New HMA Products and Trends for NJDOT

Bridge Deck Water-Proof Wearing Course (BDWC)

Water Proof Wearing Course Mix

- Mix designed to provide a thin, rut and fatigue resistance mixture for bridge deck overlays
- Can be placed on bridge deck without vibratory rollers
- Asphalt mixture must also be “water proof” or low permeability
- “Sealing older bridge structures”

Some of Our Problems: I-80 Bridge Deck

“ When we paved over the deck with a membrane the contractor did not expose the open joint for a few weeks. During that time it rained extensively. The 12.5H76 material is very porous. When the contractor exposed the open joint a river of water lay on the membrane and ran down the sloped deck along the open joint. Since the joint area was always wet the asphaltic joint was not able to be constructed with optimum results. They are now popping out. When we placed the asphaltic joint immediately after paving completed this condition was minimal.”

I-80 Bridge Deck

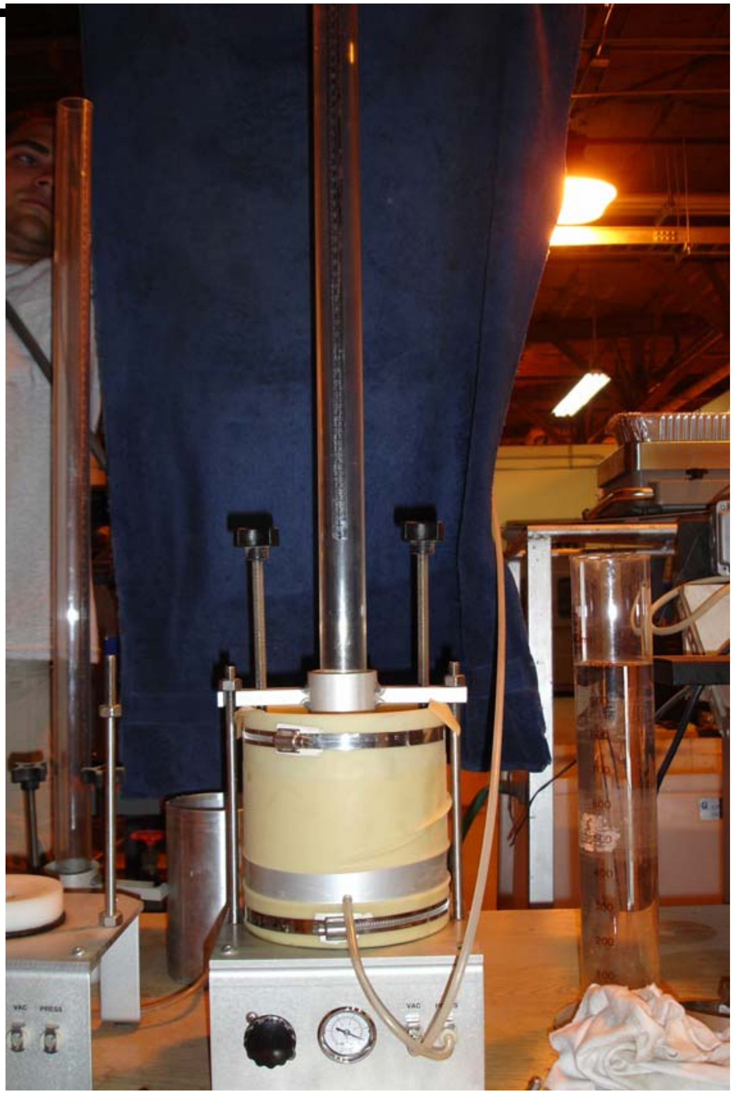
- Problems attributed to:
  - Potentially high air voids in 12H76 mix placed on bridge deck
    - No vibration on during rolling
    - Coarse, stiff mix with most likely low asphalt

I-80 Lab Testing

- Cores taken from Bridge Deck and brought to Rutgers for forensics and permeability testing
- Air Voids:
  - Core #2 = 10.4%
  - Core #4 = 13.7%
  - Core #5 = 13.7%
  - Core #6 = 14.2%
- Only 2 cores in good enough shape for permeability testing (#2 and #5)

