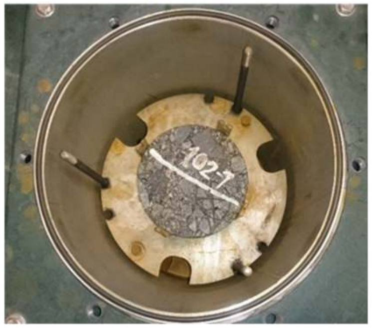
NABin-seminar
15 October 2019




Moisture Induced Sensitivity Test (MIST)

Shafiqur Rahman, PhD
Researcher
VTI – The Swedish National Road and Transport Research Institute
Linköping, Sweden
shafiqur.rahman@vti.se

FINDING A BETTER WAY

Outline

- Background on moisture damage
- Different moisture conditioning approaches
- MIST
- Application of MIST in two projects

Background

vti




- Moisture damage is one of the major problems
- Moisture in all physical states contributes to various forms of damage:
  - Stripping
  - Raveling
  - Rutting
  - Cracking
- Three main processes:
  - Moisture diffusion
  - Binder erosion due to fast water flow
  - Cyclic pore pressure development

Background




- Long-term damage:
  - Moisture diffusion
  - Molecular process
  - Binder physio-chemical properties change
  - Cohesive strength reduces
  - Adhesive bond weakens
  - Results in stripping/raveling
- Short-term damage:
  - Pumping action
  - Cyclic pore pressure generation
  - Mechanical damage
  - Erosion
  - Accelerates long-term damage

Different moisture conditioning approaches

- The boiling water (ASTM D3625)
- Static immersion (AASHTO T182)
- Rolling bottle (CEN prEN 12697-11)
- Tunnicliff and Root conditioning (NCHRP 274)
- The saturation ageing tensile stiffness (SATS; EN 12697-45)
- The Hamburg wheel tracking (HWT; AASHTO T234) and
- The modified Lottman (AASHTO T283) tests (freeze–thaw cycle)
- **Determination of the water sensitivity of bituminous specimens (EN 12697-12:2018)**
- **Bestämning av vattenkänslighet genom pressdragprovning (TDOK 2017:0650) (Sweden)**

Different moisture conditioning approaches

Drawbacks:

- Variable (lack of tight control on the water saturation)
- Do not correlate well with field performance
- Disregards the pumping action (short-term moisture processes)
- Long testing time (> 24 hours)

“The development of a new test that considers the various moisture failure mechanisms in a relevant time frame is necessary.”
- A. Varveri et al.

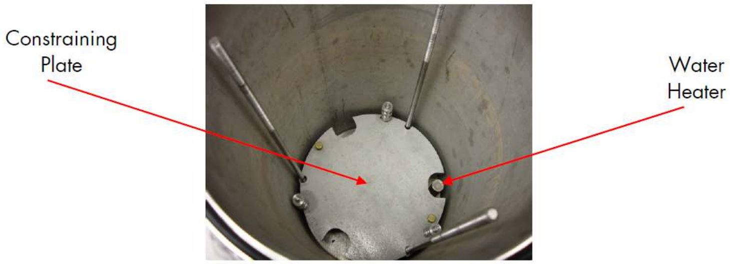
MIST (Moisture Induced Sensitivity Test)

- Accelerated conditioning method under cyclic loading.
- Designed to simulate the stripping mechanisms.
- Simulates moisture damage due to water, repeated traffic loading and elevated in place temperatures.
- Can be conducted on compacted laboratory and field samples.
- Shorter test time (< 24 hours)
- Adjustable temperature, pressure and number of cycles
- Automated and sensors monitored

MIST (Moisture Induced Sensitivity Test)

