MODIFICATION OF RUBBERIZED ASPHALT WITH POLYOCTENAMER

Dr. David A. Anderson – Consultant
Bernie Burns – Degussa Corporation

Symposium
Cheyenne, Wyoming
June 23-25, 2004

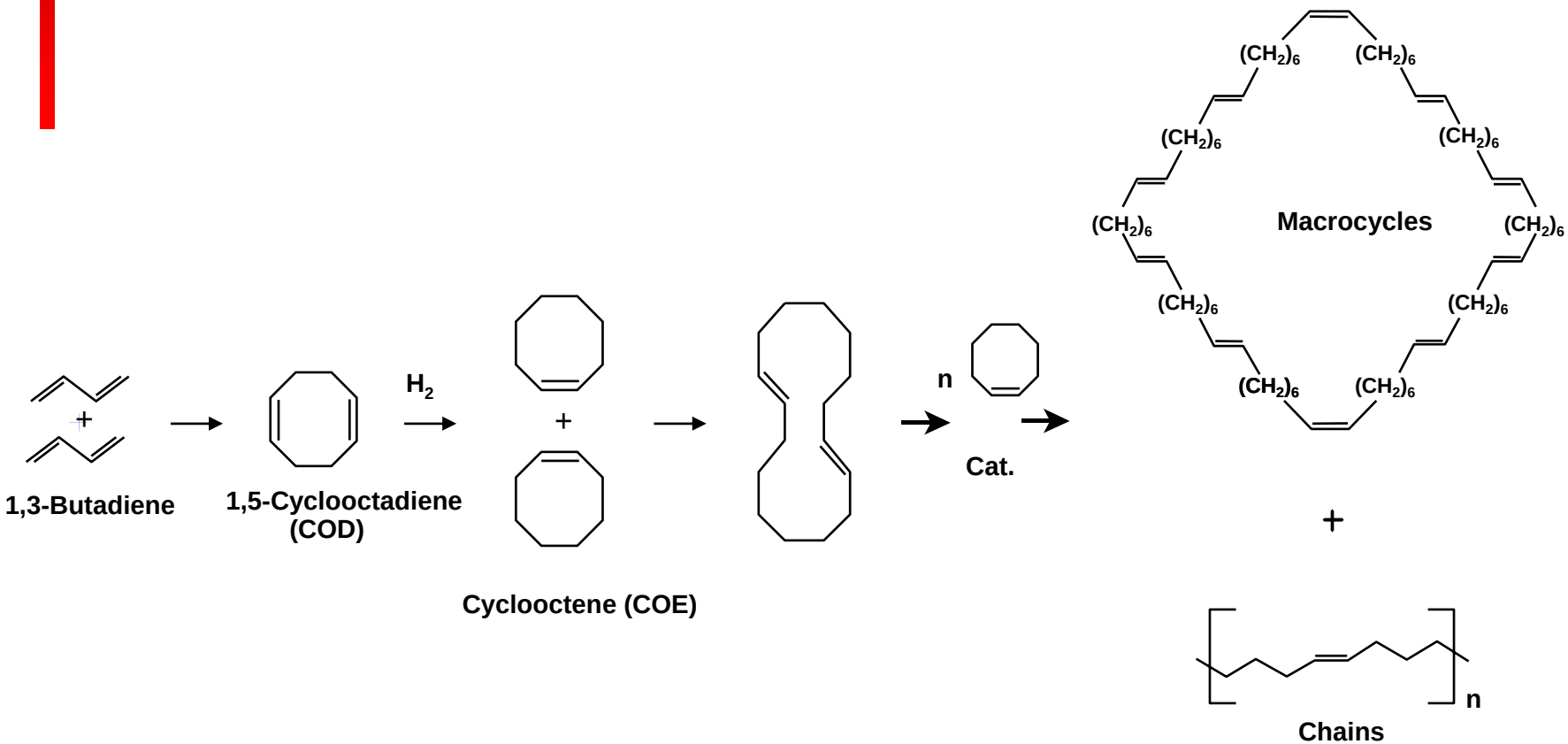
Outline for today's presentation

- Introduce a new modifier for use in asphalt paving applications
  - ✓ Ground Tire Rubber asphalt mixtures
- Describe the modifier and its properties
- Present laboratory binder and mixture data
- Highlight some initial field trials
- Discuss advantages and potential uses

