



# ISAET '21

## 7th International Symposium on Asphalt Emulsion Technology

### Effects of Tack Coat Material Type and Application Rate on Pavement Performance

Louay N. Mohammad, Ph.D., P.E., Fellow ASCE

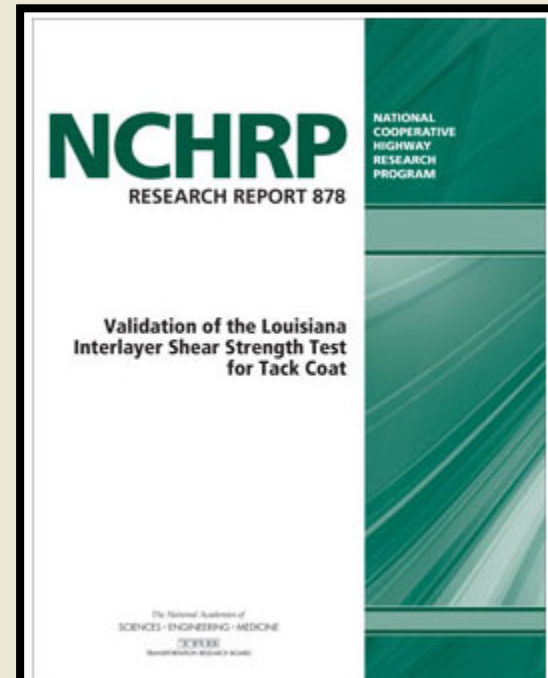
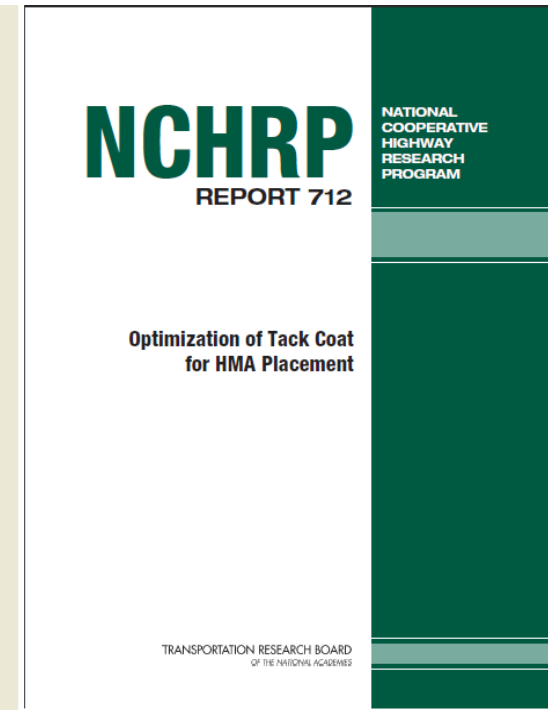
Irma Louise Rush Stewart Distinguished Professor  
Department of Civil and Environmental Engineering  
Louisiana Transportation Research Center  
Louisiana State University

October 26-28, 2021  
Virtual



# Key Topics

- **Durability**
  - Pavement Performance
  - Bonding
- **Tack Coat Research**
  - NCHRP Project 9-40
    - » Report No. 712
  - NCHRP Project 9-40A
    - » Report No. 878
- **Summary and Conclusions**



# ***Acknowledgement***

## **NCHRP**

- Technical Review Panel
- State DOTs

## **LTRC Asphalt Lab**

## **State DOTs**

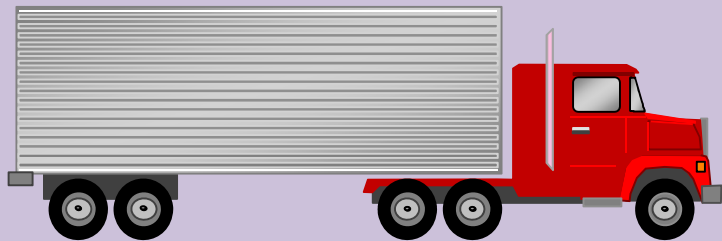
- Missouri; Louisiana; Florida; Tennessee; Nevada; Oklahoma

## **Material Suppliers and Contractors**

- Asphalt Products Unlimited
- Ergon Asphalts
- Blacklidge
- Coastal Bridge
- ...

# Durable Flexible Pavement

- Permanent deformation
- Fatigue cracking – repeated load
- Low temperature cracking
- Moisture induced damage
- Raveling
- etc ...



# *Durable Flexible Pavements*

- **Mixture Design**

- Components Materials
- BMD
- Sustainable Development

- **Construction**

- Tack Coat Practices
- Thermal segregation
- Warm Mix Asphalt
- Increased density
- ...

## Laboratory Design

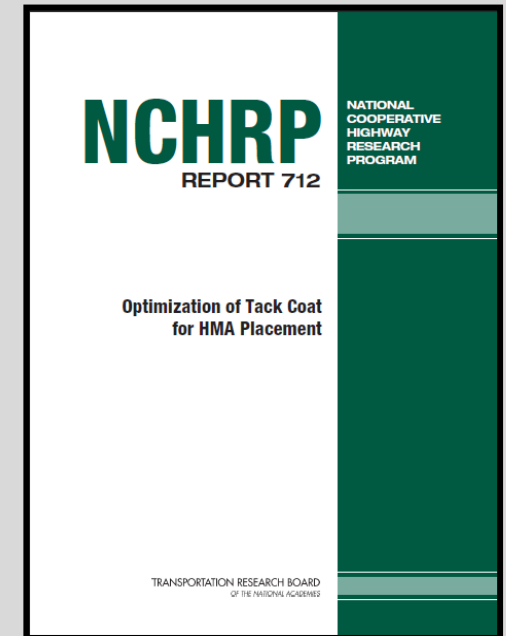
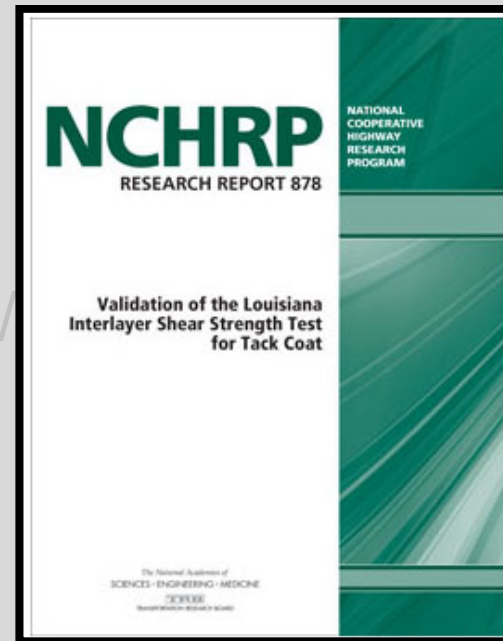


## Field Construction



# Durable Flexible Pavements

- Mixture Design
  - Components Materials
  - Engineered Performance /
  - Sustainable Development
- Construction
  - Tack Coat Practices
  - Thermal segregation
  - Warm Mix
  - Increased