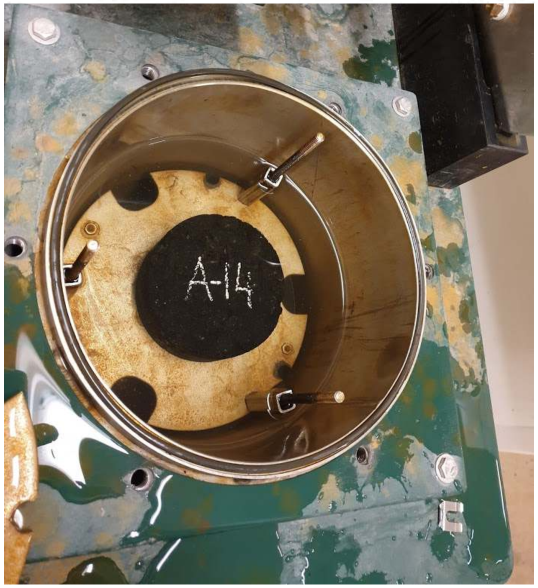
MIST Components

Fig 1. MIST Top View



- Conditioning inside a cylindrical sample chamber (3 levels for up to 3 samples)
- The device includes a hydraulic pump and piston mechanism
- Cyclically adds and relieves pressure inside the sample chamber (through a bladder inside the sample tank).
- The test is performed at elevated temperatures (adjustable) to further accelerate the potential damage (long-term damage)

MIST (Moisture Induced Sensitivity Test)



- The tests involves placing a sample inside the sample chamber, filling the chamber with water, closing the sample chamber lid and starting the test.
- The machine automatically heats up the water/sample and start cycling (to desired temperature and pressure).
- The entire cyclic conditioning process takes approximately 3 hours.

MIST (Moisture Induced Sensitivity Test)

vti

SPECIFICATIONS	
Temperature Accuracy	±1 °C/±1.8°F
Max Temperature	60 °C/140 °F
Sample Height	25 mm to 150 mm/1" to 6"
Sample Diameter	100 mm to 150 mm/4" to 6"
Pressure Accuracy	7 kPa/±1 psi
Pressure Control	7 kPa/±1 psi
Maximum Apparent Pressure	517 kPa/75 psi
Max Hydraulic Pressure	3.45 MPa/500 psi
Electrical	115 VAC 20 A (Optional 230 VAC 10 A)
Weight	159 kg/350 lbs
Height	1.35 m/53"
Foot Print	0.53 m x 0.53 m/21"x21" square
Hydraulic Fluid	Hydraulic oil with a viscosity of 150 to 300 SUS at 38°C (100°F)

Specifications	
Temparature range	40°C to 60°C
Maximum pressure	517 kPa
Frequency of cyclic pressure	0.5 Hz
Number of cycles	1 to 50 000
Sample height	25 mm to 150 mm
Sample diameter	100 mm to 150 mm
Maximum number of samples	3

MIST (Moisture Induced Sensitivity Test)

MIST standard

ASTM D7870/D7870M -13

Moisture Conditioning Compacted Asphalt Mixture Specimens by Using Hydrostatic Pore Pressure

Sample size, mm (dia. x height)	150x100 or 100x63
Pressure	40 psi (275.79 kPa)
Temparature	60°C (>PG60)
	50°C (<PG60 or WMA)
Number of cycles	3500
Recommended air void	6.5 to 7.5% or optimum (±0.5%)

MIST (Moisture Induced Sensitivity Test)

MIST standard

- No European standard
- Different researchers have used different temperatures and cycles
- Different mixes require different temperatures and cycles
- Ongoing project at VTI to standardize MIST

Conditioned specimens can be tested for bulk specific gravity, ratio of stiffness modulus, indirect tensile strength ratio (ITSR), flow number and visual inspection

InstroTek acceptance criteria: ITSR > 80%

Project 1: Comparing different moisture conditioning methods (on going)

Objectives

- To compare the following methods
- MIST conditioning
    - MIST 3500 cycles (approx. 2 hours, @ 0.5 Hz)
    - MIST 7000 cycles (approx. 4 hours, @ 0.5 Hz)
    - MIST 12000 cycles (approx. 7 hours, @ 0.5 Hz)
- Determination of the water sensitivity of bituminous specimens (EN 12697-12:2018)
- Bestämning av vattenkänslighet genom pressdragprovning (TDOK 2017:0650) (Sweden)
- To standardize MIST

Project 1: Comparing different moisture conditioning methods (on going)

Planning

Testing 6 mix types in first stage:

1. ABT 11: 6% bitumen, PEN 70/100, 5% air voids (no antistripping agent)
2. ABT 11: 6% bitumen, PEN 100/150, 7% air voids
3. ABT 11+ amines: 6% bitumen, PEN 100/150, 5% air voids
4. ABT 11+ amines: 6% bitumen, PEN 100/150, 7% air voids
5. To be decided
6. To be decided