Falling Head Permeability Test

- Most commonly used for asphalt
- Can test 4 or 6” diameter cores
- Rubber membrane forced on side of samples (15 psi) to prevent side leakage



Permeability Results of Bridge Deck Cores

- Core #2 = 0.477 ft/day
  - Tested with Membrane still attached!
- Core #5 = 3.539 ft/day

Membrane

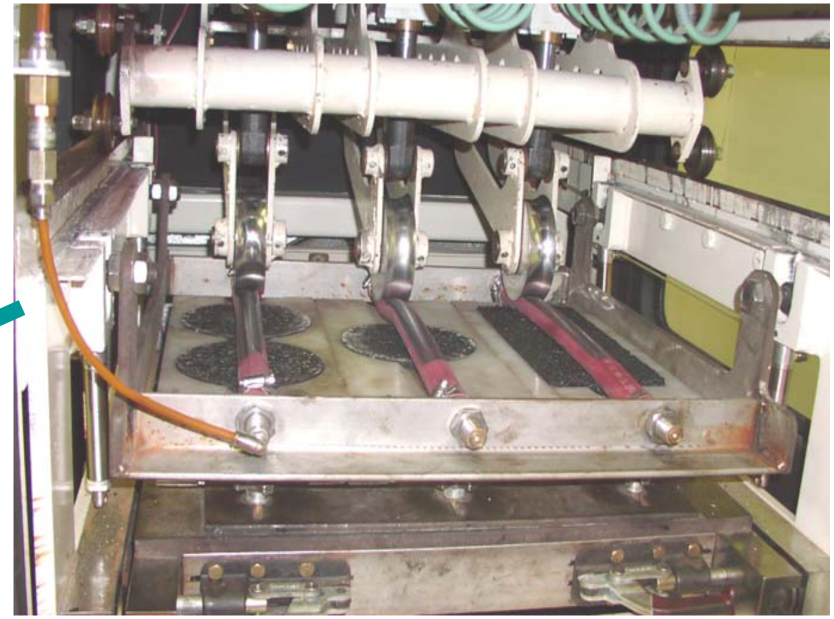
What to Do?

- Need an HMA mix that:
  - Can be placed thin at low air voids without vibration on bridge decks
  - Be rut resistant while being crack resistant
  - Produced and placed using typical construction practices
  - Should be able to be “fixed” or “corrected” when aging occurs under normal maintenance procedures
  - This problem not unique to NJDOT Bridge Decks!

GWB Mixture Evaluation

- PANYNJ looking to improve performance of GWB bridge deck overlays
  - Rutting not an issue (new material should not be worse though!)
  - Longitudinal cracking in truck lane
    - Flexing in steel orthotropic decks under loading causing high tensile straining in HMA
    - High tensile stresses immediately outside truck tires
  - Ease of construction – always must keep in mind!