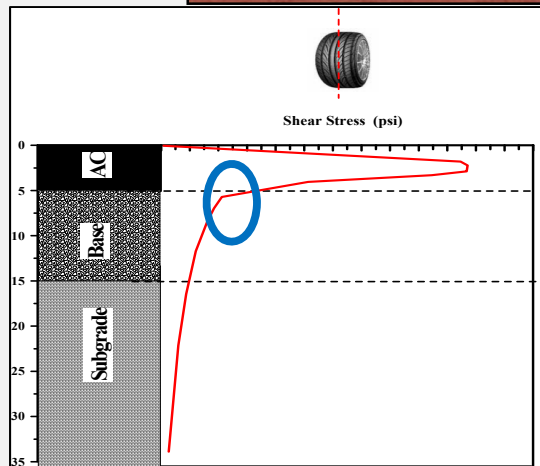


## Field Construction



# Durable Pavement – Construction Tack Coat

- ❑ **Purpose of tack coat application**
  - To ensure adequate bond between pavement layers – Monolithic Structure
  - To transmit traffic loads down through the entire pavement structure
  
- ❑ **Not properly bonded, increase tendency for**
  - Cracking,
  - Debonding (delamination/slippage/sliding),
  - ...
  - Thus failure in the new overlay
  
- ❑ **Tack coat material is relatively *inexpensive* portion compared to overall pavement construction cost**
  - Bonding failure is extremely \$\$\$ !!!



# *Improper Tack Coat Application*

Non uniform  
Streaks  
Partial coverage  
...



*Courtesy of James A. Scherocman*

# ***Proper Tack Coat Application*** ***Uniform Coverage***



0.031 gsy

**Low**



0.062 gsy

**Medium**



0.155 gsy

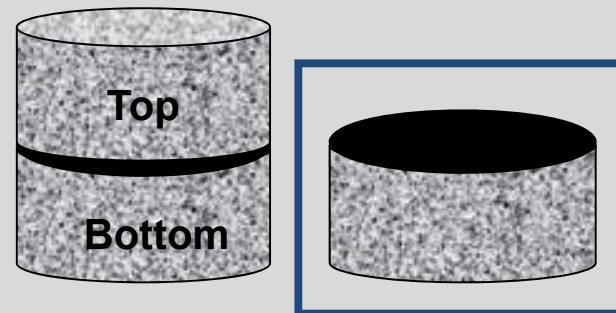
**High**

Uniform  
No streaks  
Full coverage

...

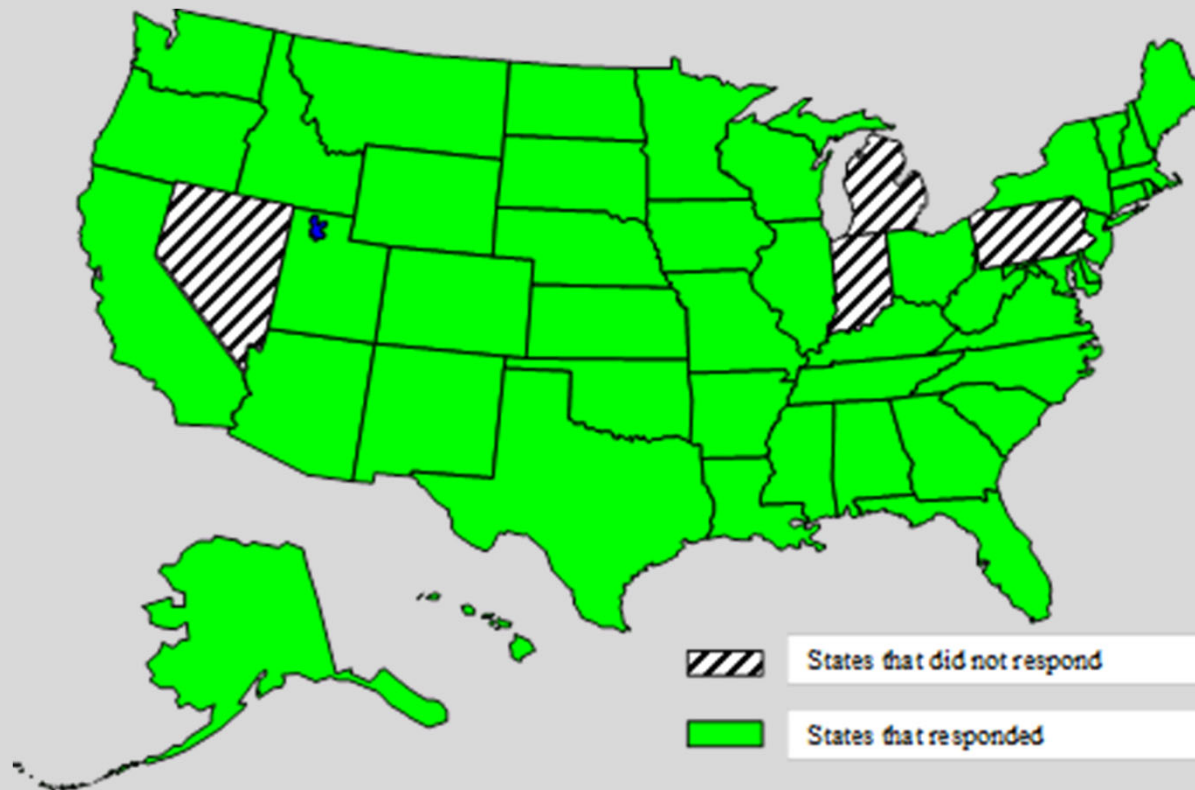
# Objectives – NCHRP Project 9-40

- Evaluate factors that affect interlayer bonding
  - Tack coat **material type** and **application rate**
  - Pavement **surface type**
  - **Temperature**
  - **Construction condition**
- Develop AASHTO test methods and practices related to tack coats
  - Tack Coat **Quality**
    - spray application
  - Interlayer **Bond Strength**



# Outcome – NCHRP Project 9-40

- **Worldwide Survey on Tack Coat Practices**
  - **92% return**
  - Canada, Denmark, Finland, South Africa, and the Netherlands.
- **Best Practices and Training Manual**
  - recommended construction and testing procedures