Trans-polyoctenamer (TOR)

- Synthesized from 1,3-butadiene via cyclooctene
- Cyclooctene is polymerized to produce trans-polyoctenamer (TOR)
  - ✓ Both linear and cyclic macromolecules are formed
- Marketed by DeGussa Corporation under trade name Vestenamer®
- Material is non proprietary
  - ✓ In production since 1970
  - ✓ Used in wide range of industrial applications

Synthesis – for the chemists



Industrial uses

- Plasticizer and extrusion aid
- Control flowability in injection molding
- Tire production - used as a dispersant and compatibilizer
- Crosslinking aid in thermoplastics
- Rubber recycling (non paving)
  - ✓ Traffic barriers
  - ✓ Mats
  - ✓ Manhole rings

Properties of Polyoctenamer

Property	Value
M_W	75,000
Crystallinity @ 23C, %	30
Melting point, °C	54
Thermal decomposition, °C	275
Mooney Viscosity, 100°C	<10
Cis/trans ratio	20:80
Physical form	Solid, opaque pellets

Properties of TOR

- Crystallinity
- Low viscosity above melting point
- High proportion of macromolecules
- One double bond per eight carbon atoms
- Low toxicity
  - ✓ (e.g. FDA approved for implants)

How is TOR used in paving applications?

- Added to asphalt/GTR in pelletized form
  - ✓ Recommended dosage 4.5% by weight of GTR
  - ✓ 14 – 30 mesh GTR
- Heat from mix melts the TOR
  - ✓ Dissolved within the asphalt binder
- TOR vulcanizes when it contacts sulfur
  - ✓ Sulfur in GTR
  - ✓ Sulfur in asphalt binder
  - ✓ Bonds chemically to aggregate
- May be used in wet or dry process

Effect of TOR

- Oligomers CR contribute to tackiness and blue smoke
  - ✓ TOR cross-links the oligomers reducing "tackiness and blue smoke"
- TOR chemically cross-links the sulfur on the surface of the GTR to the sulfur in the asphalt
  - ✓ Result is a three dimensional network
  - ✓ Process completed within one hour
- Acts as a compatibilizer
  - ✓ Does not dissolve the rubber!