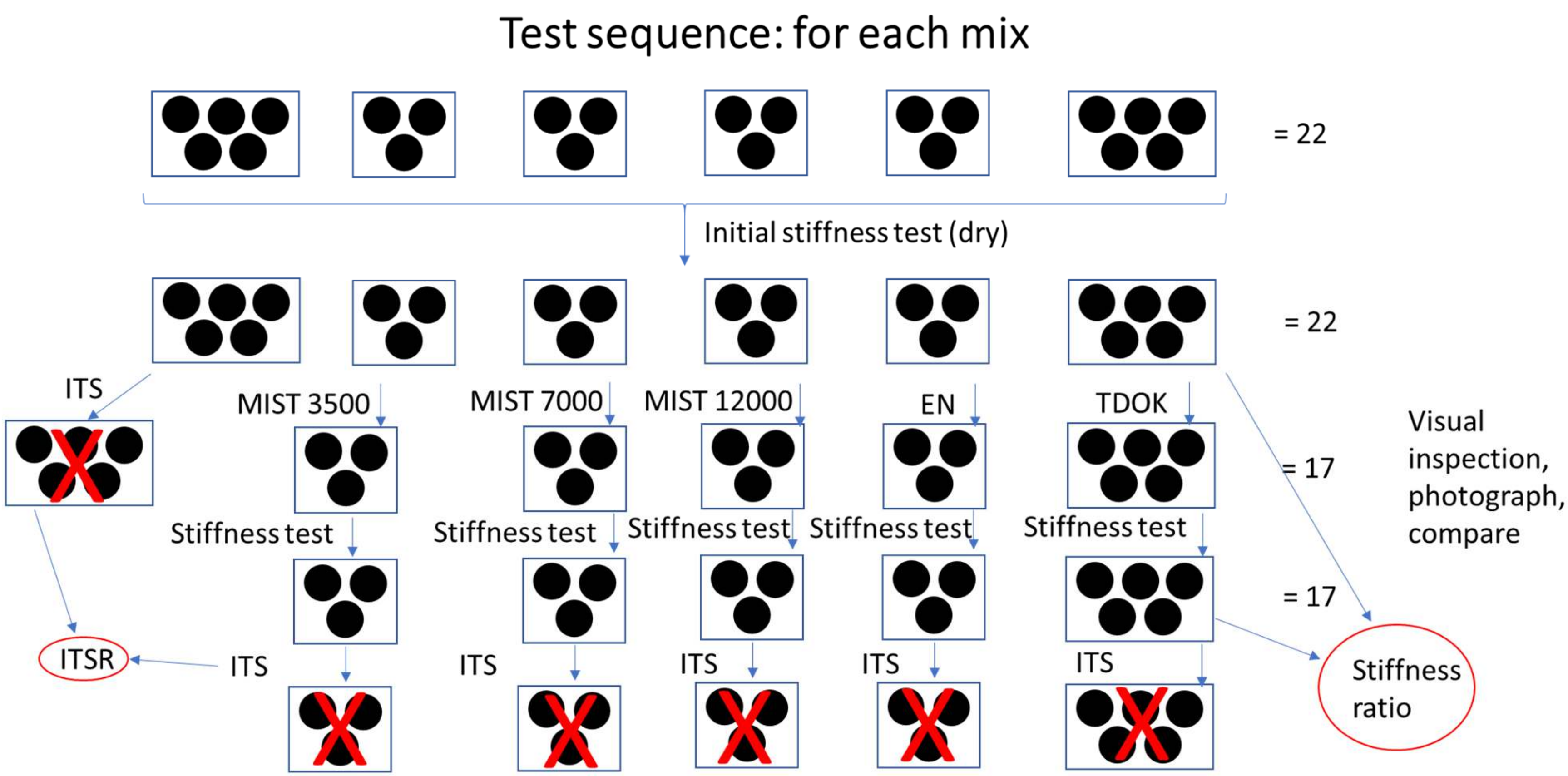
MIST conditioning: 40 psi (275.79 kPa), 40°C

- MIST 3500 cycles (approx. 2 hours, @ 0.5 Hz)
- MIST 7000 cycles (approx. 4 hours, @ 0.5 Hz)
- MIST 12000 cycles (approx. 7 hours, @ 0.5 Hz)