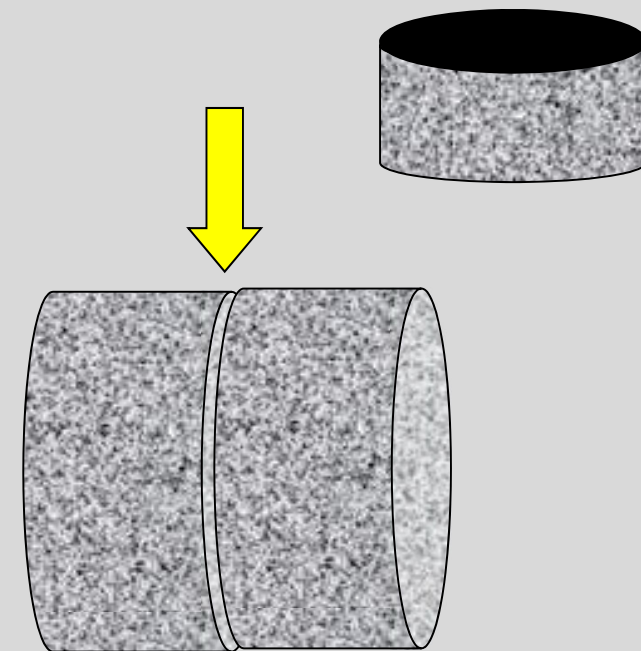
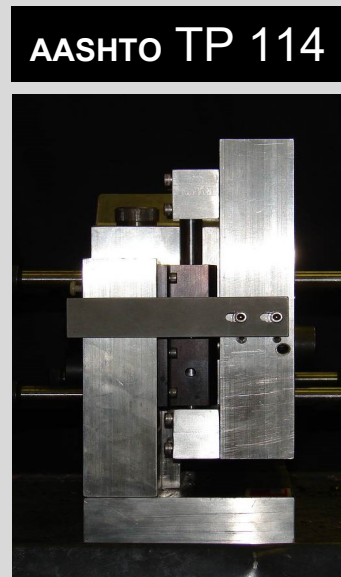
Tack Coat  
Application  
Inspection



# Outcome – NCHRP Project 9-40

- Recommended tack coat residual application rates
- **AASHTO TP 114** and **AASHTO TP 115** test method was developed to characterize **Bond Strength** and **spray quality** of tack coats
- Recommended threshold Interface Shear Strength criterion
  - Minimum **40 psi** – from **AASHTO TP 114**

Surface Type	Residual Application rate, gsy
New HMA	0.035
Existing HMA	0.055
Milled HMA	0.055
PCC	0.045



# Objective – NCHRP Project 9-40A

- ❑ Validate **AASHTO TP 114** test method and minimum recommended ISS threshold (**40 psi**) criterion
- ❑ Evaluate factors that affects interface bonding
  - Pavement Surface Type
  - Tack Coat Material Type
  - Residual Application Rate
  - Service Time – 12 months
- ❑ Investigate effect of bonding on short-term pavement performance



# Scope

- ❑ **Six field projects**
  - Missouri; Louisiana; Florida; Tennessee; Nevada; Oklahoma
  
- ❑ **Four pavement surface types:**
  - New HMA; Existing HMA; Milled HMA; PCC
  
- ❑ **Two tack coat material types:**
  - Slow setting
    - SS-1H, CSS-1H, SS-1
  - Non-tracking rapid setting
    - NTSS-1HM, CBC-1H, CRS-1 HBC)
  
- ❑ **Two tack coat residual application rates:**
  - specified by state DOTs
  - recommended by NCHRP Project 9-40

Climatic Zones:

- - Wet-Freeze
- - Wet-No Freeze
- - Dry-Freeze
- - Dry-No Freeze



Surface Type	Residual Application rate, gsy
New HMA	0.035
Existing HMA	0.055
Milled HMA	0.055
PCC	0.045

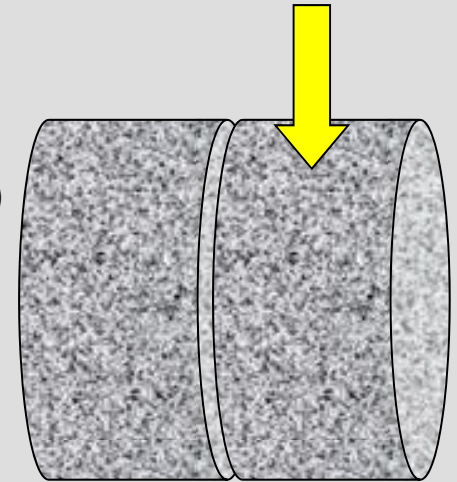
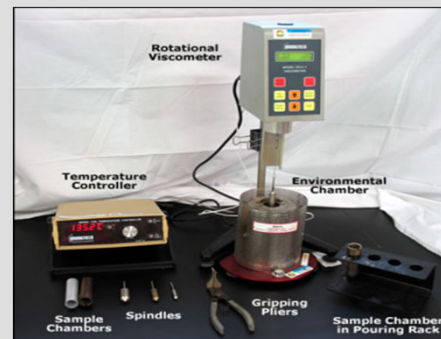
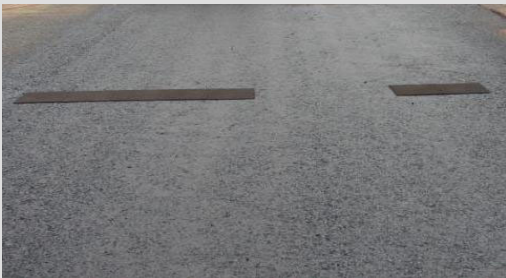
# Experimental Program

- **Field Measurements**

- Distributor Truck Calibration (**ASTM D 2995**)
- Pavement Surface Texture Measurement (**ASTM E 965**)
- Measured Field Application Rate (**ASTM D 2995**)
- Distress Survey (**LTPP Manual**)
- FWD (**Structural Capacity**)

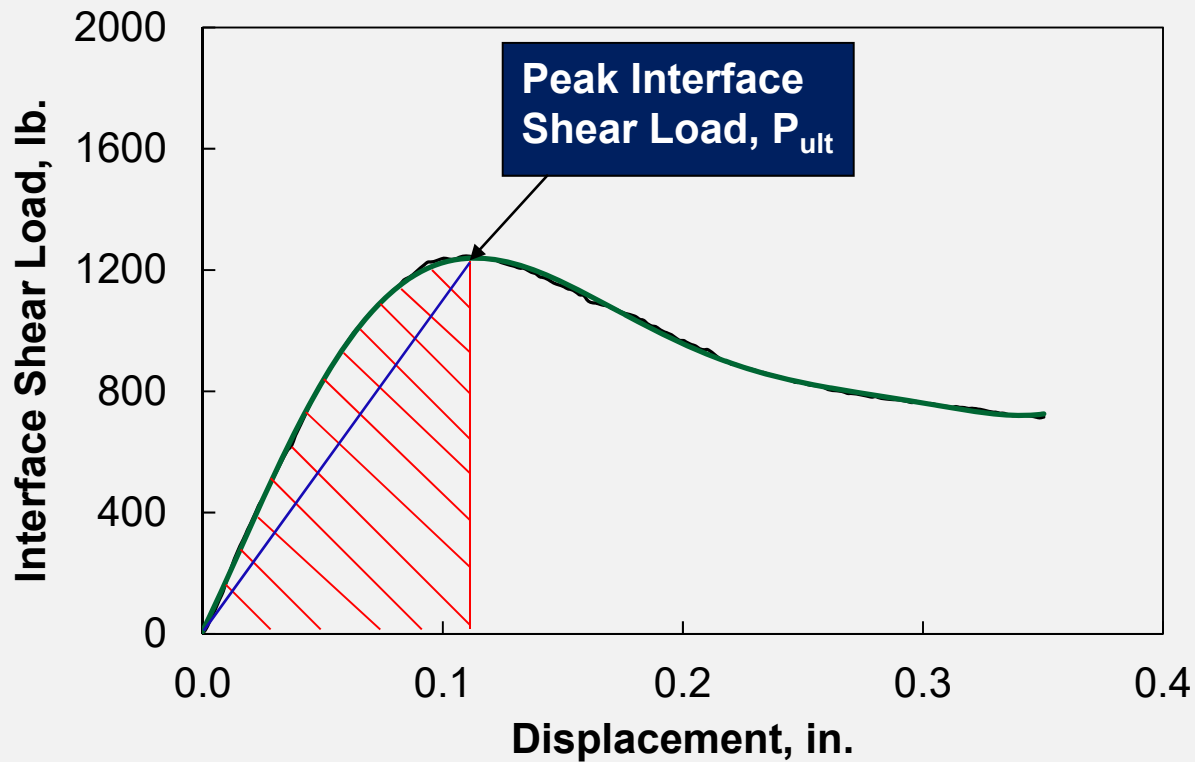
- **Laboratory Measurements**

- Interface Shear Strength Test (**AASHTO TP 114**)
- Tack Coat Material Rheological Characterization (**AASHTO M 320**)