Laboratory Studies

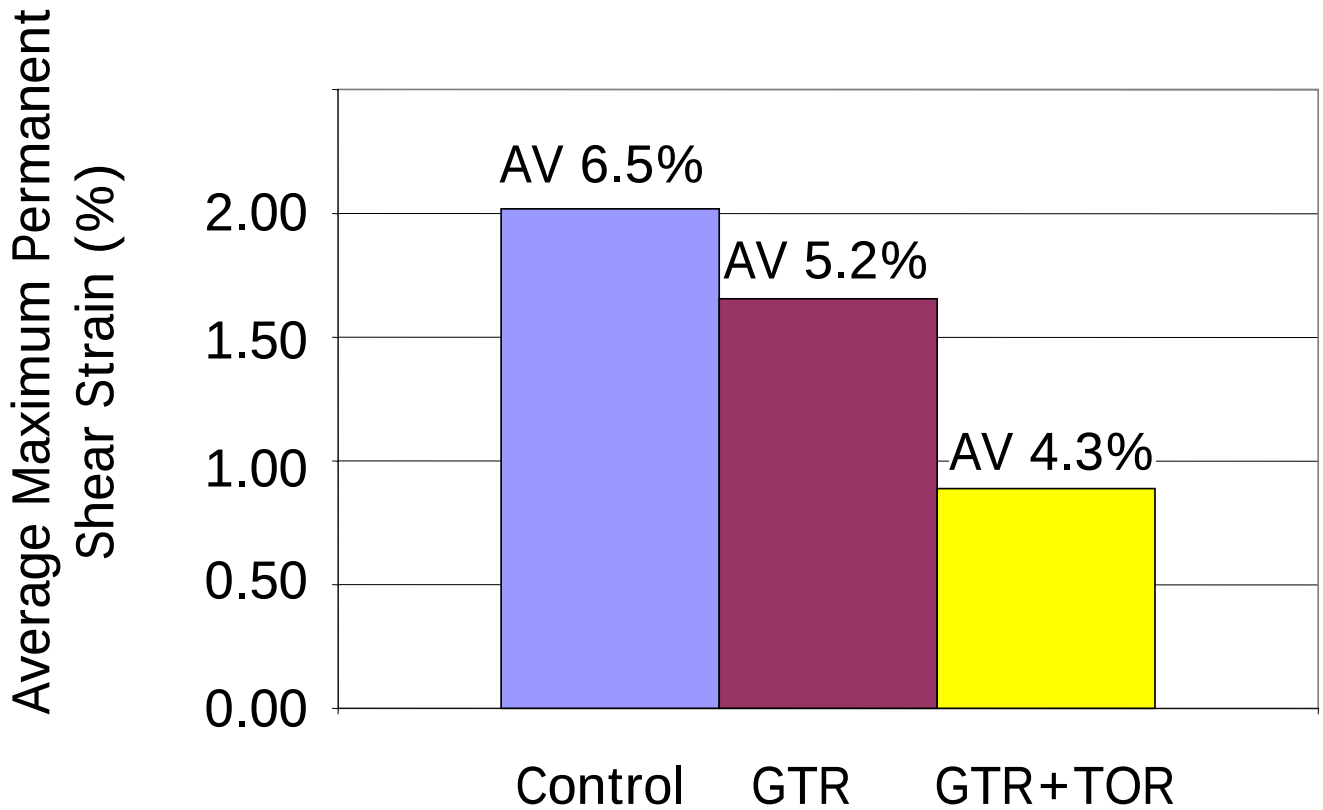
- Penn State Research Study 2003
- Arizona State University Study 2004
- FHWA Study 2004
- Clemson University Study ongoing
- Heritage Asphalt Study ongoing
- Under review by others

Penn State Study

Type	Binder PG Grade	GTR % by weight of Binder		VESTENAMER Modifier % by weight of GTR
		Mesh 14	Mesh 30	
A	58-28	0	0	0
B-1	58-28	5	NU*	0
B-2	58-28	5	NU*	4.5
C-1	58-28	10	10	0
C-2	58-28	10	10	4.5

Blended with Ross Mixer at 150°C

SST Results


Average Maximum Permanent Shear Strain (%)
2.00
1.50
1.00
0.50
0.00
AV 6.5%
AV 5.2%
AV 4.3%
Control
GTR
GTR+TOR

Conclusions from Penn State Study

- TOR definitely reacts with GTR
  - ✓ Reduces granular appearance
  - ✓ Effect is more pronounced as GTR becomes smaller
- Upper grading temperature
  - ✓ 5% GTR + TOR gave one grade increase
  - ✓ 10% GTR + TOR gave three grade increases
  - ✓ Effect greater with 14 mesh GTR
- Lower grading temperature
  - ✓ Lowered S and increased m-value
  - ✓ Increased strain to failure in DT
- Mixture Testing showed improved rutting resistance

FHWA Study

- 14-30 mesh GTR
- Four blends
  1. PG 64-22 Base asphalt cement
  2. PG 64-22 + 3% TOR*
  3. PG 64-22 + 5% GTR*
  4. PG 64-22 +5% GTR* +4.5% TOR
- Materials blended with Silverson mixer
  - ✓ 30 – 60 minutes
  - ✓ 5% GTR* +4.5% TOR heated overnight

