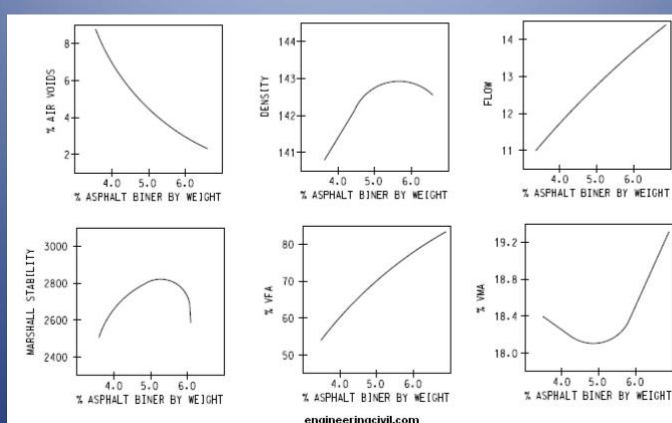
Highly Modified Asphalt Materials

WASHTO Conference
April 4, 2016
Salt Lake City, Utah

Marshall Stability

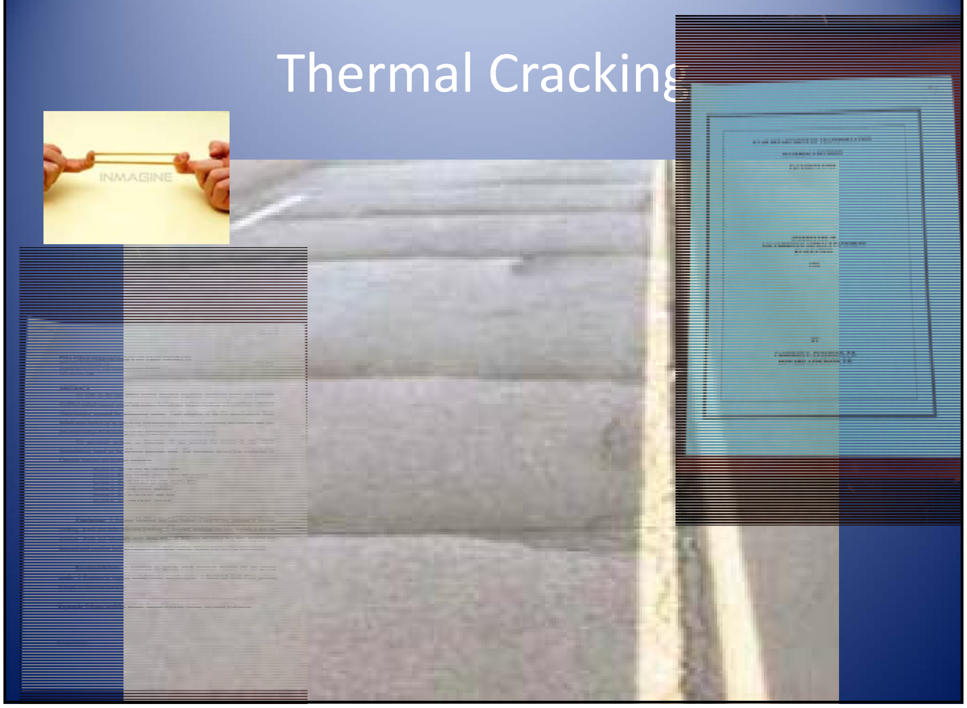
Marshall Method



Design graphs for Marshall Mix Design

Rutting - Most Critical Distress

Thermal Cracking

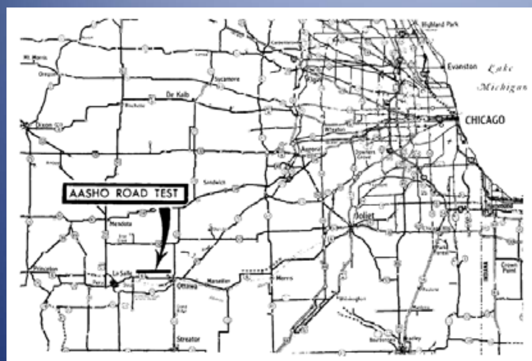


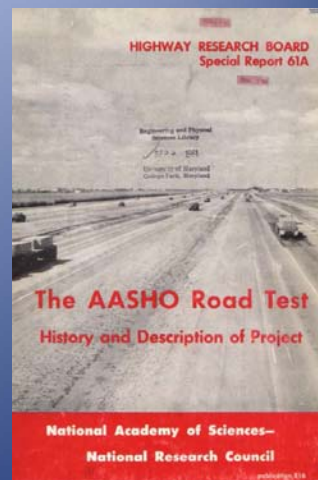
Fatigue, Durability Cracking

Dry, Brittle de-bonded Pavement

AASHO Road Test

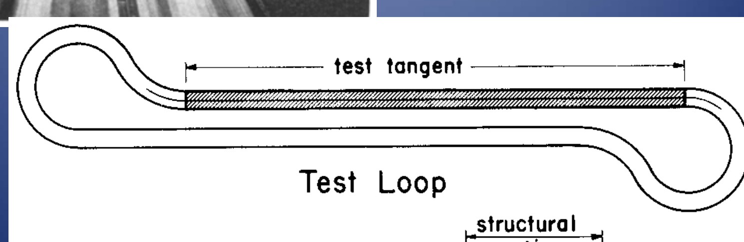
Ottawa, Illinois Constructed 1956-58





Six two-lane loops

along future I-80 alignment



AASHO Road Test

- **HMA**
- The HMA mixes used at the Road Test used:
- Crushed limestone coarse aggregate
- Natural siliceous coarse sand
- Mineral filler which was limestone dust
- Penetration grade asphalt cement (85-100 pen)

- For the HMA surfaced test sections (in Loops 3-6), the surface course was 1.5 inches thick. The HMA mixes were designed by the Marshall method using 50 blows per face. The typical field asphalt contents were about 5.4 and 4.4 percent by weight of total mix for the surface and binder courses, respectively. The field air voids averaged 7.7 percent.

AASHO Road Test

Sieve	Surface Course Gradation Limits	Binder Course Gradation Limits
1 in.	–	100
3/4 in.	100	88-100
1/2 in.	86-100	55-86
3/8 in.	70-90	45-72
No. 4	45-70	31-50
No. 10	30-52	19-35
No. 20	22-40	12-26
No. 40	16-30	7-20
No. 80	9-19	4-12
No. 200	3-7	0-6

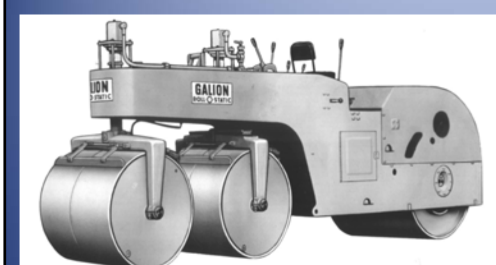
Pictures: The Historical Construction Equipment Association.

First Drum roller, steal drums drawn by stock, with a seat atop for the teamster.