Project 1: Comparing different moisture conditioning methods (on going)

vti

Planning for each mix type



Project 1: Comparing different moisture conditioning methods (on going)

vti

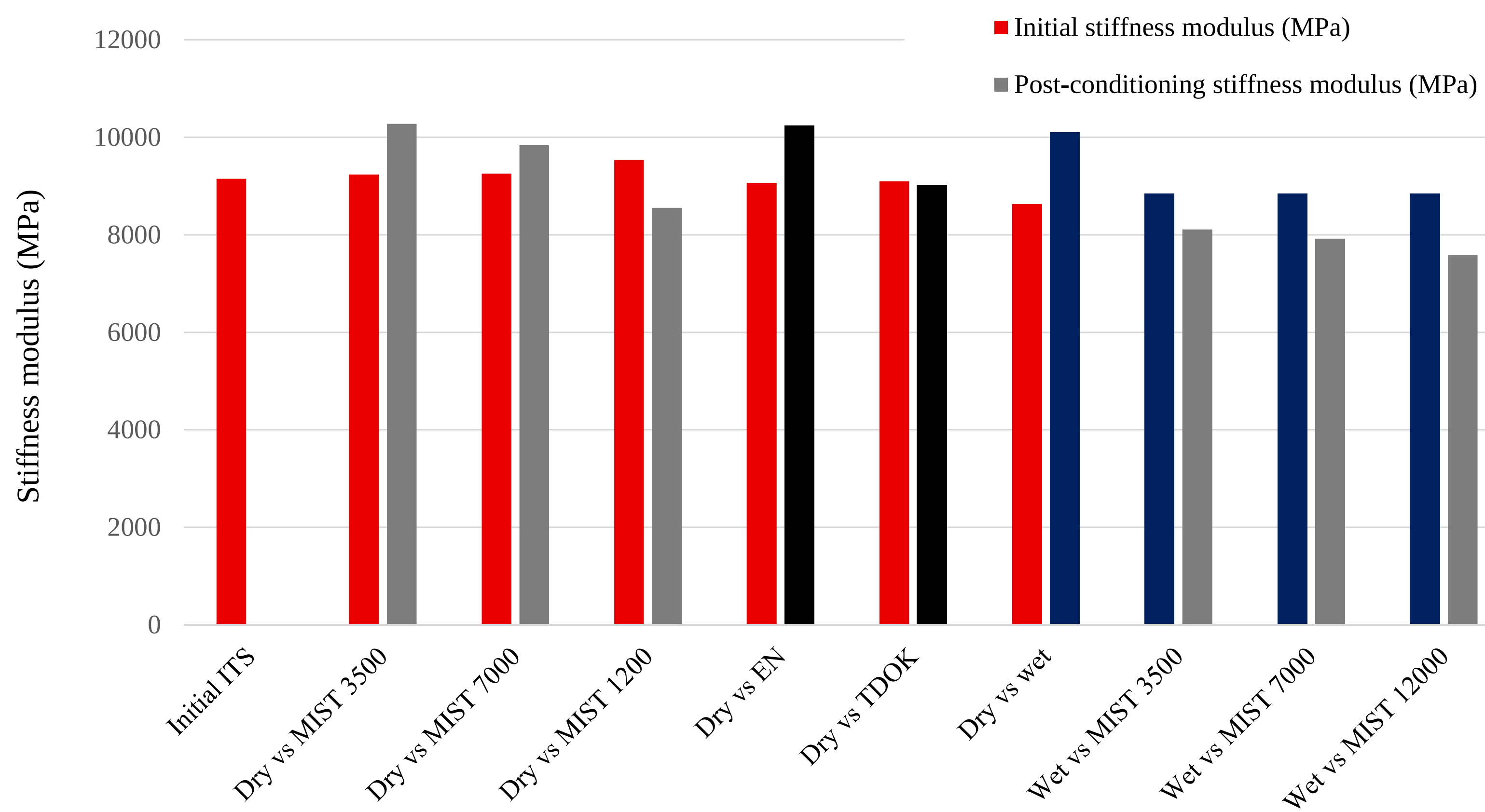
Obtained results (10°C) for Mix 1:

Conditioning method	Initial stiffness modulus (MPa)	Post-conditioning stiffness modulus (MPa)	% Change in stiffness modulus	ITSR (%)
Initial ITS	9149	N/A	N/A	N/A
Dry vs MIST 3500	9236	10275	11.2	78.8
Dry vs MIST 7000	9256	9842	6.3	99.7
Dry vs MIST 1200	9535	8554	-10.3	89.2
Dry vs EN	9069	10240	12.9	71.7
Dry vs TDOK	9098	9018	-0.9	66.0
Dry vs wet	8628	10105	17.1	N/A
Wet vs MIST 3500	8843	8113	-8.2	N/A
Wet vs MIST 7000	8843	7921	-10.4	N/A
Wet vs MIST 12000	8843	7589	-14.2	67.6