# Laboratory Measurement – AASHTO TP 114

## Tack Coat Materials Bond Quality

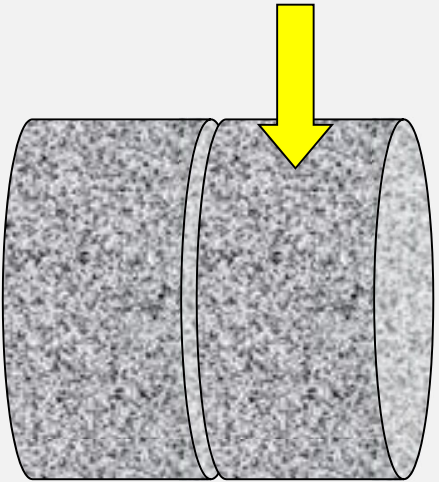


$$ISS = \frac{P_{ult}}{\frac{\pi D^2}{4}}$$

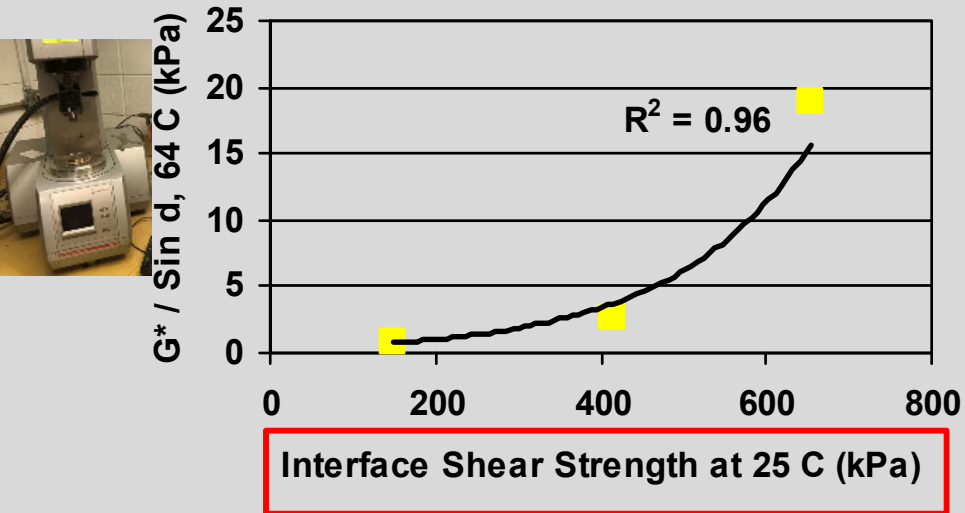
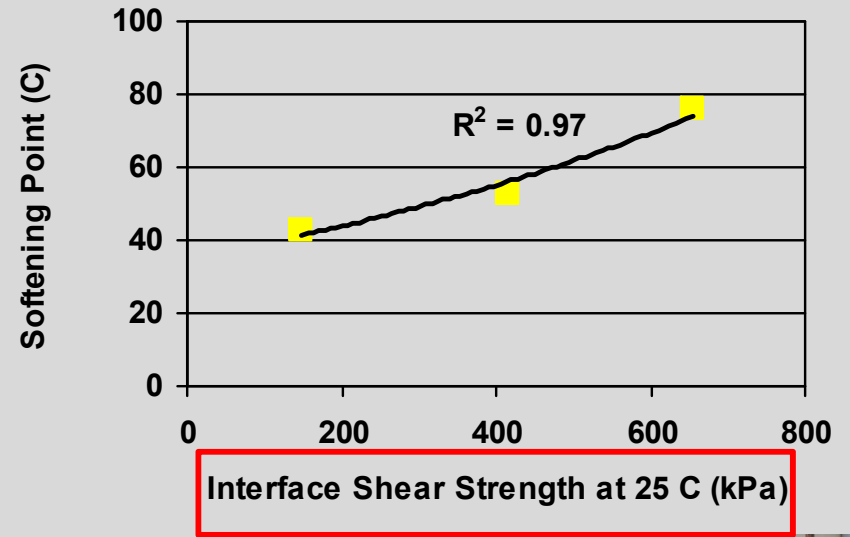
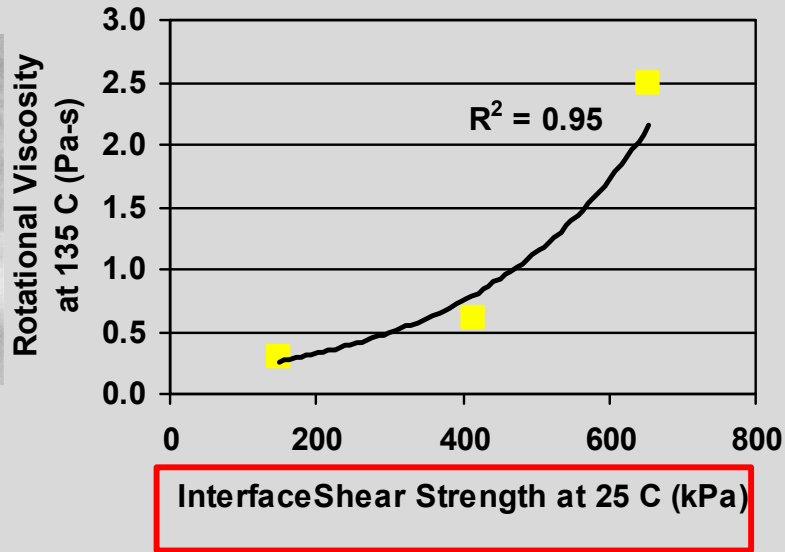
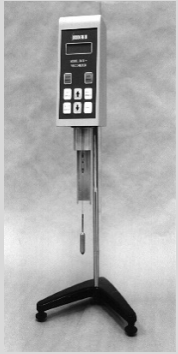
$$IBE = \frac{\text{Area Under the Curve upto } P_{ult}}{\frac{\pi D^2}{4}}$$

$$K - \text{modulus} = \frac{ISS}{\text{Displacement at } P_{ult}}$$

- Interface Shear Strength (ISS, psi) : **COV < 15%**
- Interface Bond Energy (IBE, lb.-in/in<sup>2</sup>)
- Interface Shear Stiffness (k-modulus, psi/in)