Three-wheel roller: 1960 Buffalo-Springfield VM32D. Tandem and three-wheel rollers date to the steam era. The one front and two rear drums compact earth, gravel and asphalt across its full width.

Pictures from The Historical Construction Equipment Association.

Rollers of the Time



Tri-Tandem roller: Galion TC14-20G. A tandem roller with a third drum, this 20-ton machine was used to compact asphalt pavement from the 1940s until the late 1960s.

Tandem roller: 1958 Buffalo-Springfield KT19A. Weighing up to 14 tons, a tandem roller does its work with two static, dead-weight steel drums across the machine's full width.

Today’s Material Transfer Devise (MTV)

Today's Asphalt Milling Machine

Photo By Bill Jacobus

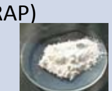
Today's HMA Compactor

"Why did the AASHO Road Test use a 4% Void Design"

- Conservative approach to avoid rutting while providing a fair amount of binder for durability and fatigue resistance. Marshall Mix Design.
- Past experience: HMA is prone to rutting with 2% or lower air voids (especially with neat binders and rounded aggregates).
- Voids above 7 to 8 percent provide impermeable pavement, great loss of pavement life.

AASHO Road Test Then and Now

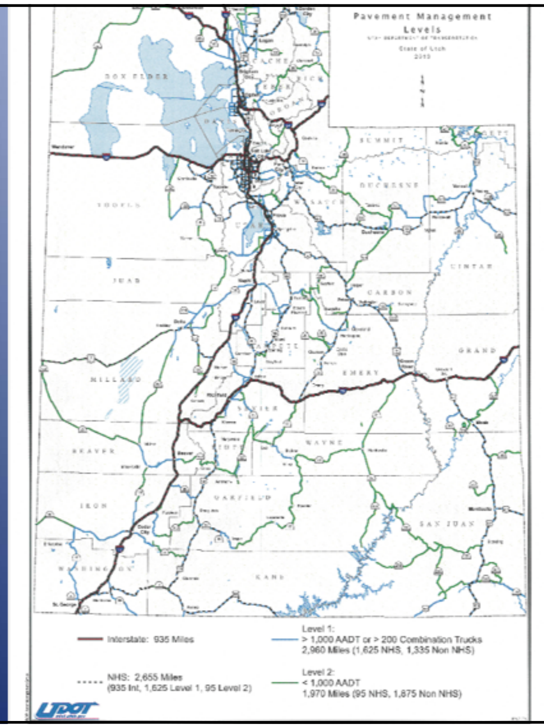
Less Rutting Risk - NOW	More Risk for Rutting - NOW
Polymer Modified Binders 100% Crushed Aggregates Rut Performance Test (Hamburg) Superpave Mix Design Use of Recycled Asphalt Pavement (RAP) (Rotomill equipment did not exist) Hydrated Lime modification Heavy Compaction Equipment (Vibratory) Material Transfer Devise (MTV)	Greater Traffic, loads High Tire Pressures , radial tires