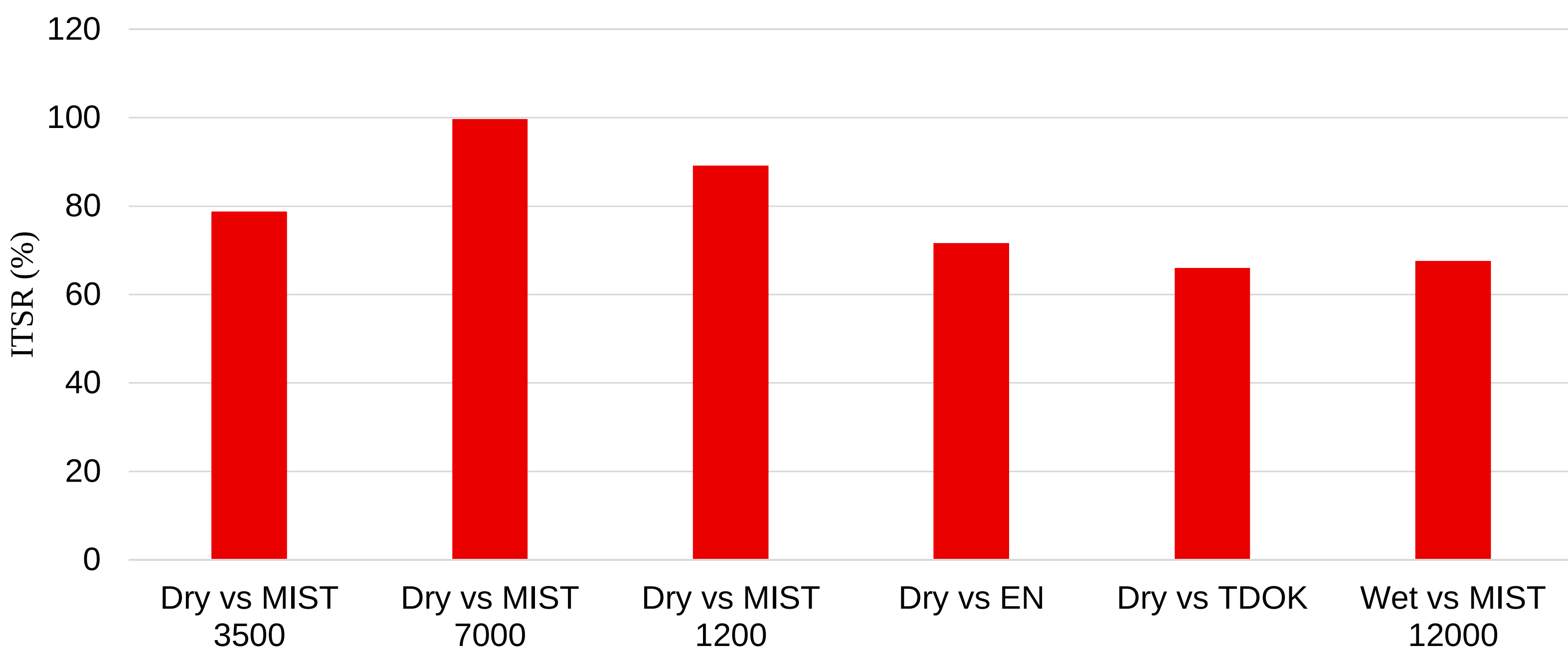
Project 1: Comparing different moisture conditioning methods (on going)