FHWA Study

Property	Base Binder	Base + GTR	Base + TOR	Base + GTR + TOR
Mass Change,%	-0.119	-0.162	-0.102	-0.129
M320 Grade	67 – 25	70 - 26	73 – 24	74 - 27
T_{cr} MP1a	-23.5	-24.7	-25.3	-23.5
Linearity	Linear to 30% strain			

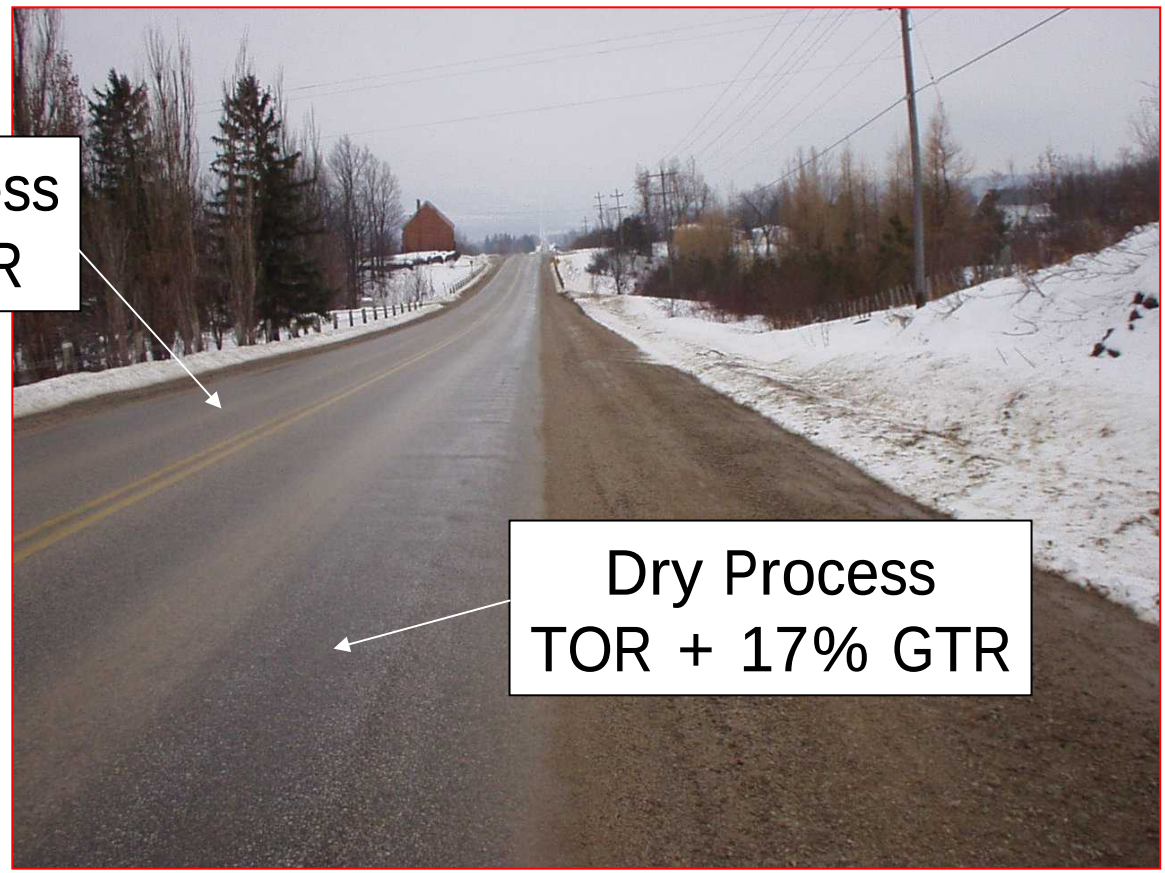
Field Trials

- 1998- Grey County, Ontario, Route 7
  - ✓ 1 kilometer single lane, 4.5% TOR
- 1999- Grey County, Ontario, Route 12,
  - ✓ 3%, 4% and 6% TOR
- 2000 - 3 Trials in Arizona and New Jersey
- 2001 - 9 Trials in AZ, PA, NE and IL
- 2002 - 20 Trials in AZ, PA and NE
- 2003 – 5 trials in NE, 10 in IL
- In total – over 50 sections in place