4% Air Void Design

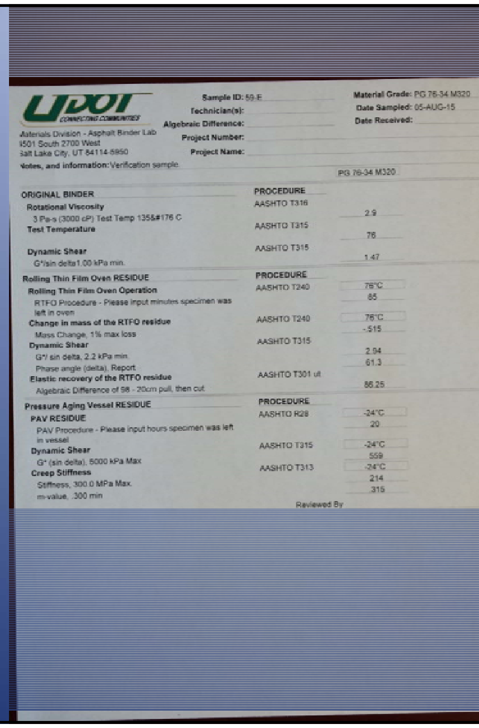
HiMA

- Definition: Asphalt Binder with approximately 7 percent polymer forming a continuous phase in the binder.
- UDOT Experience: Two projects last summer
- U.S. 6 Soldier Summit to White River
- SR 191 South West of Duchesne
- Over 32 High Polymer Hamburg Tests run



U.S. 6 Hi Polymer Binder Spec.

PG 76-34	
Meet AASHTO 320 specification for PG 76-34	See AASHTO Spec.
Meet Elastic Recovery with 20 cm pull, then cut	ER ≥ 90%



UDOT
CONNECTING COMMUNITIES

Materials Division - Asphalt Binder Lab
4501 South 2700 West
Salt Lake City, UT 84114-5950

Sample ID: 59-E
Technician(s):
Algebraic Difference:
Project Number:
Project Name:

Material Grade: PG 76-34 M320
Date Sampled: 05-AUG-15
Date Received:

Notes, and information: Verification sample.

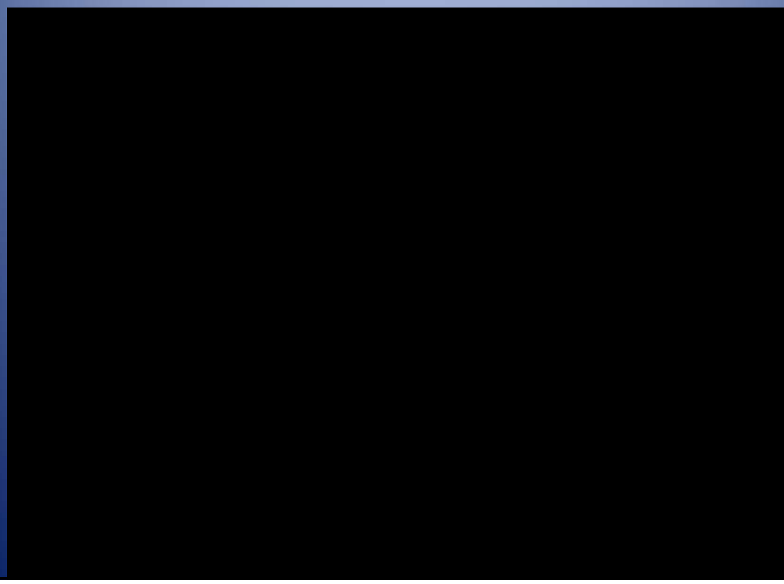
		PG 76-34 M320
ORIGINAL BINDER	**PROCEDURE**	
Rotational Viscosity	AASHTO T316	
3 Pa-s (3000 cP) Test Temp 135&#176 C		2.9
Test Temperature	AASHTO T315	76
Dynamic Shear	AASHTO T315	
G*/sin delta1.00 kPa min.		1.47
Rolling Thin Film Oven RESIDUE	**PROCEDURE**	
Rolling Thin Film Oven Operation	AASHTO T240	76°C
RTFO Procedure - Please input minutes specimen was left in oven		85
Change in mass of the RTFO residue	AASHTO T240	76°C
Mass Change, 1% max loss		-.515
Dynamic Shear	AASHTO T315	
G*/ sin delta, 2.2 kPa min.		2.94
Phase angle (delta), Report		61.3
Elastic recovery of the RTFO residue	AASHTO T301 ul	
Algebraic Difference of 98 - 20cm pull, then cut		86.25
Pressure Aging Vessel RESIDUE	**PROCEDURE**	
PAV RESIDUE	AASHTO R28	-24°C
PAV Procedure - Please input hours specimen was left in vessel		20
Dynamic Shear	AASHTO T315	-24°C
G* (sin delta), 5000 kPa Max		559
Creep Stiffness	AASHTO T313	-24°C
Stiffness, 300.0 MPa Max.		214
m-value, .300 min		315

