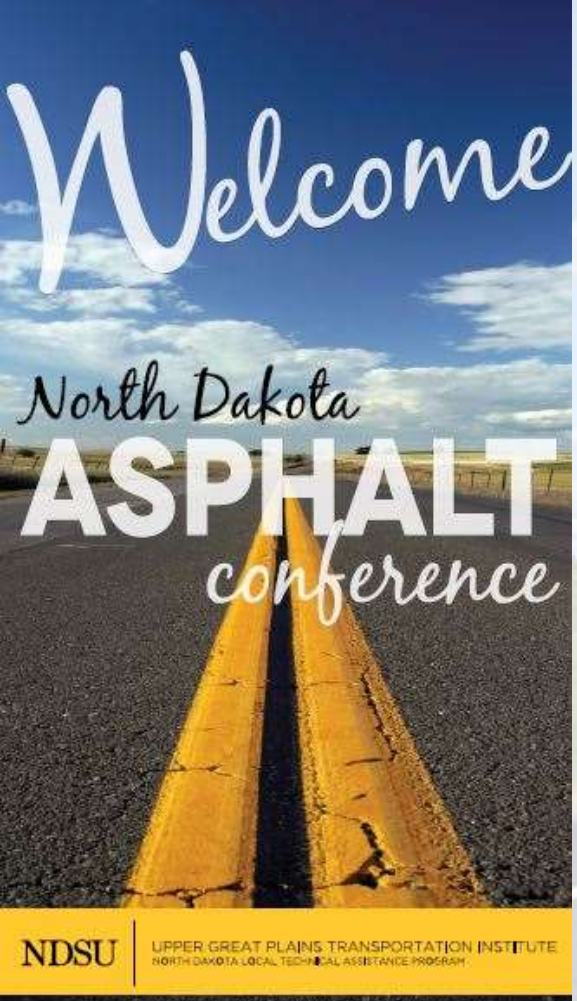


•Binder Basics: Polymer Modified Asphalt and the Multiple Stress Creep Recovery (MSCR) Test