Equipment

- Dry or wet process
  - ✓ Traditional procedures applicable
  - ✓ TOR and GTR may be added to mix individually or by preblending
- No special handling required

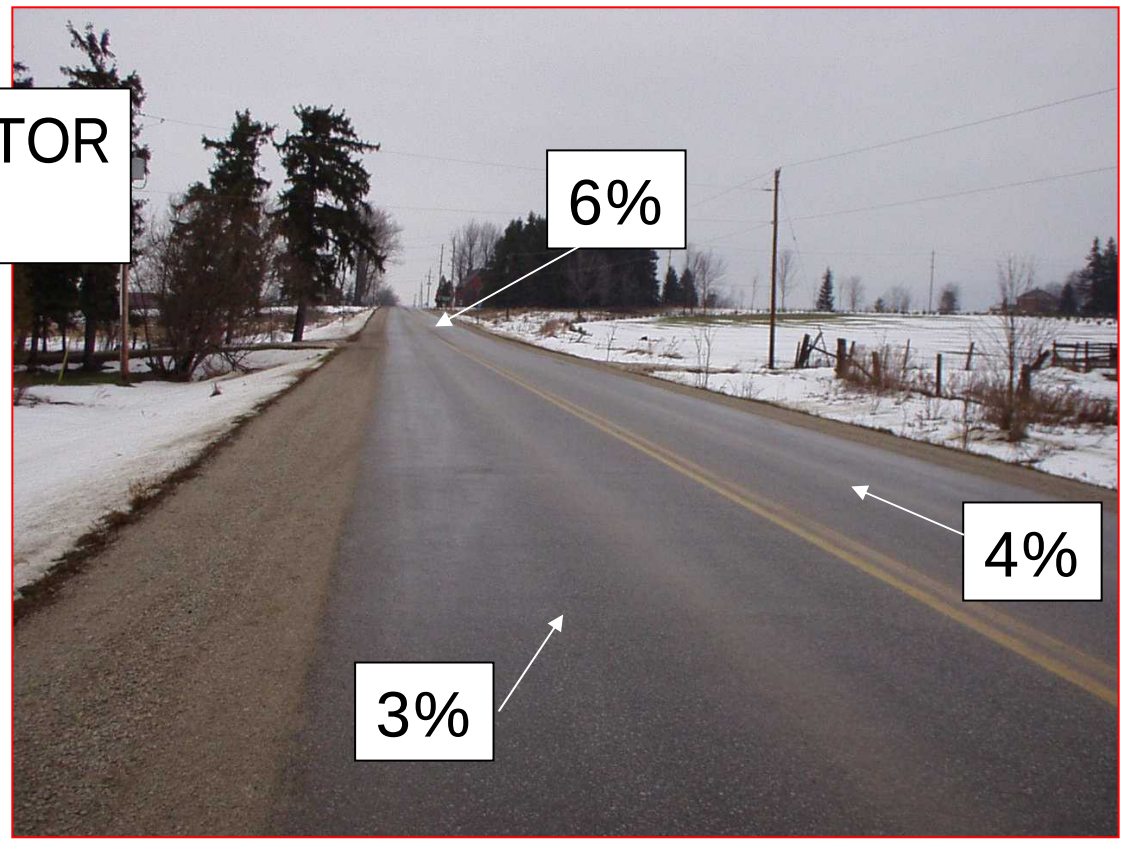
Route 7, Grey County, Ontario, Canada
After 5 years of service