vti

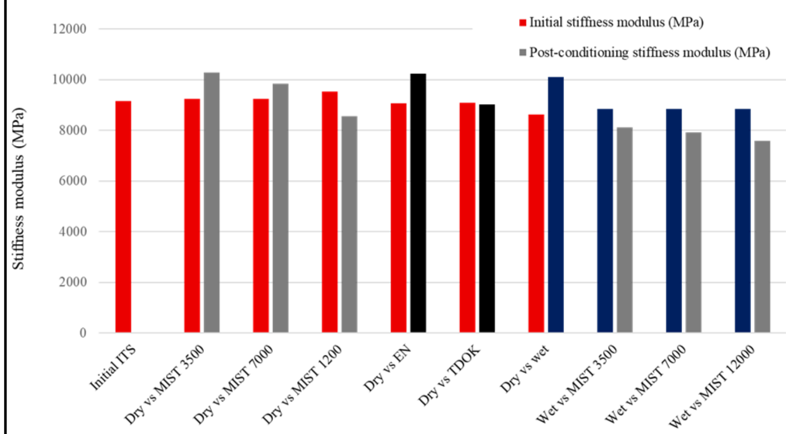
Obtained results for Mix 1:

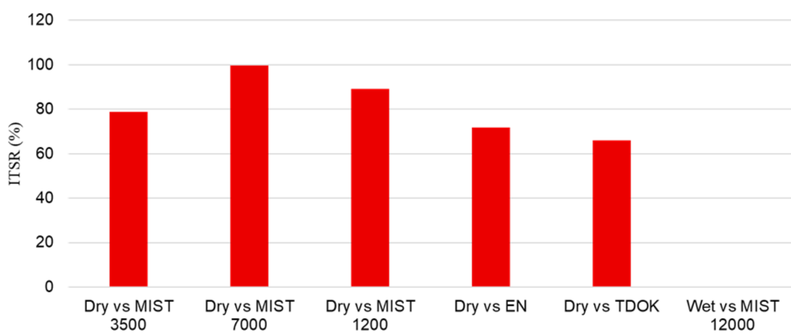


Project 1: Comparing different moisture conditioning methods (on going)



Project 1: Comparing different moisture conditioning methods (on going)



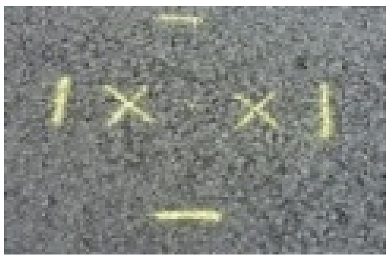


Observations

- Stiffness should be compared in wet conditions
- Temperature was same. Only difference with MIST was the cyclic pressure.
- Different conditioning time
- ITSR for MIST was not consistent
- MIST with 3500 cycles probably enough (temperature may need to be increased)
- TDOK method showed good reduction
- Important is how to correlate with field performance

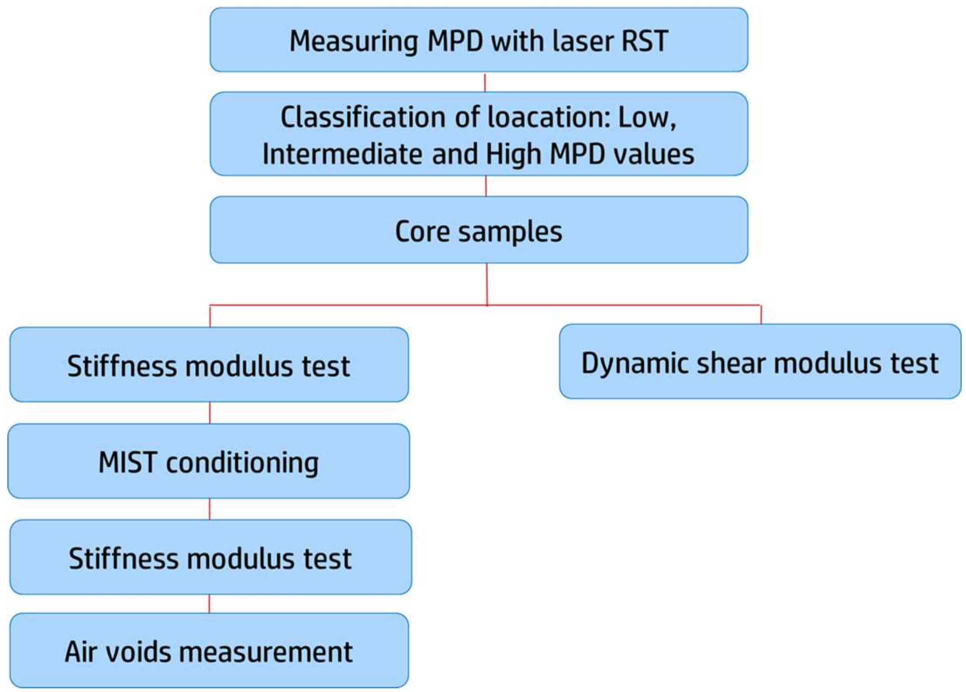
Project 2: High-speed Pavement Macrotexture Measurements for Assessing Homogeneity of Paved Mixes

