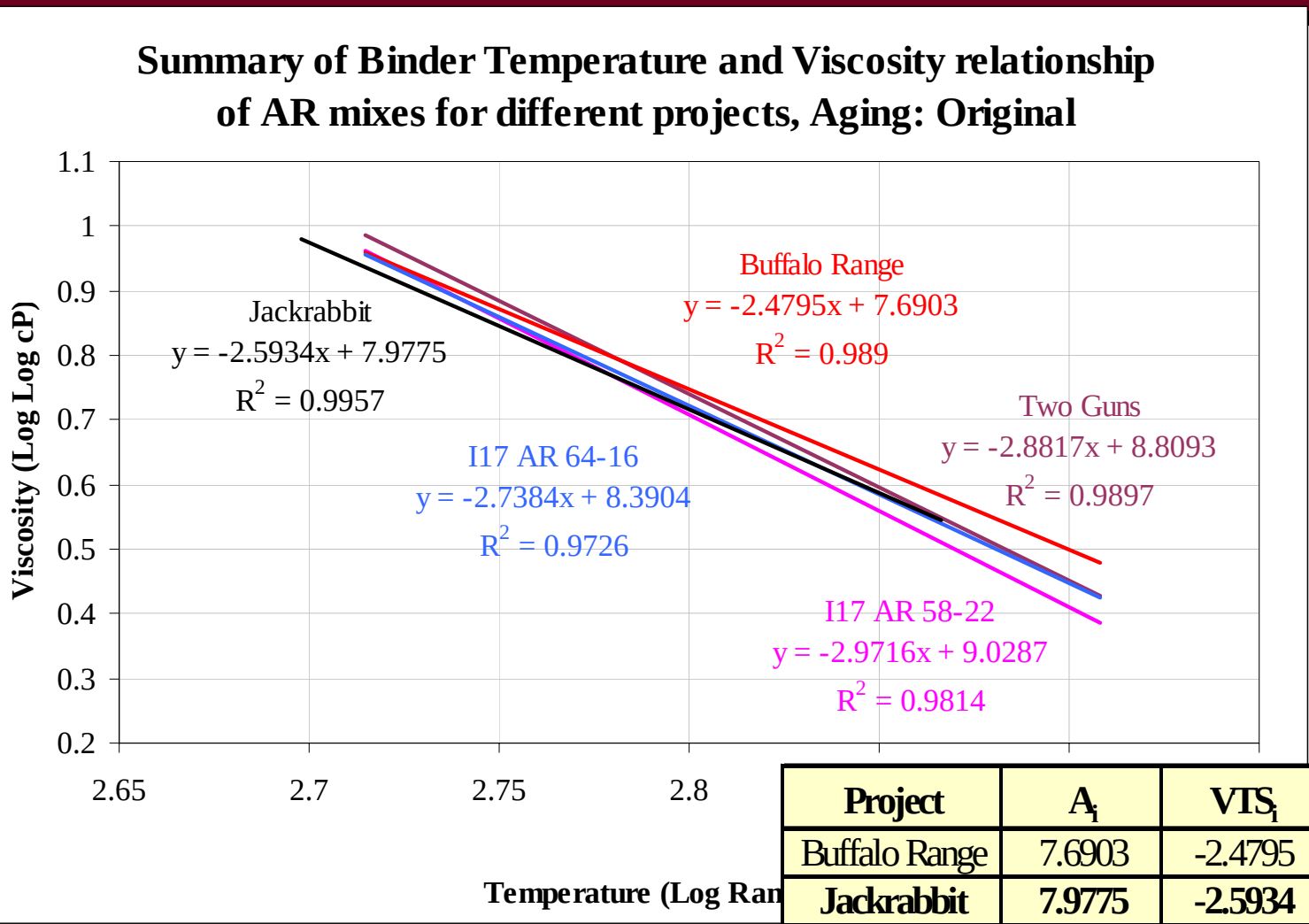
- Few Projects (4-5) that showed early Failure:
- One project of interest: I-40 Jackrabbit
  - Constructed in August 2004
  - 2005 serious Rutting Problems in Gap Graded mix
  - Stripping may be the cause