Asphalt Pavement Analyzer

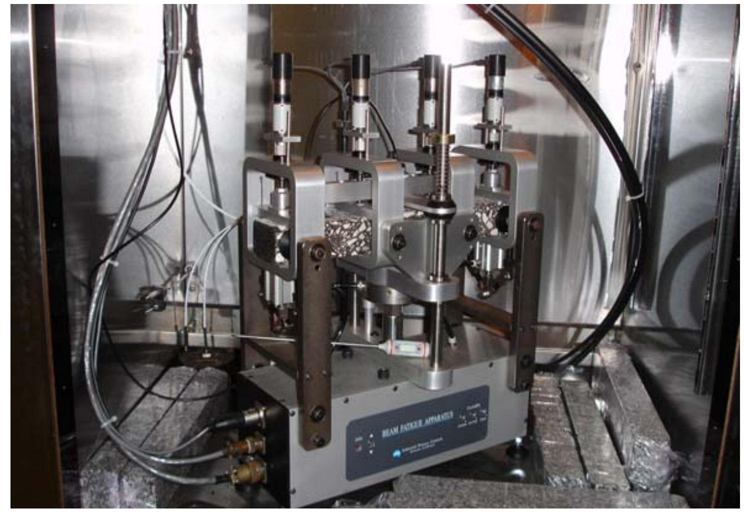


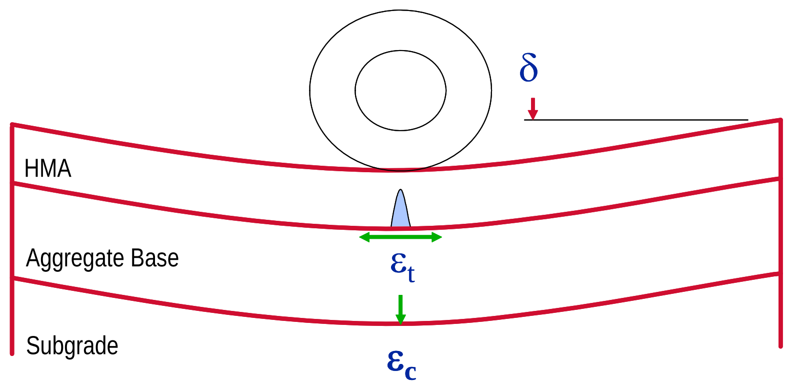
AASHTO TP 63

- 100 lb wheel load; 100 psi hose pressure
- Tested at 64ºC for 8,000 loading cycles

Fatigue Evaluation (Vertical)

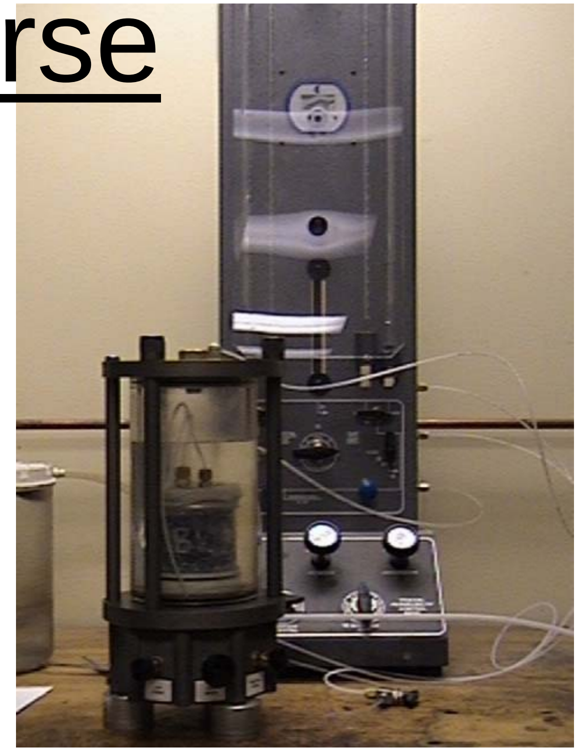
- Flexural Beam Fatigue Device, AASHTO T-321
- Tests mix's ability to withstand repeated bending which causes fatigue failure
- Data = number of loading cycles to failure (loss of stiffness)
- Run at 2000 μ-strain and 10 Hz (high deflection, fast moving vehicle)





Permeability Testing of Water-Proof Wearing Course

- Water-proof wearing course mixture was found to be “impermeable” – could not get water to flow through sample