• Jeff Shoger
Flint Hills Resources, LP

North Dakota Asphalt Conference

Bismarck, ND - April 10-11-2018

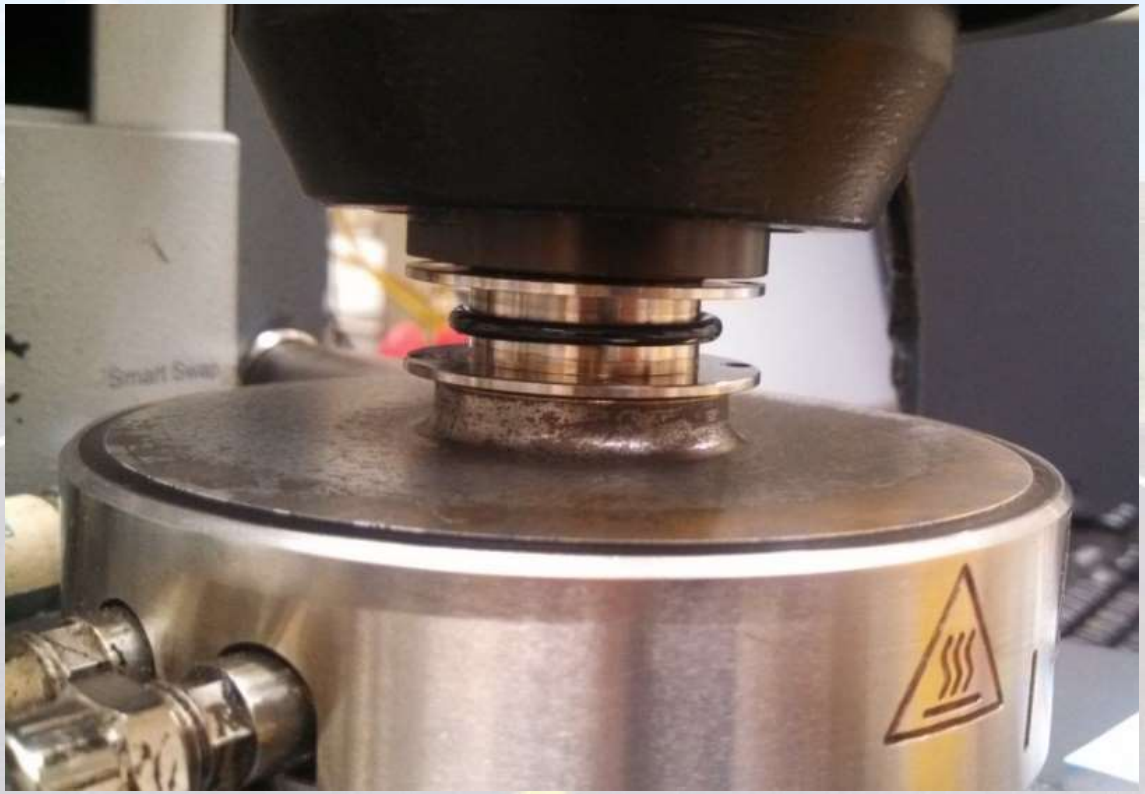
MSCR Test Development

- AASHTO M320 (standard PG grading) was found to be inadequate for characterizing different types of modifications
- Lack of correlation between G*/Sin(δ) and field performance for modified asphalt
- G*/Sin(δ) stress level was too small

MSCR Test Components

- Uses the DSR
- Increases the stress level to determine what traffic level the asphalt resists flow
- Measures two parameters
  - Jnr (non-recoverable creep compliance) which correlates with field rutting performance
  - Percent Recovery, which indicates the presence of sufficient and effective polymer modification

Dynamic Shear Rheometer (DSR)



Benefits of Modification

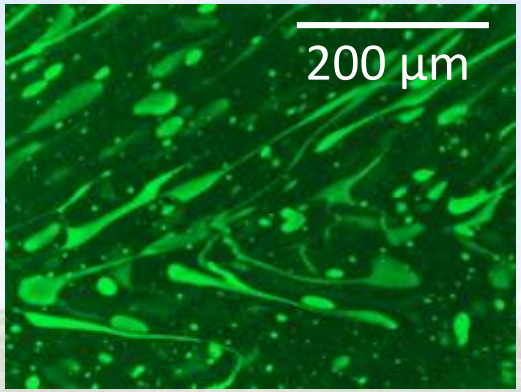
- The asphalt industry needs economical pavements that perform for a long time
- Modification improves the glue that binds the aggregates together for better:
  - Resistance to permanent deformation
  - Reduction of large-scale aggregate movement
  - Adhesion
  - Fatigue life
  - Resistance to cracking

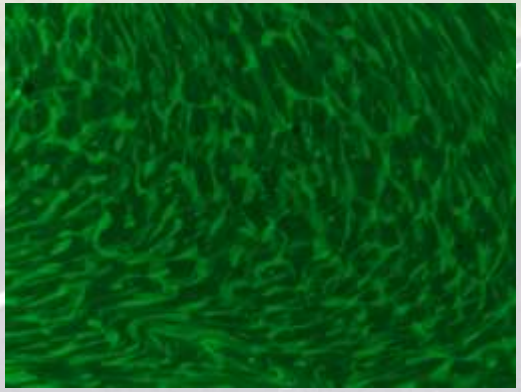
Polymer Properties

- Elastomeric polymers stretch and elastically recover their shape when released

- A valuable property in:
  - Running shoes
  - Rubber bands
  - Vehicle tires
  - And asphalt pavement!