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

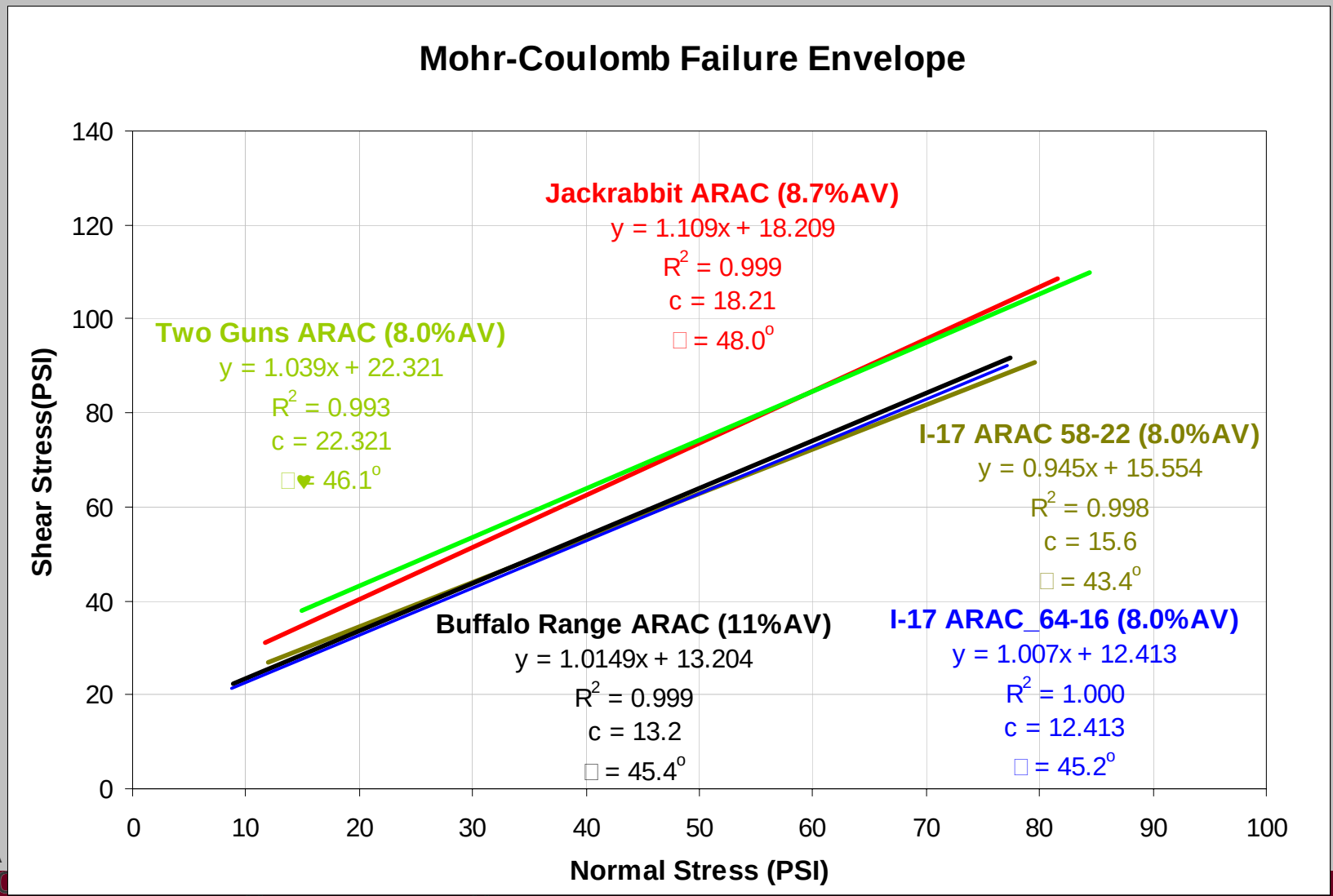


Project	A_i	VTS_i	R^2	Rank
Buffalo Range	7.6903	-2.4795	0.9890	1
Jackrabbit	**7.9775**	**-2.5934**	**0.9957**	**2**
I17 AR 64-16	8.3904	-2.7384	0.9726	3
Two Guns	8.8093	-2.8817	0.9897	4
I17 AR 58-22	9.0287	-2.9716	0.9814	5