Samples cored from 6-inch diameter gyratory sample →

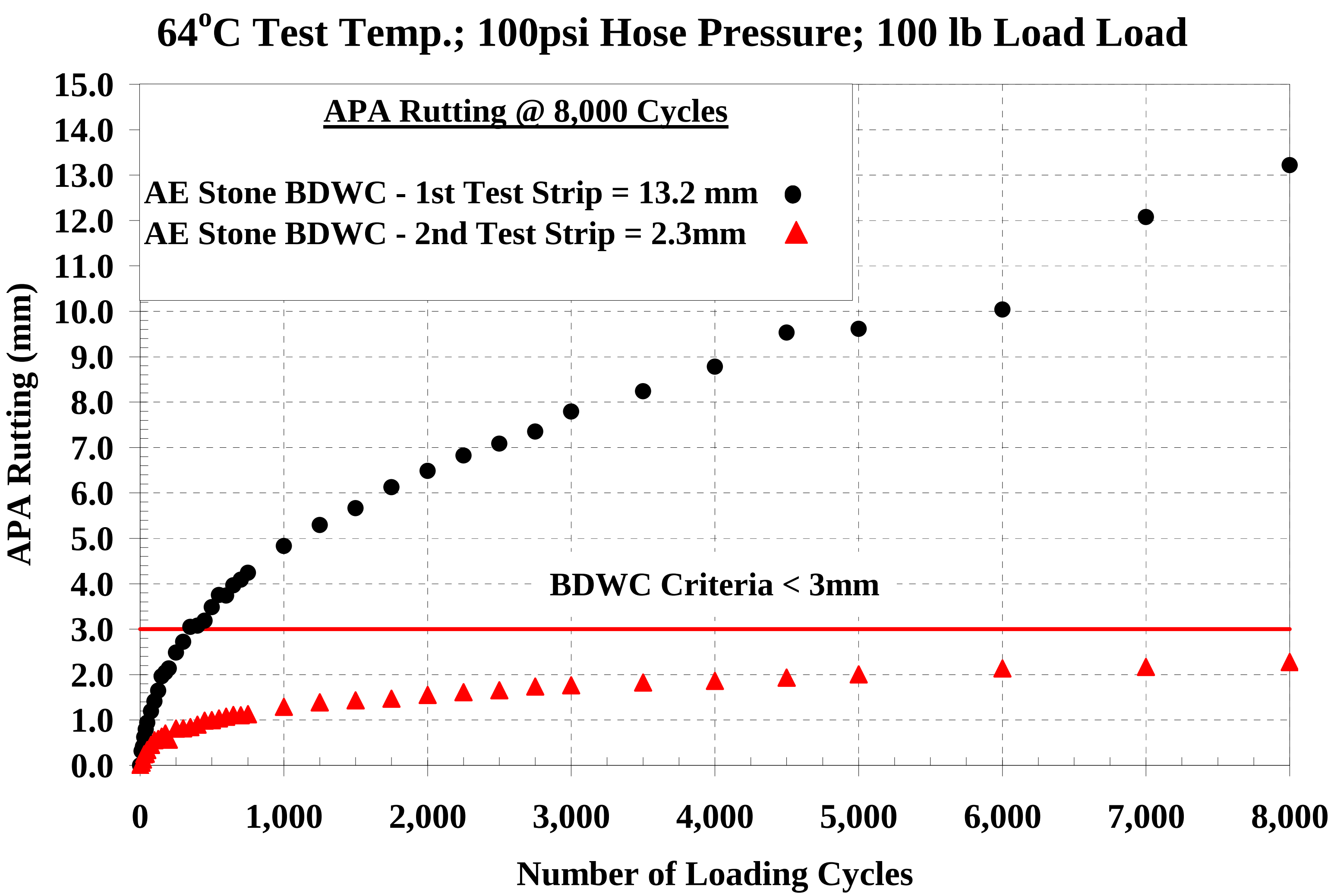
Water Proof Wearing Course – Design Acceptance

1. Perform volumetric design and NJDOT verification
2. Supply Rutgers University loose mix for performance testing
3. Produce mix through plant and pave test strip off site
4. Sample during production and supply Rutgers University loose mix for performance testing