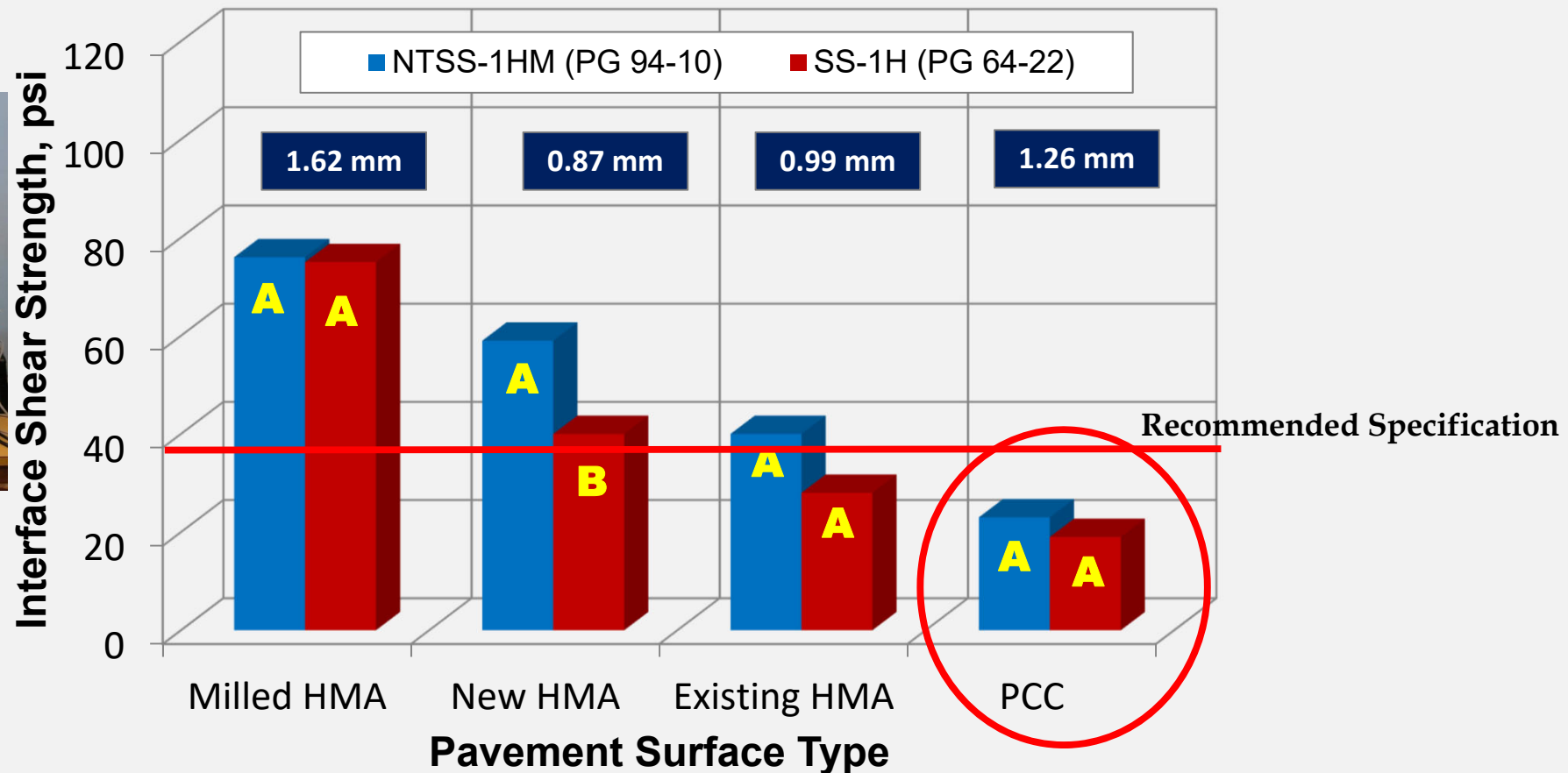


# Relationship between *ISS* vs. *Rheology Test Results*



# Effect of *Pavement Surface Type* on ISS

## MISSOURI PROJECT

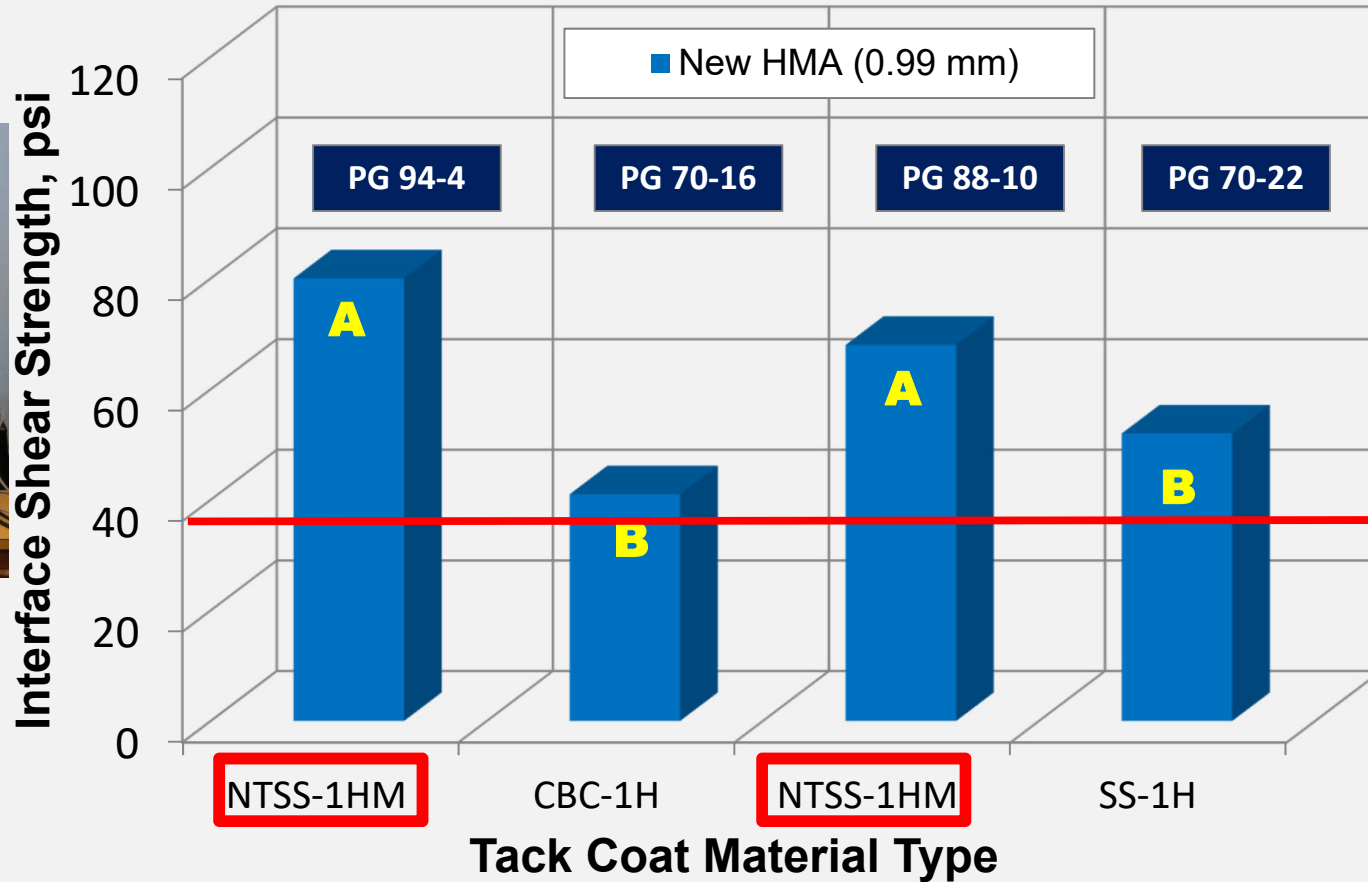


□ All tack coat material were compared at 0.05 gsy residual application rate



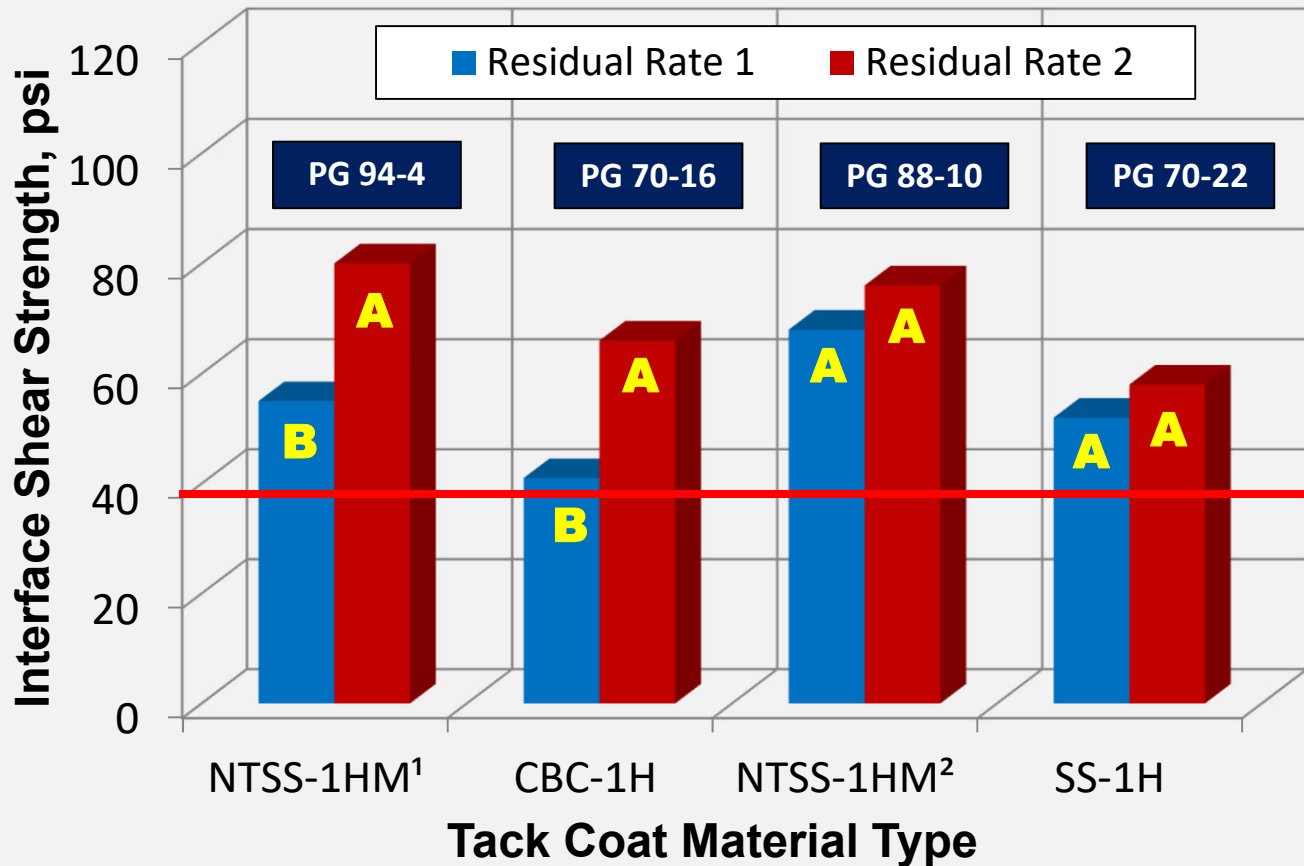