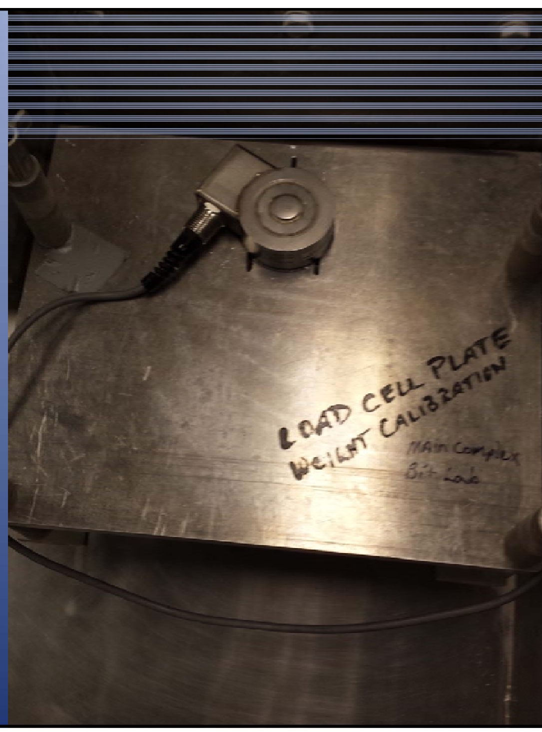
Reviewed By

Hamburg Equipment

20 lbs extra load applied

Hamburg Test + 20 lb





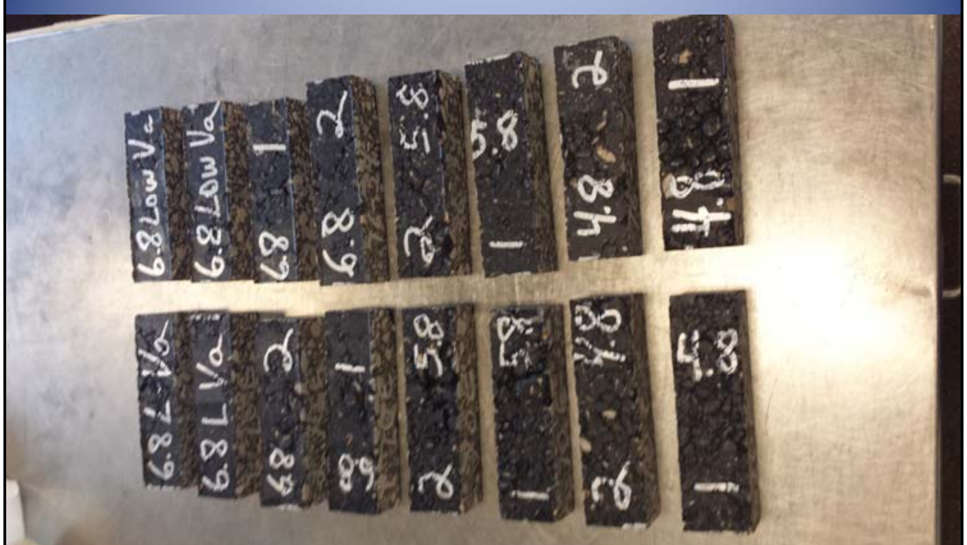
Hamburg Test
showing extra steel plates on load cell