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

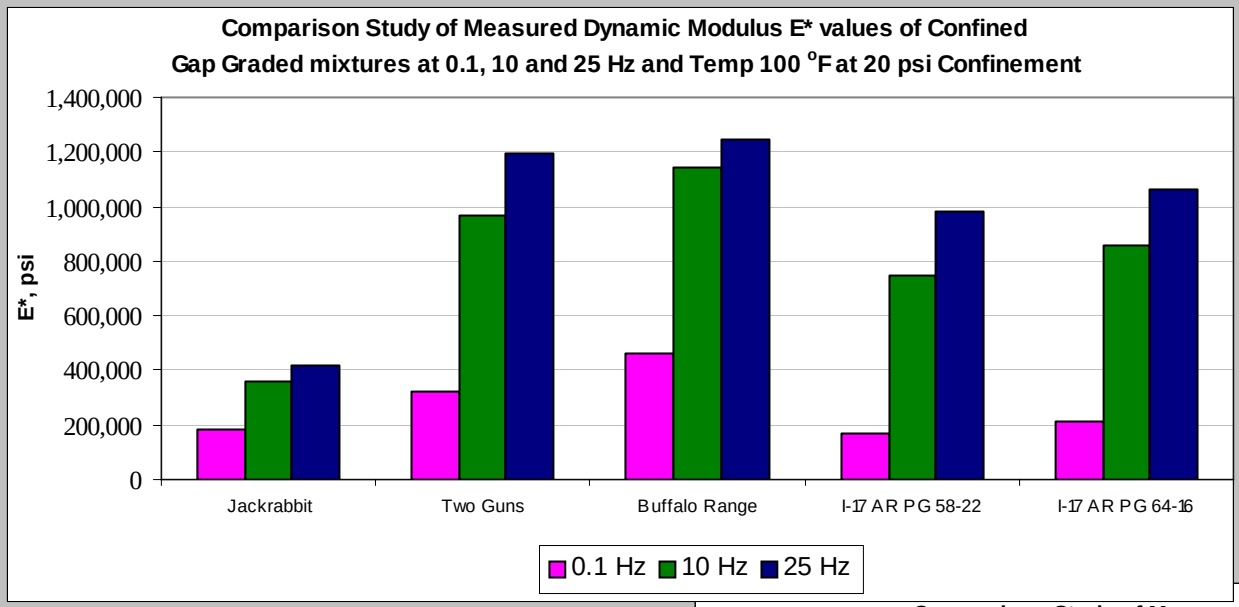
Triaxial Shear Strength Tests

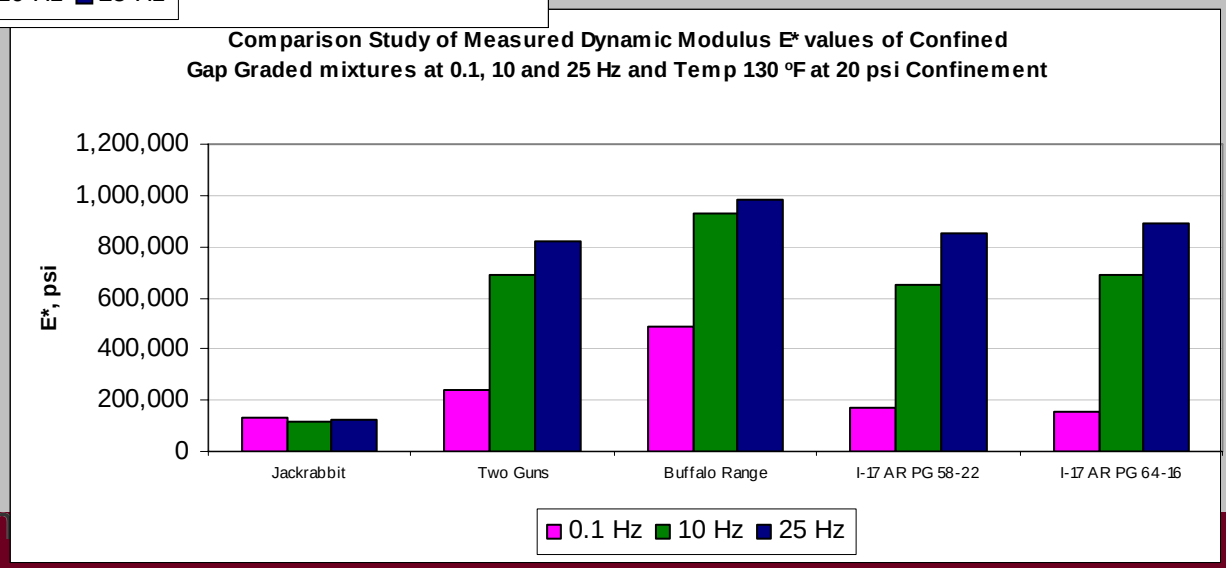


DYNAMIC MODULUS TEST

- 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 ^{o}F, three frequencies: 0.1, 10 and 25 Hz, and 20 psi confinement level.