Engineered PMAC viewed under a Fluorescence Microscope





Unreacted	
% R = 21.0	Jnr = 0.68 Pa^{-1}

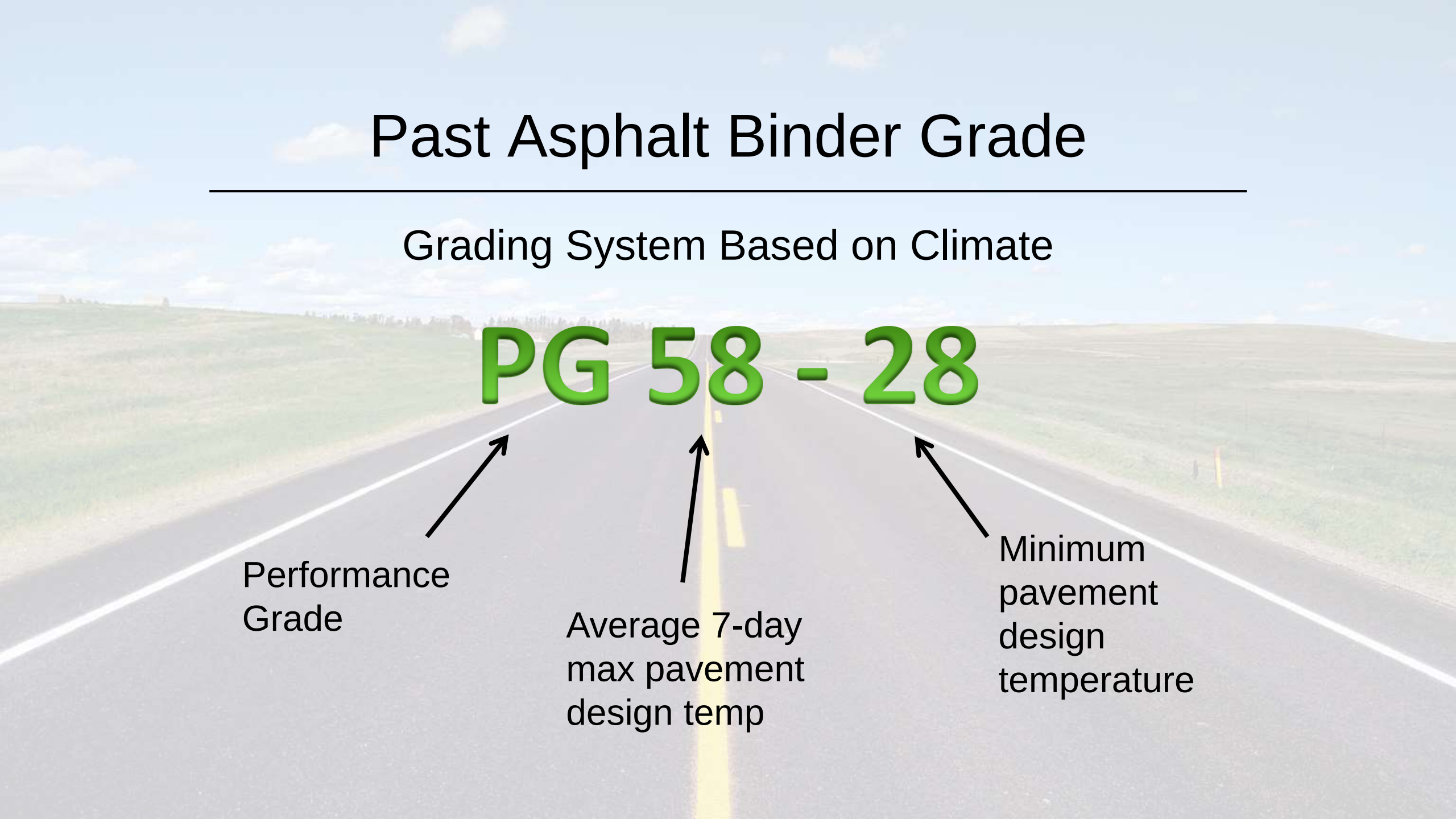
Partially Reacted	
%R = 46.4	Jnr = 0.39 Pa^{-1}