# Effect of Tack Coat Type on ISS

## LOUISIANA PROJECT (LA 1053)



# Effect of Residual Application Rate on ISS

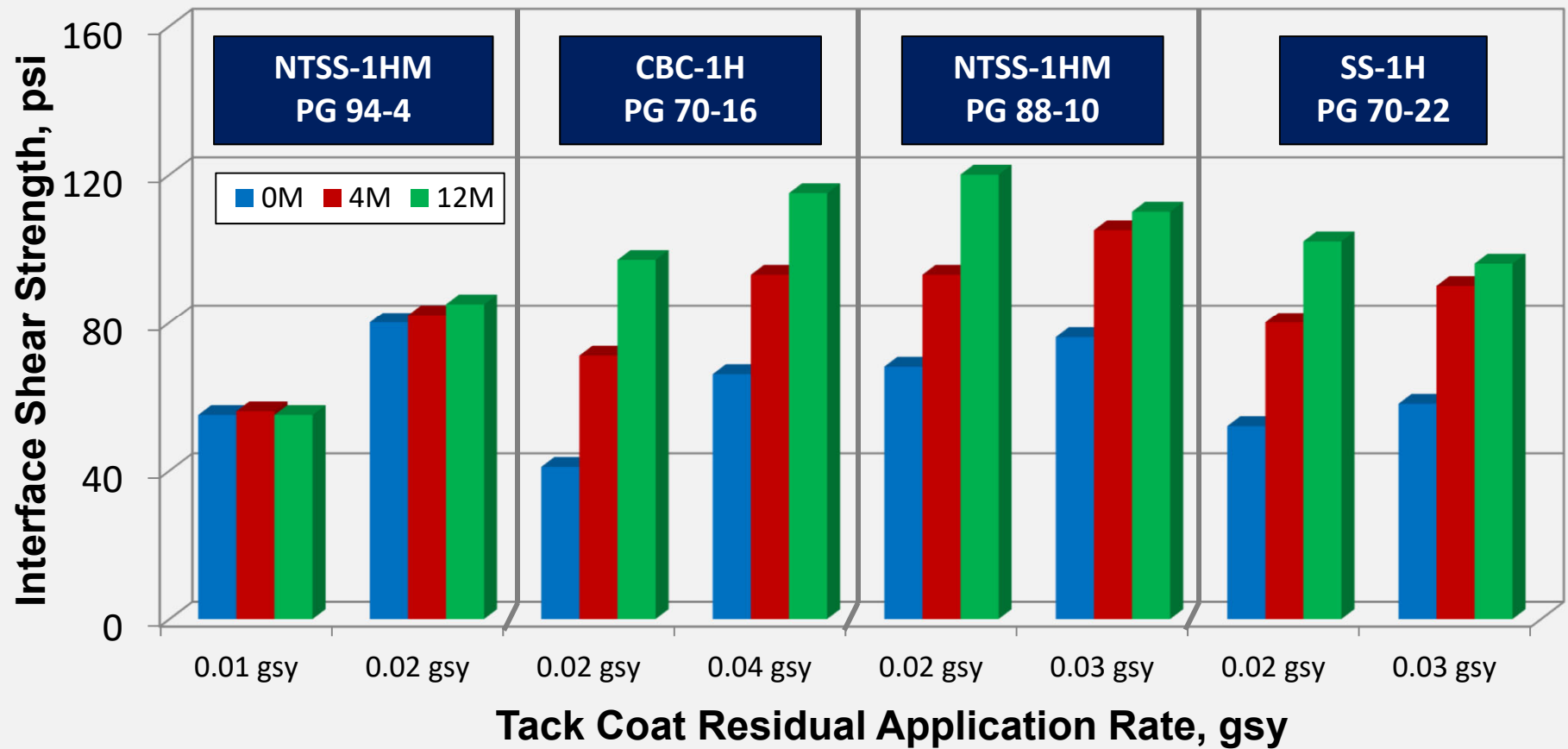
## LOUISIANA PROJECT (LA 1053) New HMA



Tack Coat Material	Residual Rate, gsy	
	1	2
NTSS-1HM <sup>1</sup>	0.01	0.02
CBC-1H	0.02	0.04
NTSS-1HM <sup>2</sup>	0.02	0.03
SS-1H	0.02	0.03