E* Test Results

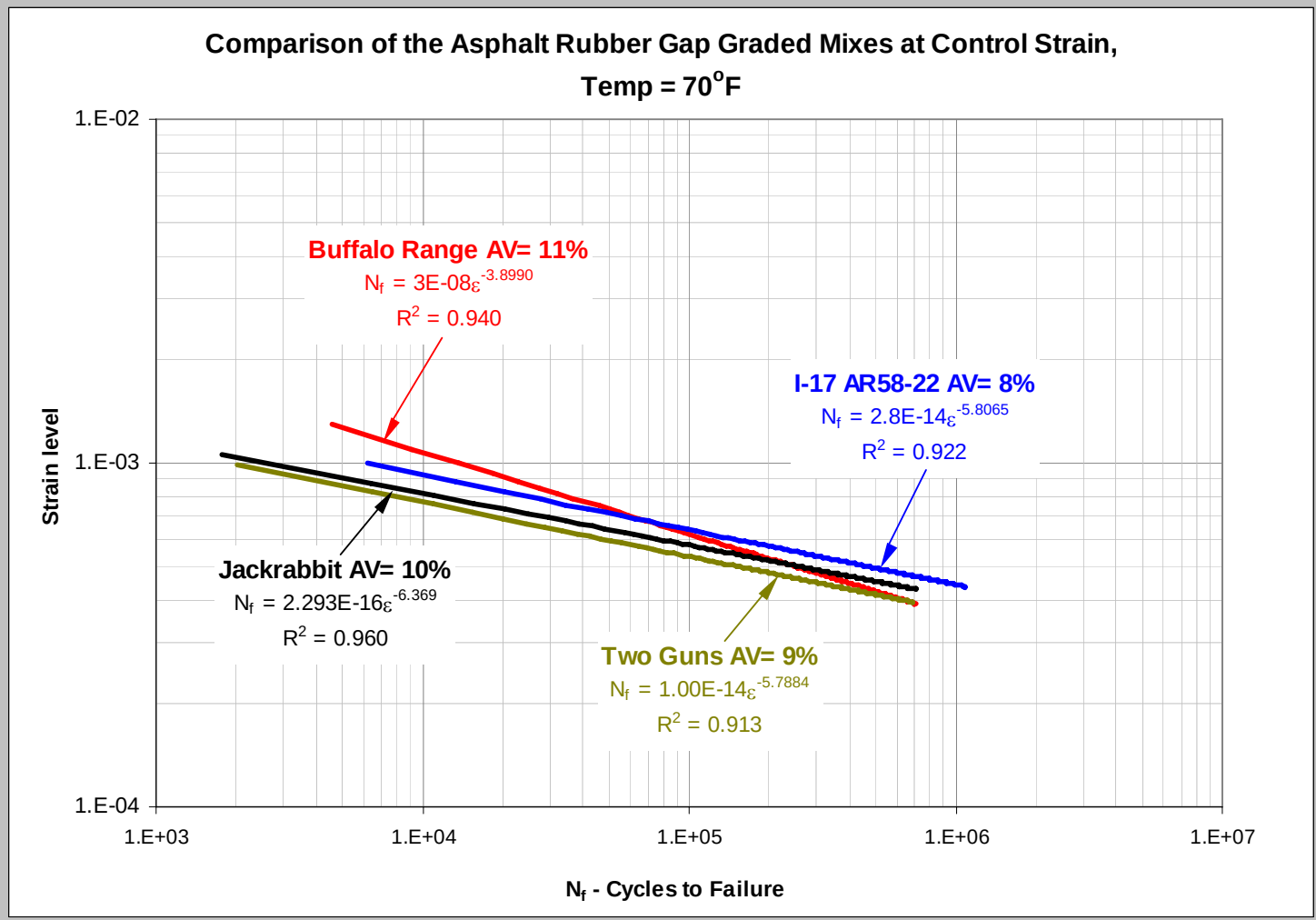




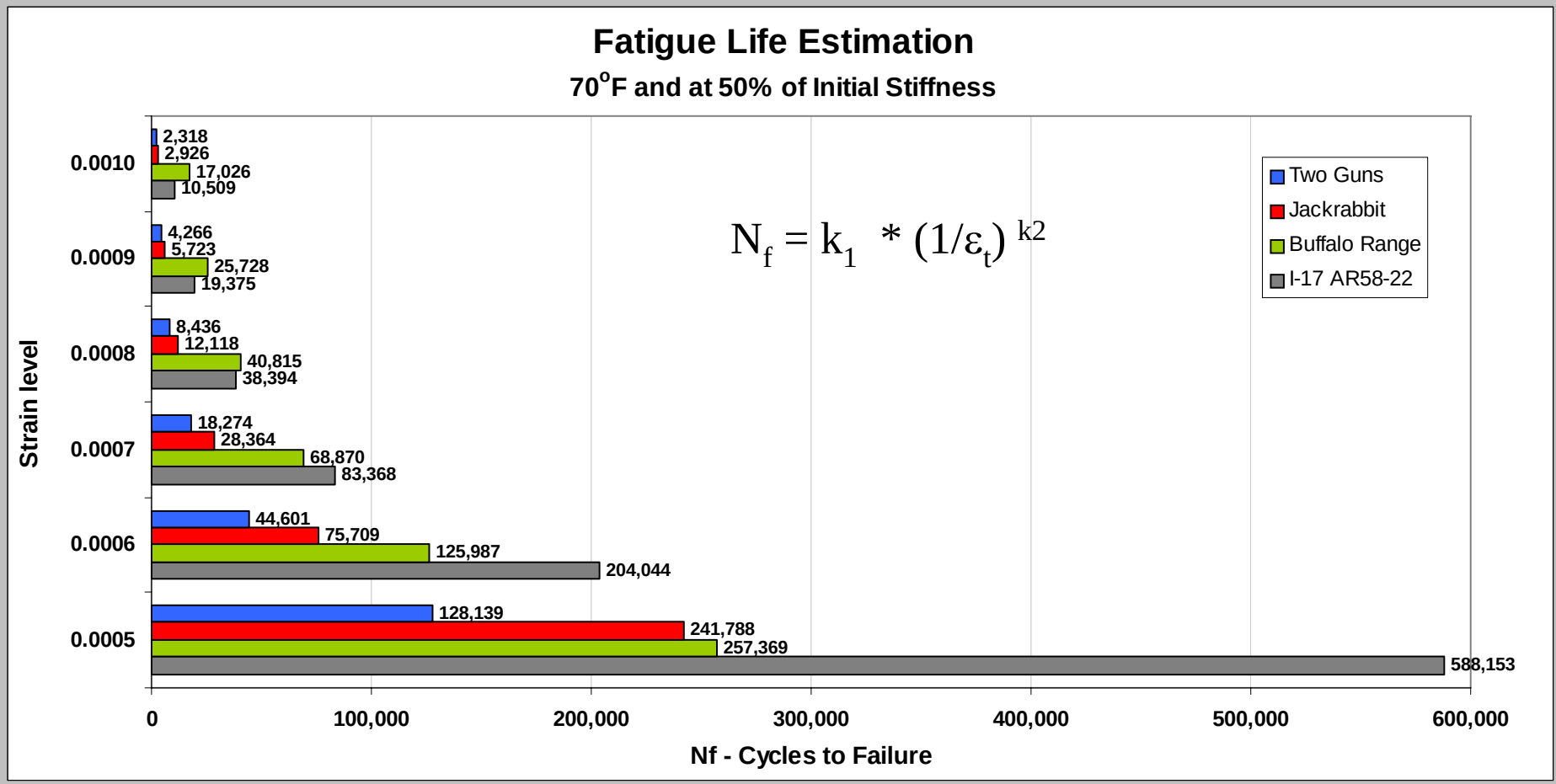
FLEXURAL BEAM FATIGUE TEST

- 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 με)
- Load frequency: 10 Hz
- Test temperature: 100,70, and 40oF for gap graded mixtures and 70 and 40oF for open graded mixtures

Comparison of ARAC Mixtures at 70ºF



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

PROJECT	*INITIAL AADTT*
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

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

PROJECT	*AVERAGE SUBGRADE MODULUS(Psi)*
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
84rd Annual Meeting Transportation Research Board
Washington D.C. –January 12th 2005

Maria Carolina Rodezno
Graduate Research Assistant

ASU Arizona State University — Civil and Environmental Engineering

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.

Ira A. Fulton
school of engineering

MEPDG RESULTS-RUTTING

MEPDG Prediction- AC Rutting (in)					
Project	*BR*	*TG 1*	*TG2*	*JR1*	*JR2*
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 of failure.

THANK YOU

Questions?