Fully Reacted	
%R = 58.3	Jnr = 0.31 Pa^{-1}

Past Asphalt Binder Grade

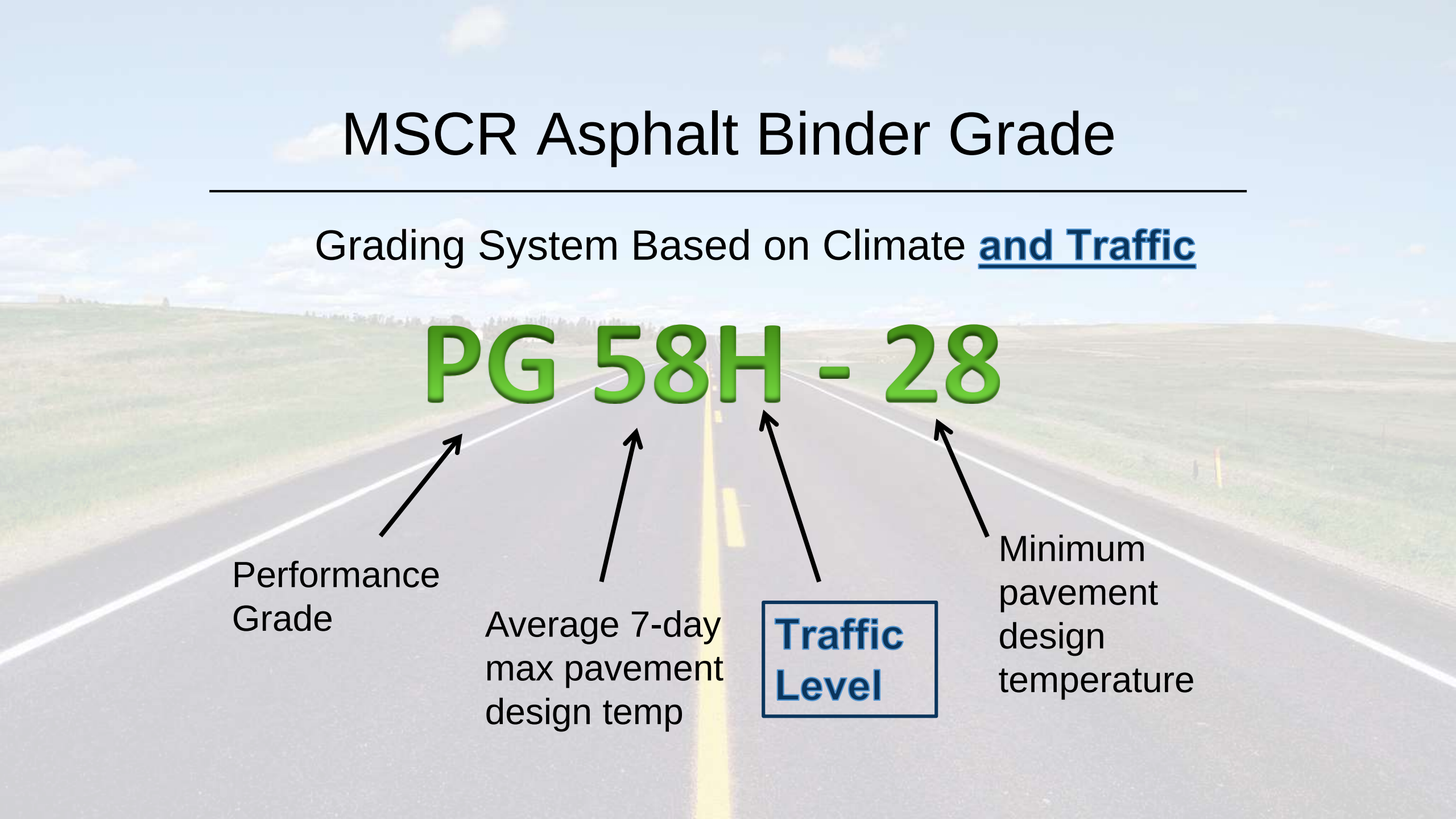
Grading System Based on Climate

PG 58 - 28



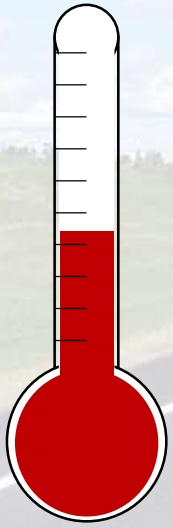
MSCR Asphalt Binder Grade

Grading System Based on Climate **and Traffic**



Past Temperature Grade “Bumps”

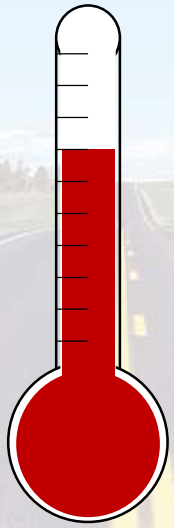
58°C
(136°F)



PG 58-28

- Standard traffic

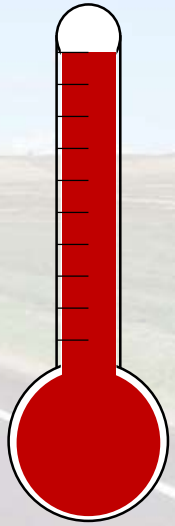
64°C
(147°F)



PG 64-28
1 “Bump”

- Slow or heavy traffic

70°C
(158°F)



PG 70-28
2 “Bumps”

- Stationary or high volume traffic

MSCR Traffic “Bumping”

PG 58**S**-28

- Standard traffic

PG 58**H**-28

1 “Bump”

- Heavy traffic

PG 58**V**-28

2 “Bumps”

- Very heavy traffic

PG 58**E**-28

3 “Bumps”