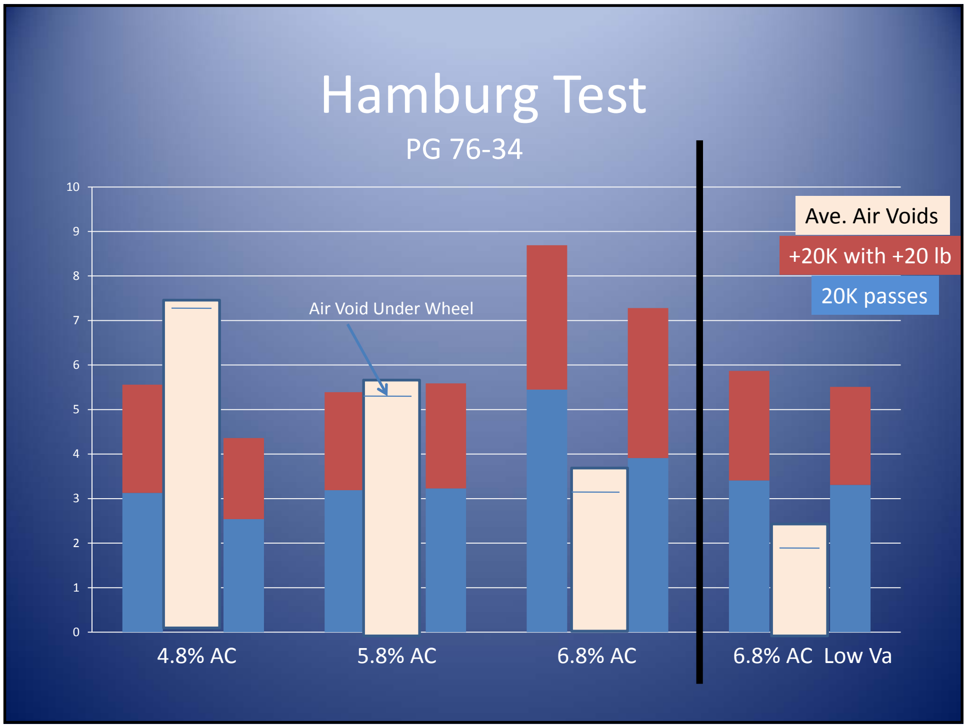
Hamburg Test
Showing load cell out put

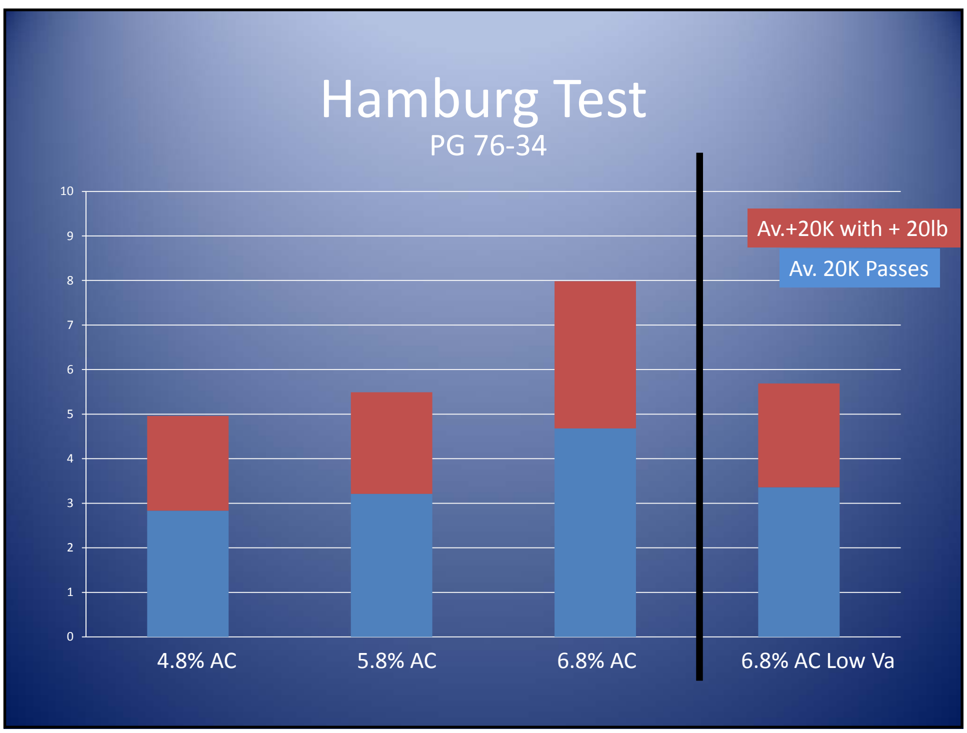
Hamburg Test Data

PG 76-34

	%AC	Air Voids/Rut Void	20,000	+ (20,000 + 20 lb)	Total Rut
Slab 1	4.8	7.4/7.1	3.13	2.43	5.56
Slab 2	4.8	7.6/7.7	2.54	1.82	4.36
Slab 1	5.8	5.8/5.0	3.19	2.20	5.39
Slab 2	5.8	5.7/5.8	3.23	2.36	5.59
Slab 1	6.8	3.6/3.2	5.45	3.24	8.69
Slab 2	6.8	3.8/3.0	3.91	3.37	7.28
Slab 1 Low Va	6.8	2.3/1.9	3.41	2.46	5.87
Slab 2 Low Va	6.8	2.6/1.6	3.31	2.20	5.51