vti



Objectives and methodology

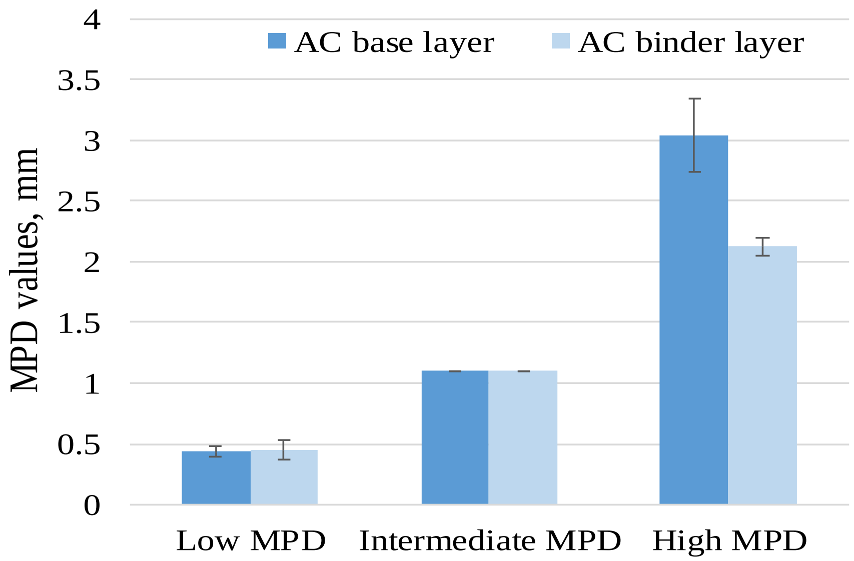
- To assess segregation in pavements using mean profile depth (MPD) values
- To correlate segregation to performance

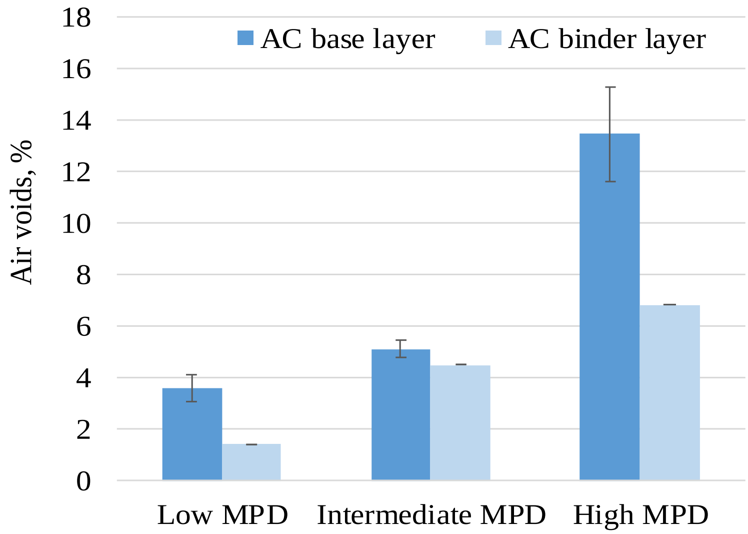


Project 2: High-speed Pavement Macrotexture Measurements for Assessing Homogeneity of Paved Mixes