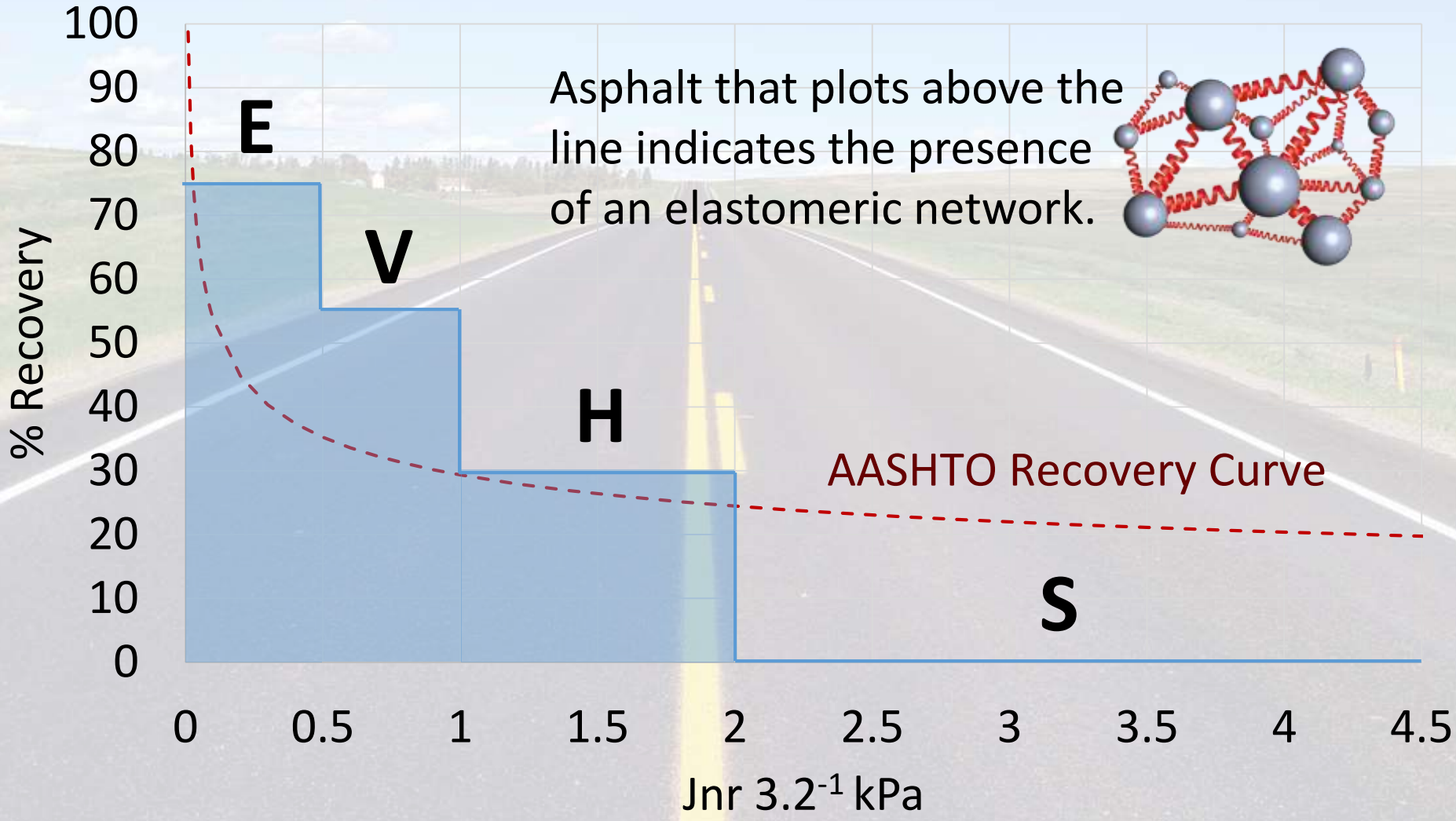
- Extreme traffic

MN-DOT Binder Guidelines

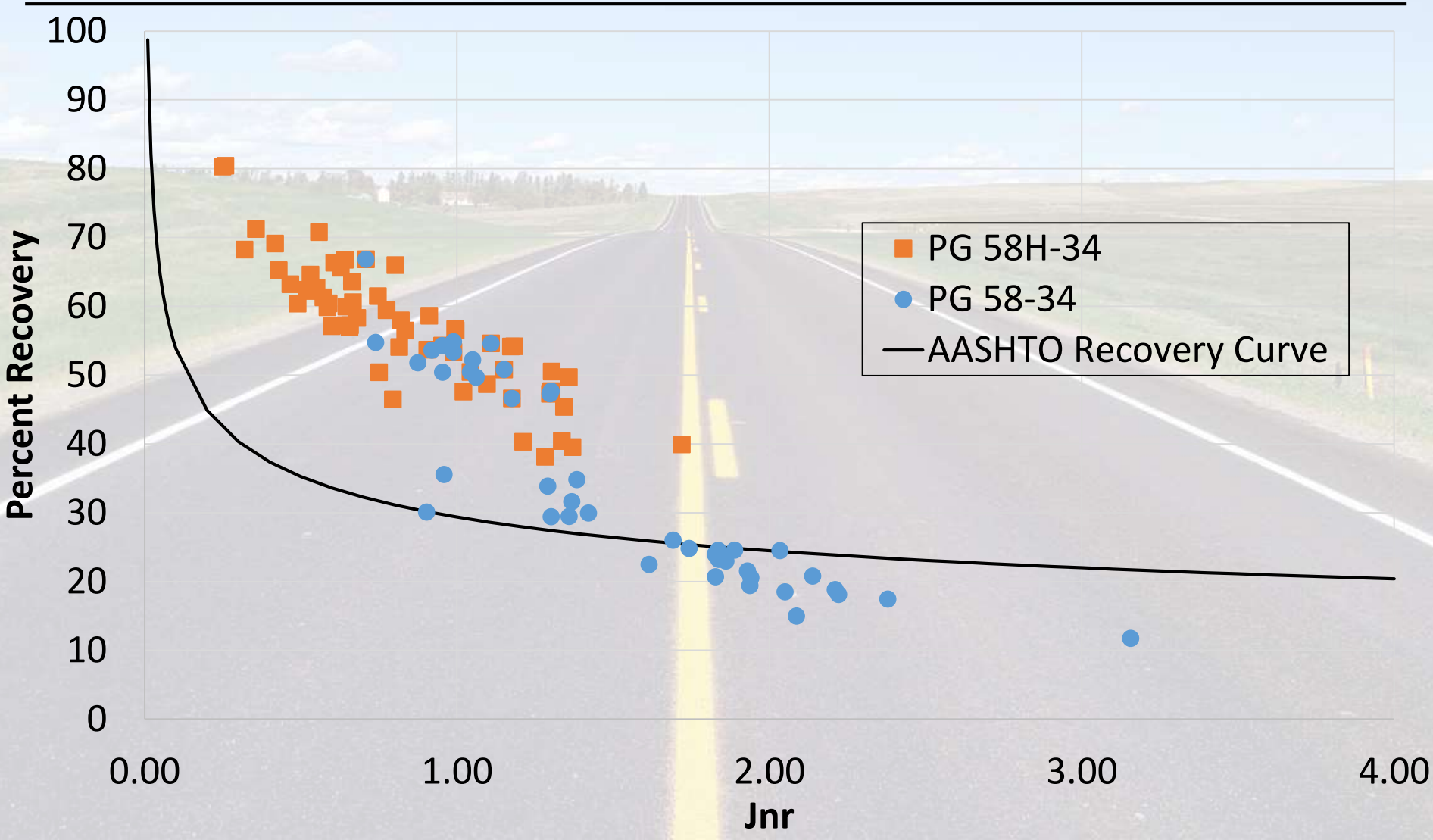
Type of Construction	Recommended Asphalt Binder for < 3 Million ESALs (20 yr)	Recommended Asphalt Binder for 3 - 10 Million ESALs (20 yr)	Recommended Asphalt Binder for > 10 Million ESALs (20 yr)
Overlay Wearing Mixture (Top 4")[3]	PG 58S-28	PG 58S-28[1]	PG 58H-28[1]
New Construction[2] Wearing Mixture (Top 4")[3]	PG 58H-34	PG 58H-34[1]	PG 58V-34[1]
All Non-Wear Mixture (Below 4" from Surface)	PG 58S-28		

1. Selecting a higher PG grade and/or mixture type (traffic level), for higher ESALs within the category, will provide better resistance to rutting.
2. New construction includes: reconstruction, rubblization, CIR, reclaiming (FDR)
3. For Non-Trunk Highways with traffic levels <3 million ESAL, consider modifying the "top 4" criteria to "top 3".

AASHTO M332 (modified by CSBG)