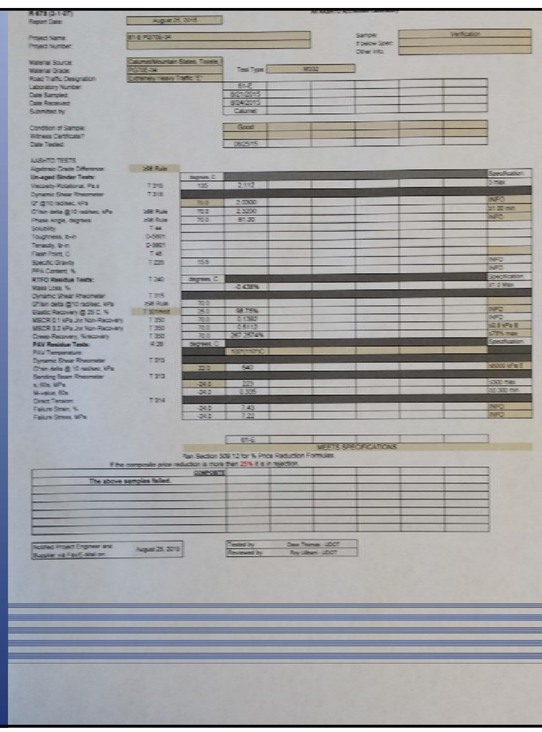



Hamburg Test
PG 76-34
10
9
8
7
6
5
4
3
2
1
0
Air Void Under Wheel
Ave. Air Voids
+20K with +20 lb
20K passes
4.8% AC
5.8% AC
6.8% AC
6.8% AC Low Va


Hamburg Test
PG 76-34
10
9
8
7
6
5
4
3
2
1
0
Av.+20K with + 20lb
Av. 20K Passes
4.8% AC
5.8% AC
6.8% AC
6.8% AC Low Va

U.S. 191 Hi Polymer Binder Spec.

PG 70E-34	
Meet AASHTO M 332 – Performance-Graded Asphalt Binder for PG 70E-34 with the additional requirement for $J_{nr3.2}$	Table 1 with J_{nr}, Max 0.1 KPa^-1
RTFO Residue, AASHTO 240, Meet AASHTO T350 Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer.	Meet MSCR Recovery ≥ 90%
PAV Residue, 20 hours, 2.10 Mpa, 100°C, AASHTO R 28 Direct Tension Test, AASHTO T 314	@ -24°C, Failure Strain, 1.5% min @ -24°C, Failure Stress, 4.0 Mpa min