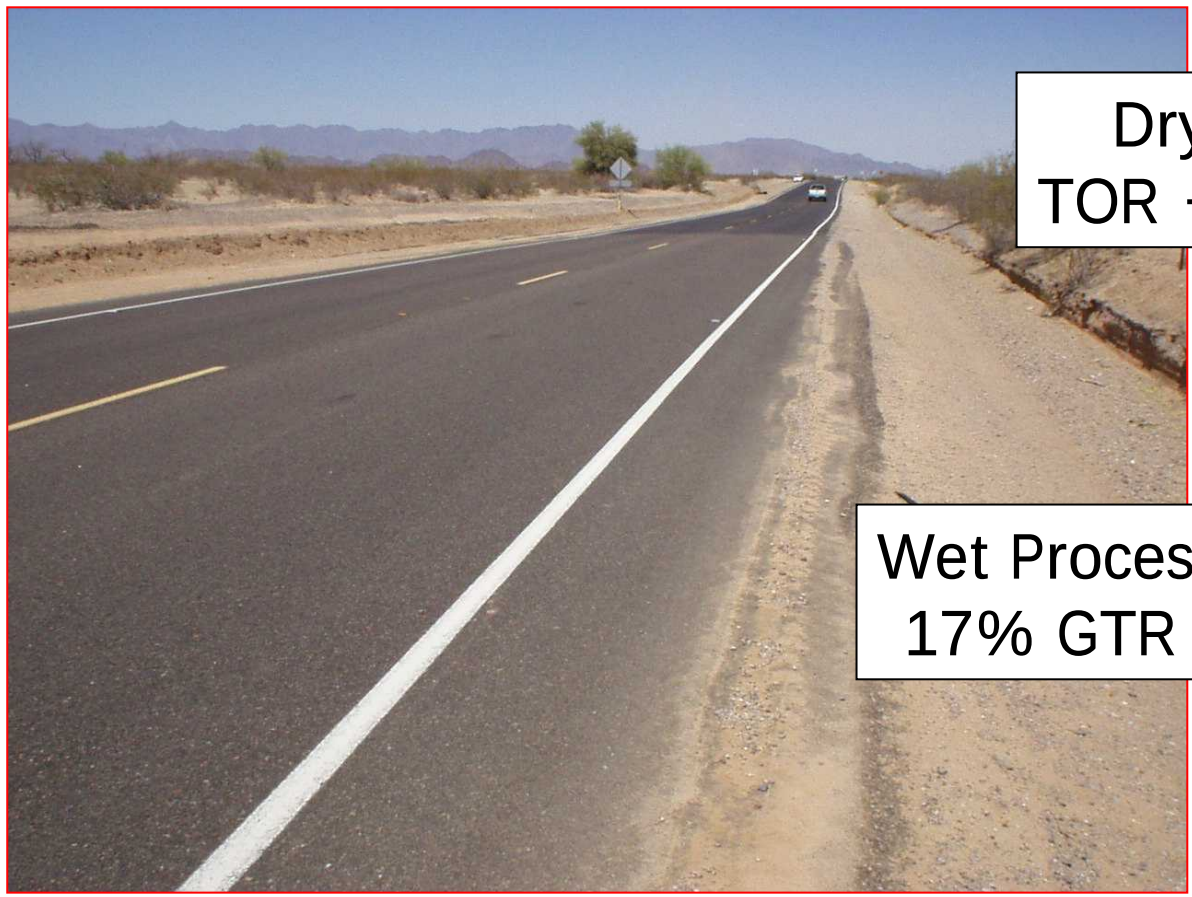
Route 12 Grey County, Ontario, Canada After 4 years service

3, 4% and 6% TOR
+ 17% GTR

Conclusion:
Use 4.5% TOR



Rt. 238, Maricopa County, Arizona



Test data

- Marshall Design
  - ✓ Stability = 2,147 lbs
  - ✓ Flow = 16
  - ✓ TSR = 0.82
- Testing on Cores
  - ✓ Air voids 5.9%
  - ✓ SST Deformation at 5,000 cycles = 0.29%