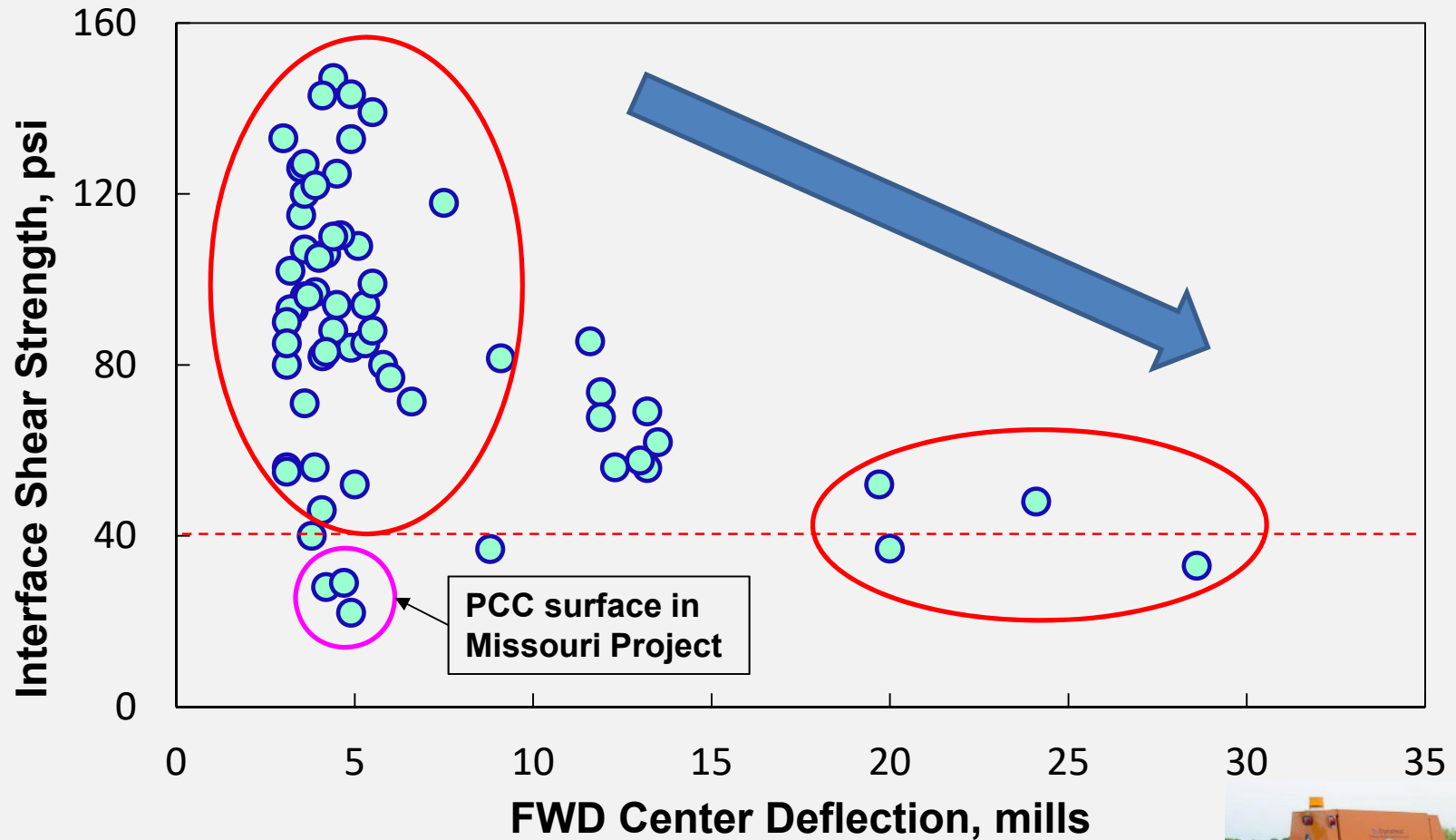
# Effect of *Service Time* on ISS

## LOUISIANA PROJECT (LA 1053) NEW HMA



ISS increased with increase in service time

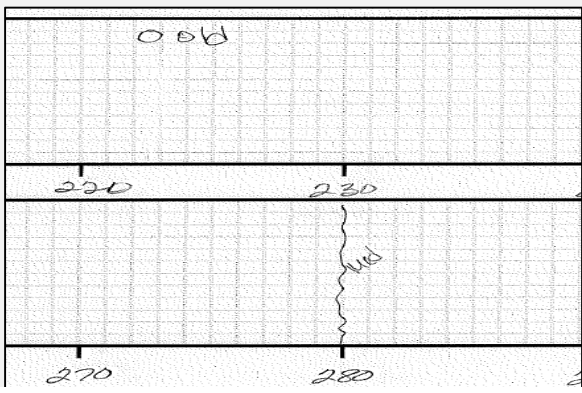
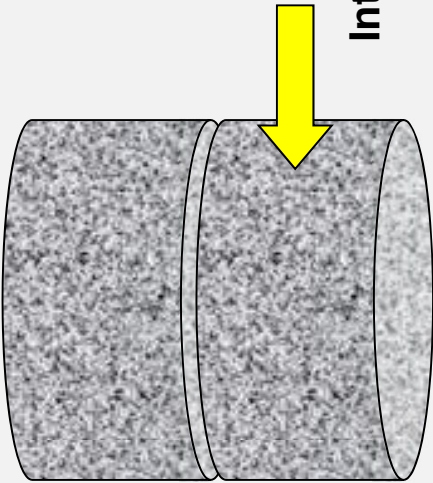
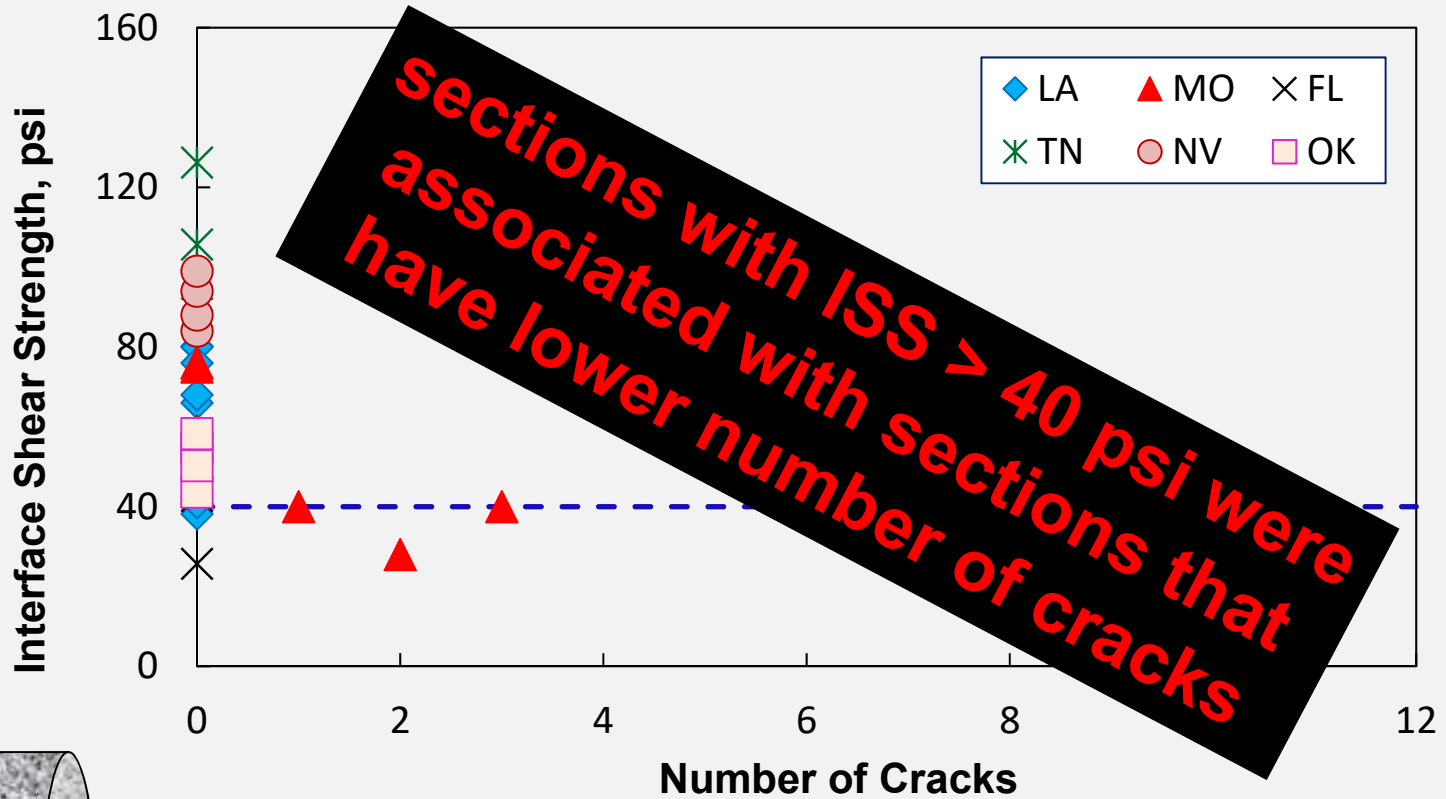
# Structural Capacity (FWD) vs ISS



□ Indicates surface deflection (structural capacity) depends on — the interface bonding between pavement layers



# Pavement Cracking vs Bond Strength (ISS)



# Key Takeaways

## □ Effect of tack coat type on ISS

- Non-tracking **rapid setting** tack coats with stiff base asphalt (NTSS-1HM) exhibited the **highest ISS**, and **slow setting** resulted in the **lowest**

## □ Effect of pavement surface type on ISS

- ISS was largely dependent on
  - Type of pavement surface (HMA versus PCC)
  - Type of pavement surface texture (milled versus non-milled)
- Milled surface yielded highest ISS, followed by new HMA, existing HMA, and PCC surface types
  - Higher surface roughness provided greater shear resistance

## □ Effect of residual application rate on ISS

- **ISS** improved with **increase in residual application rate** for all tack coat types and pavement surface types