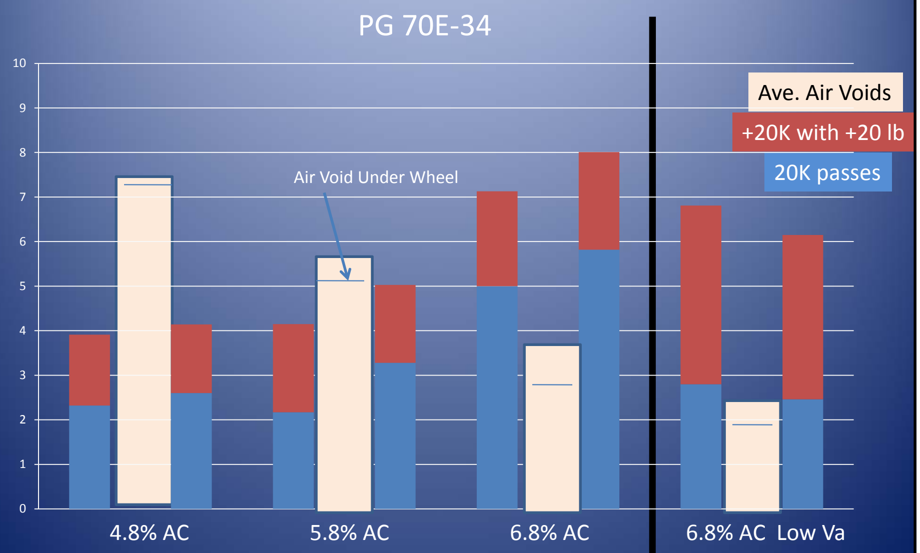
Hamburg Test Data

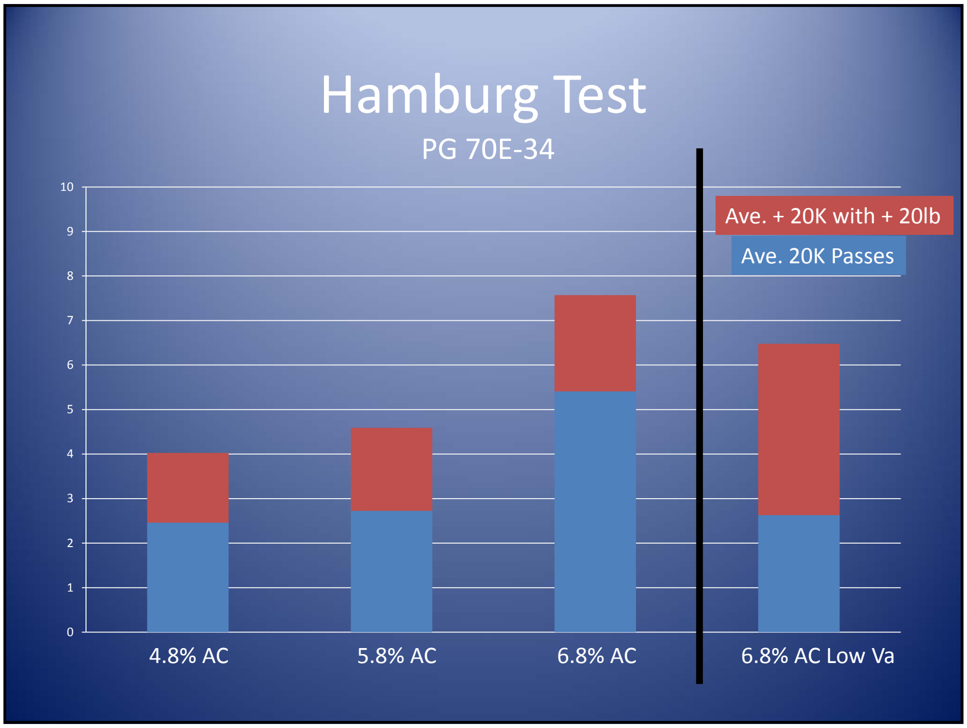
PG 70E-34

	%AC	Air Voids/Rut Void	20,000	+(20,000 + 20 lb)	Total Rut
Slab 1	4.8	7.3/7.2	2.32	1.59	3.91
Slab 2	4.8	7.8/7.8	2.6	1.54	4.14
Slab 1	5.8	5.5/4.7	2.17	1.98	4.15
Slab 2	5.8	5.9/5.9	3.28	1.75	5.03
Slab 1	6.8	3.8/3.0	5	2.13	7.13
Slab 2	6.8	3.9/2.7	5.82	2.19	8.01
Slab 1 Low Va	6.8	2.3/1.8	2.8	4.01	6.81
Slab 2 Low Va	6.8	2.8/2.2	2.46	3.69	6.15

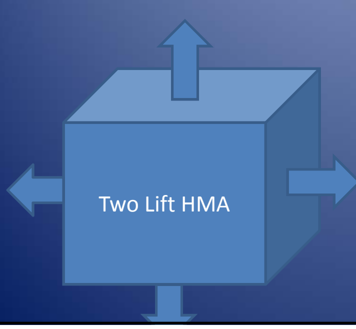
Hamburg Test

PG 70E-34



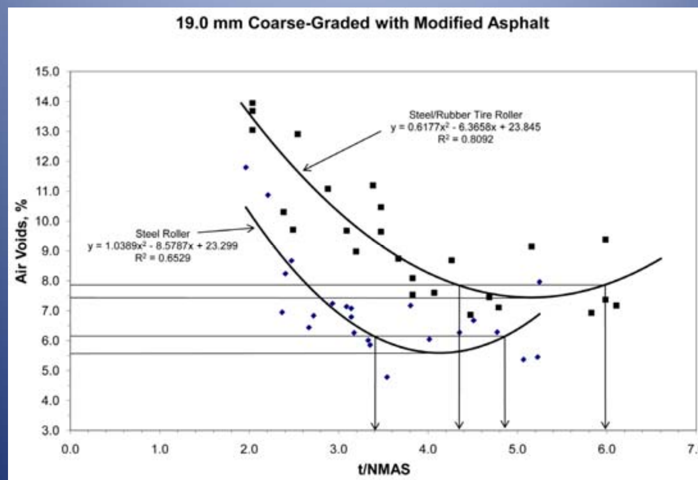


One Lift HMA Application	Two Lift Application
+ Thick Lift = more time to compact + No need for a tack coat + Saves time, one pass operation + Higher Asphalt Content – more compactable and durable + Less total cores taken, less testing +- Grinding on a thick lift could be allowed	-Two complete mat installs with rolling required -Complete acceptance testing separate for each lift, cores, gradation, AC content etc. - Tack Required + Greater Chance to get smoothness + or - Very limited grinding

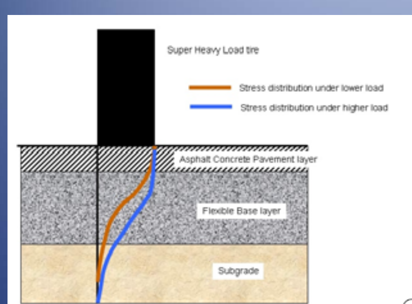


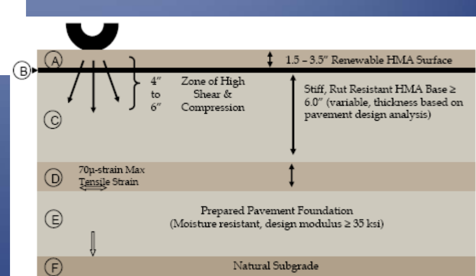
Lift Thickness/Nominal Agg. Size Vs. Air Voids

NCHRP Report 531
2008, L. Allen Cooley.