Route 238 Maricopa County Arizona

2” Overlay
Dry Process
TOR + 17% GTR

Conventional
Chip Seal

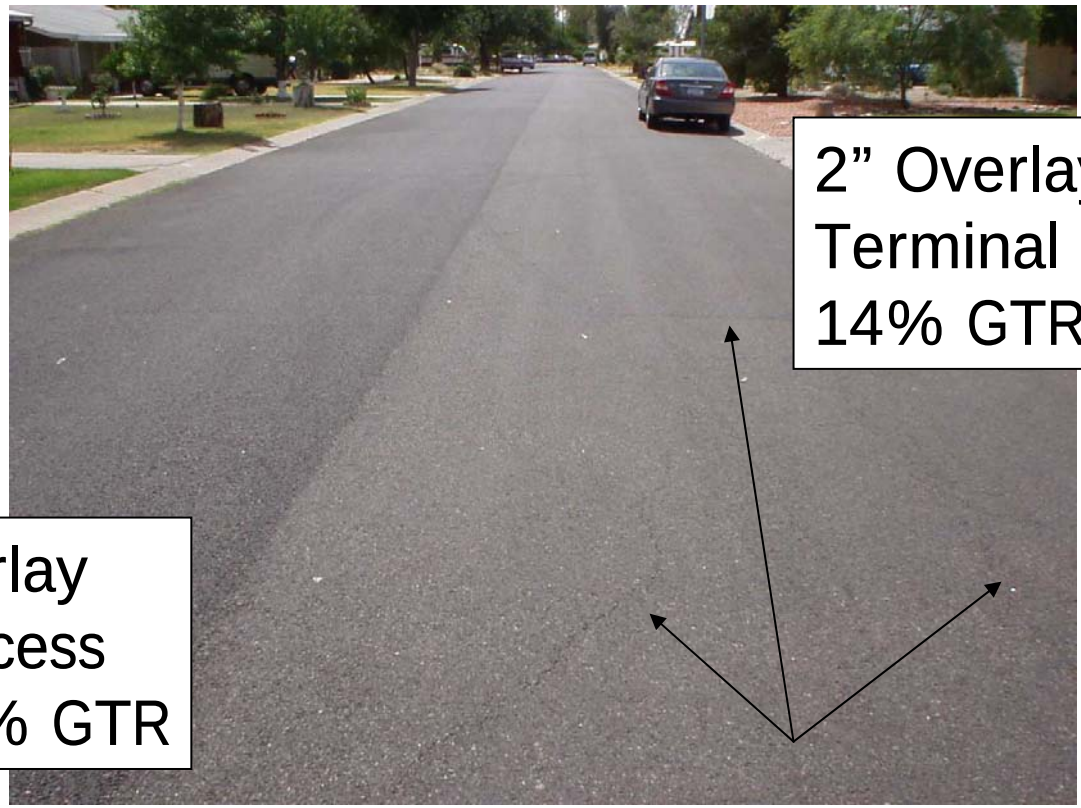
Flagstaff AZ -Lynch St. July 2000 Flagstaff's worst