# Key Takeaways

## ❑ Effect of service time on ISS

- In general, ISS increased with increase in service time
  - tack coat curing

## ❑ Pavement Structural Capacity (FWD test results)

- Mean center deflection decreased with service time
- Densification of overlays was attributed to
  - in-service trafficking
  - improved ISS

## ❑ Short-term pavement performance

- ISS values correlated well with short-term performance
- test sections with ISS < 40 psi increased cracking

## ❑ Tack coat material type and application rate affect on Pavement Performance

- Appropriate material and applicator rate

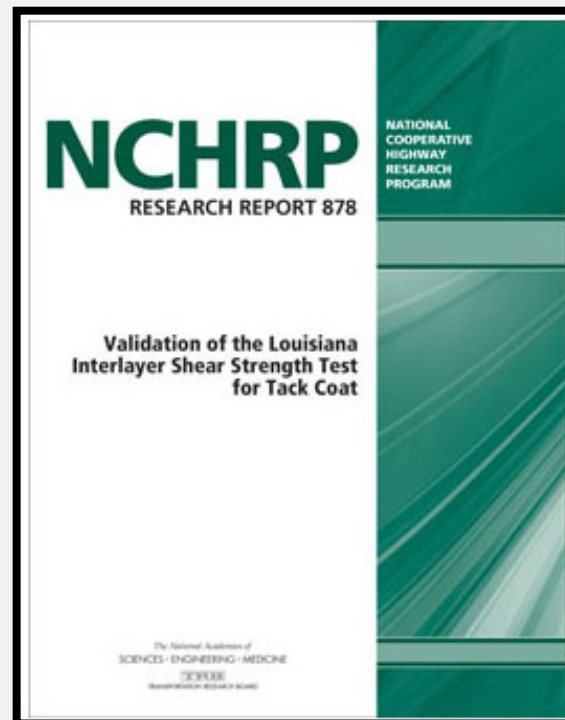
# Recommendations

## ❑ AASHTO TP 114 test

- Quality control and quality assurance testing of tack coat construction
- Evaluation of interface-bonding condition of in-service pavements

## ❑ Use of minimum ISS threshold criterion (40 psi)

- As the specification for satisfactory pavement performance





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 **LSU**  
LOUISIANA STATE UNIVERSITY

Photo: Jim Zietz, Office of Public Affairs