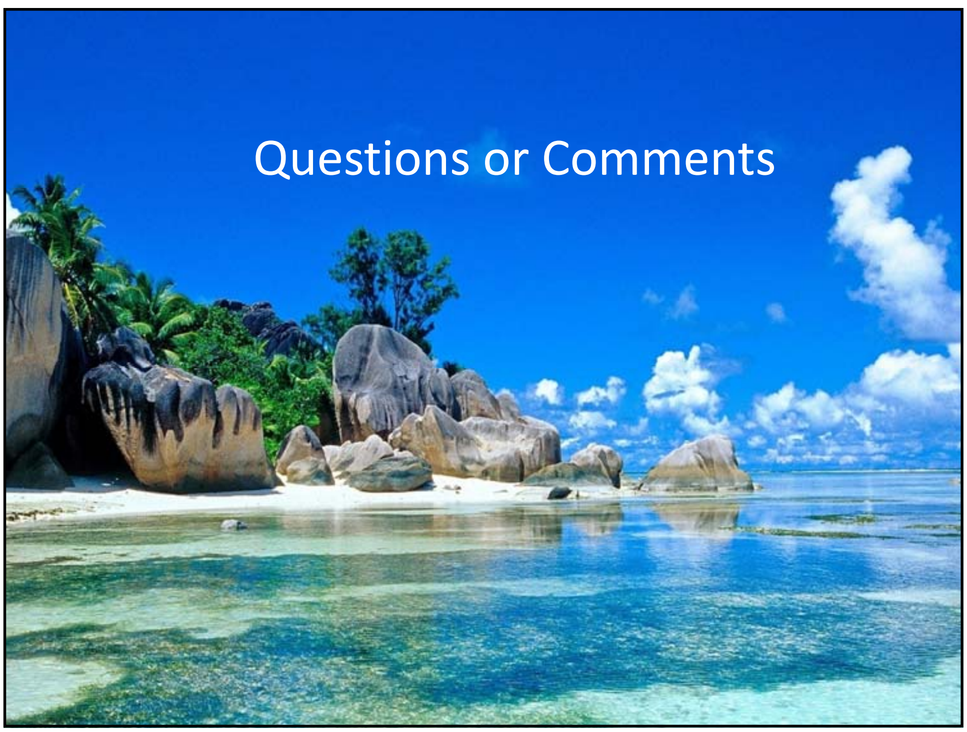
Surface Coarse is then placed on the HMA lift as it our standard

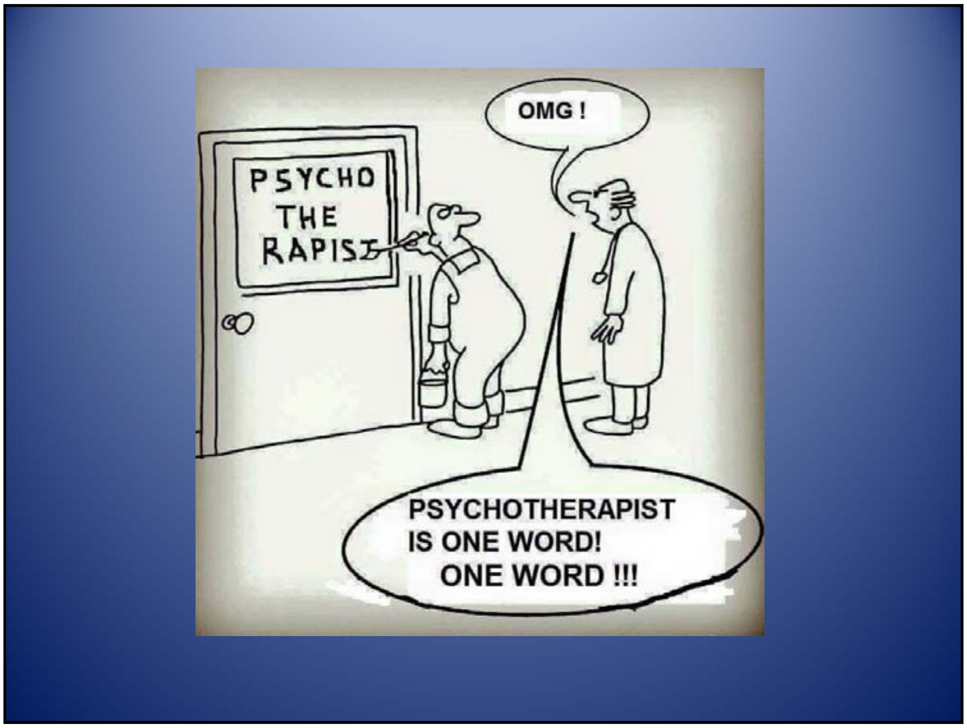




Acknowledgments

- Clark Allen, Central Lab Technician
- Tim Wozab, Central Lab Technician
- Steve Park, Region 3 Materials Engineer
- Dave Gill, Region 3 Pavement Management Engineer
- Scott Andrus, State Materials Engineer




OMG !
PSYCHO
THE
RAPIST
PSYCHOTHERAPIST
IS ONE WORD!
ONE WORD !!!