Flagstaff AZ -Lynch St. After 3.5 years

2” Overlay
Dry Process
TOR + 17% GTR

Phoenix - July 2001

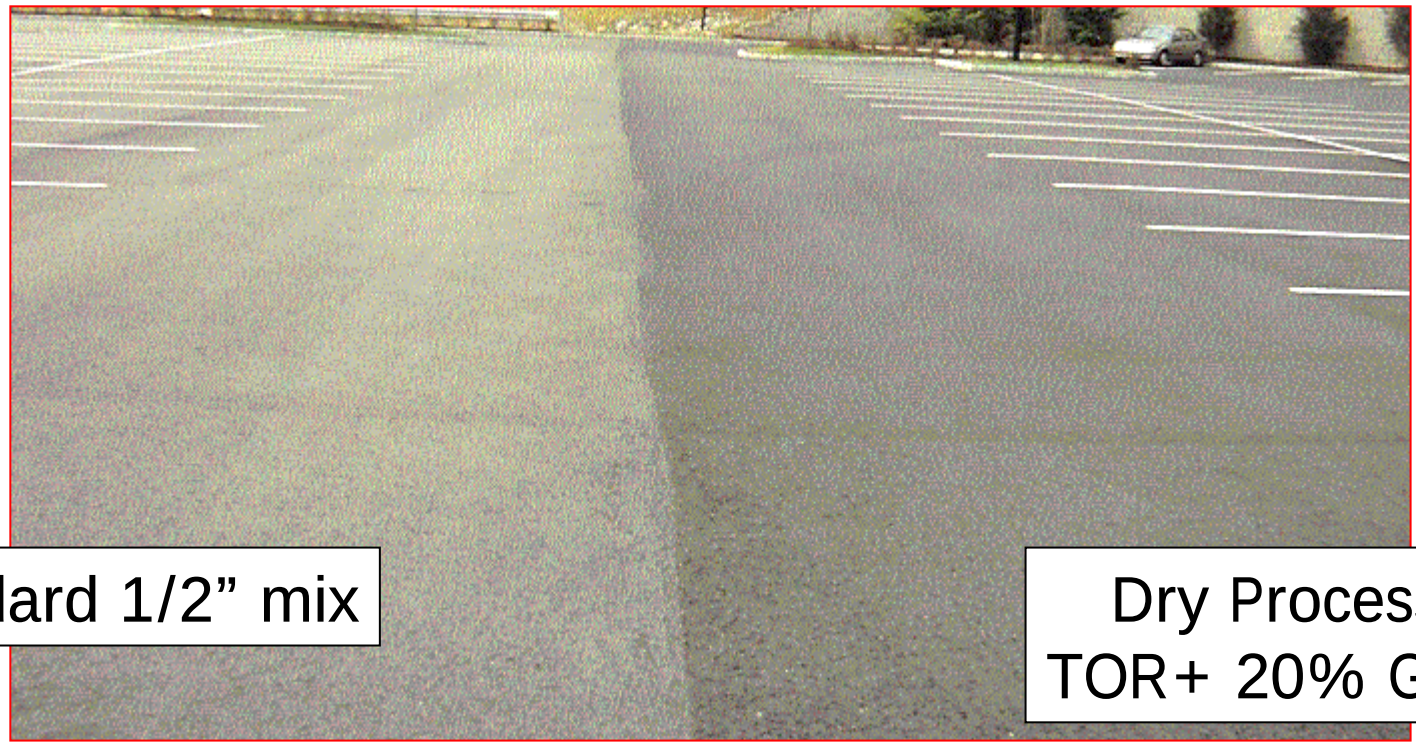
Phoenix, July 2003
After 2 Years



2” Overlay
Terminal Blend
14% GTR + 2% SBS

2” Overlay
Dry Process
TOR+ 14% GTR

New Jersey, Degussa Corp. Parking Lot After 3 years



Standard 1/2” mix

Dry Process
TOR+ 20% GTR

Route 642- W. Milton PA
After 2 years

SMA
¼" Top Size
Dry Process
TOR + 4.75% GTR

North Chicago Road, Nebraska After 1.5 years

2” Overlay
5.5 miles
Dry Process
TOR + 17% GTR

East Liverpool, OH - over brick road After 1 year

Dry Process
Over Brick Road
TOR +10% GTR

Conclusions

- TOR + GTR can extend PG grade (5% = 1 grade)
- TOR chemically bonds GTR to the asphalt and the aggregate
- TOR reduces the "blue smoke" associated with the use of GTR modified asphalt alone
- TOR enhances workability – reduced "tackiness"
- TOR can be used with traditional methods and equipment – wet or dry process
- TOR enhances performance – reduced cracking and rutting

Acknowledgements

- Federal Highway Administration
  - ✓ John D'Angelo and Satish Ramaiah
- Penn State University
  - ✓ Mansour Solaimanan and Darin Hunter