vti

Results

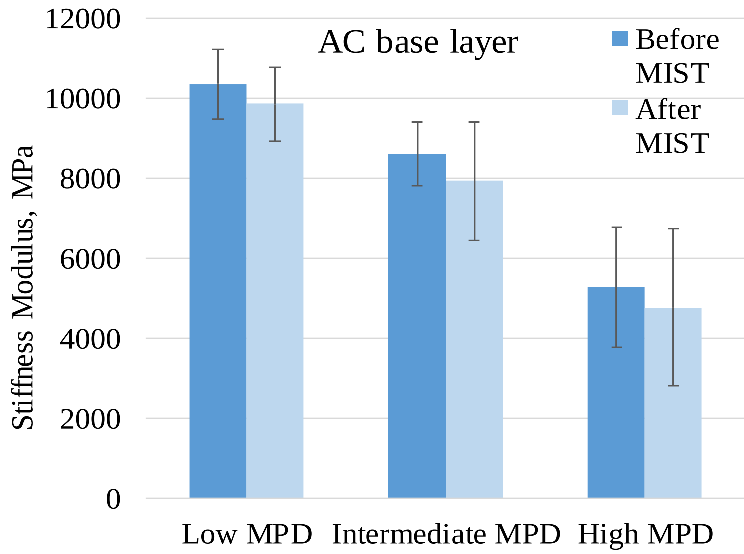


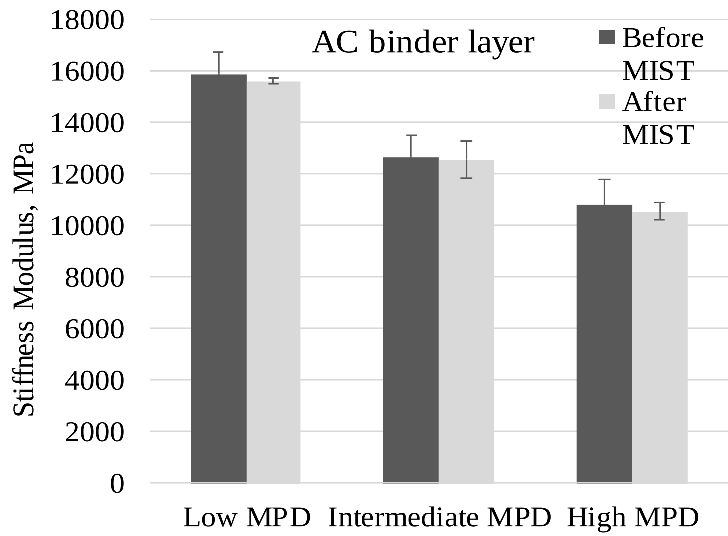


- Air voids correlate well with MPD values

Project 2: High-speed Pavement Macrotexture Measurements for Assessing Homogeneity of Paved Mixes

Results

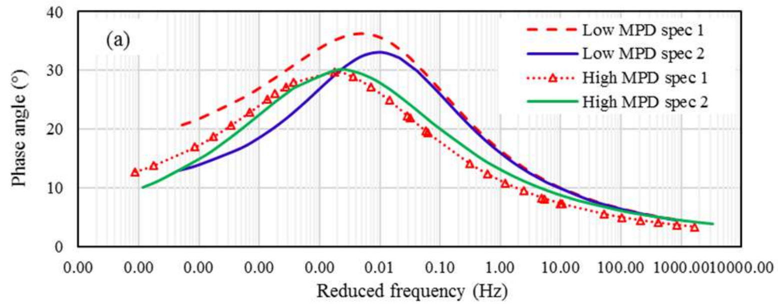


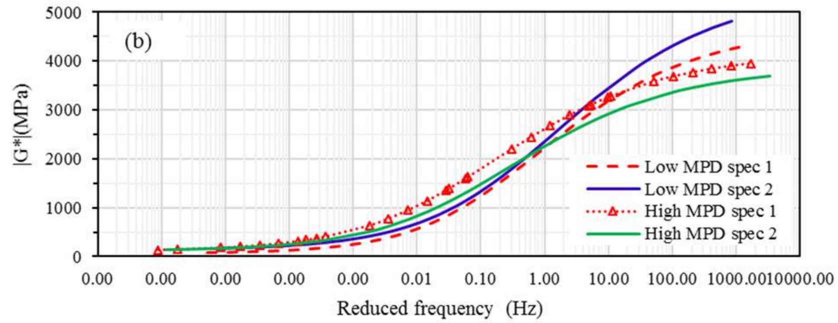


- Segregated part (high MPD) shows inferior stiffness characteristics as well as higher air void
- Segregated portion also showed increased susceptibility to moisture.

Project 2: High-speed Pavement Macrotexture Measurements for Assessing Homogeneity of Paved Mixes

Results





- A higher phase angle for specimens from low MPD areas indicate a more viscous behavior of the mix that is the result of a higher binder content.
- Dynamic modulus was higher at low temperature and high frequency regions for specimens from low MPD areas.
- At high temperature and low frequency regions, no significant differences in dynamic shear modulus between low and high MPD areas were observed.


Thank You !