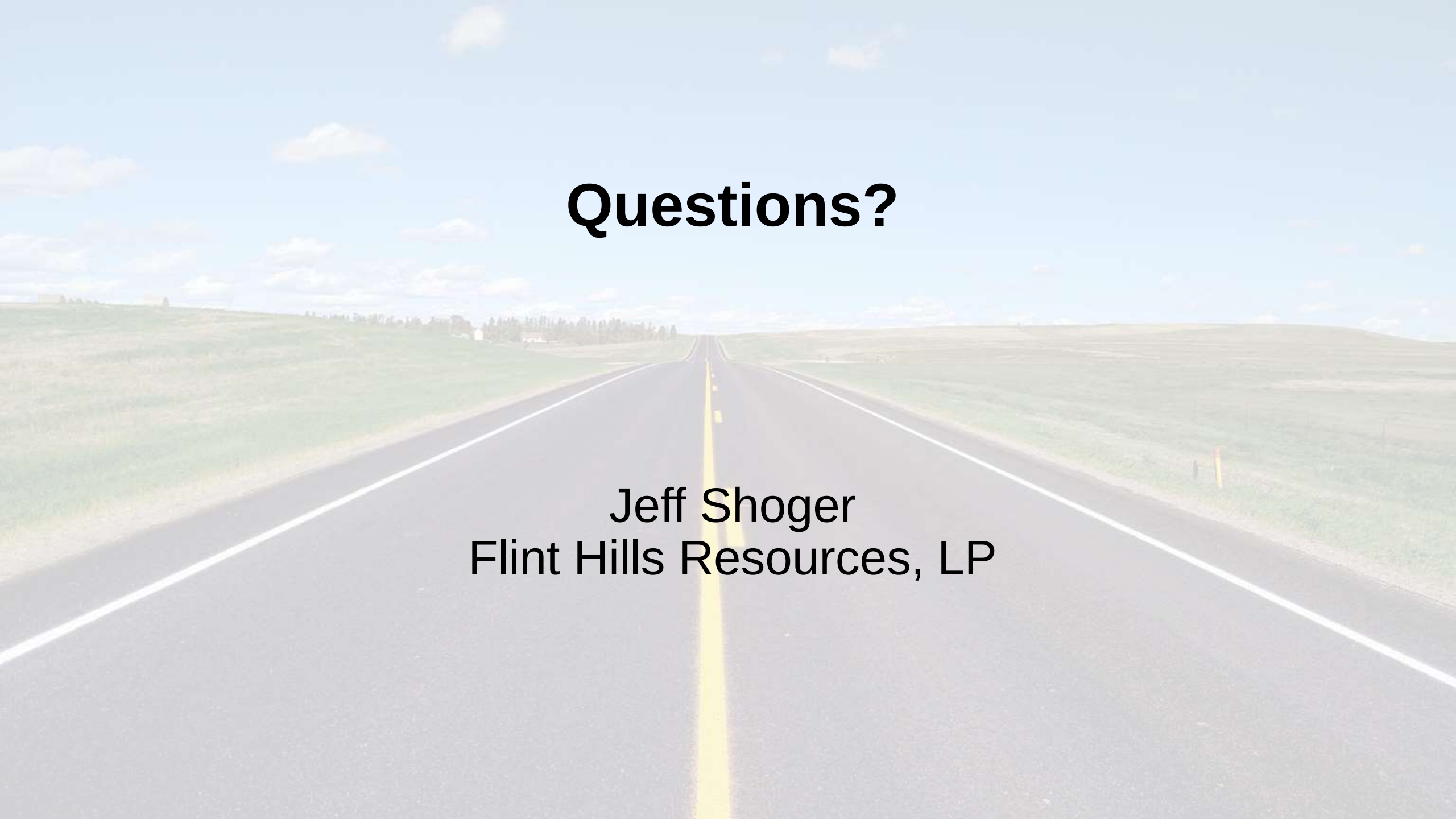
PG 58-34 vs PG 58H-34



FHR Production Samples 2013 -2017

Grade	High Performance Grade		% Recovery
	Average	Lowest	Lowest
PG 58-34	61.8	58.9	**11.8**
PG 58H-34	63.3	59.9	38.1
PG 64-34	66.6	64.4	43.4
PG 58V-34	67.3	64.0	60.2
PG 64-28	67.2	65.2	**19.8**
PG 58H-28	67.6	65.3	35.8

Red values plot below AASHTO Recovery Curve



Questions?

Jeff Shoger
Flint Hills Resources, LP

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Dakota Asphalt Pavement Association, Inc.

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NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

NDDOT North Dakota Department of Transportation

The Associated General Contractors AGC North Dakota

U.S. Department of Transportation Federal Highway Administration