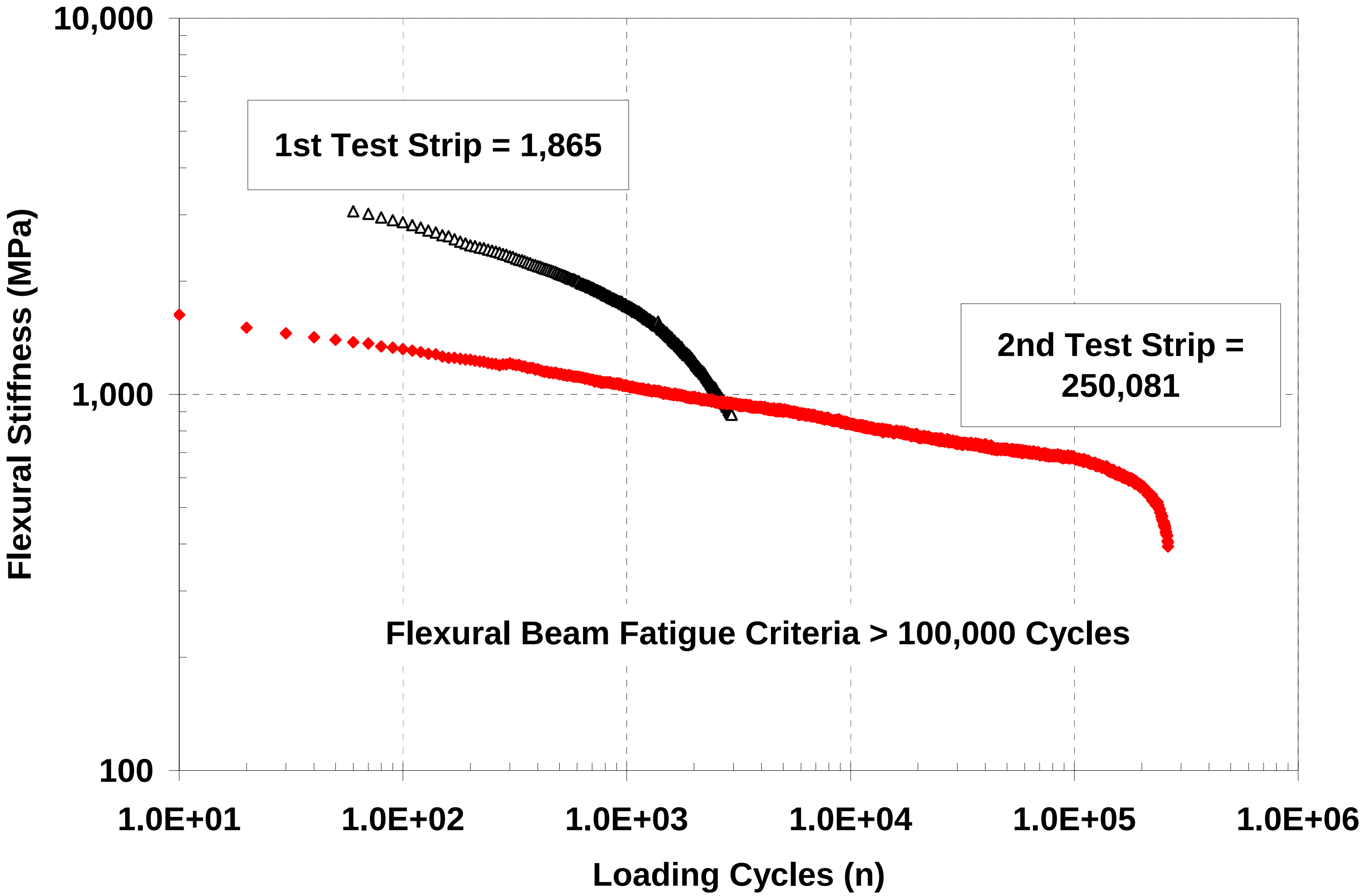
Why Do Performance Testing?

- AE Stone's 1st (Right) and 2nd (Left) test strip
- Right lane flushed and did not set like as anticipated
- Performance testing showed poor results
- Why? Eventually found out AE Stone did not switch over proper value on tank – used wrong asphalt binder!

1^{st} vs 2^{nd} Test Strip Material



1st vs 2nd Test Strip Material



1^{st} Project – Rt 87 Absecon Inlet Bridge

- A.E. Stone produced first BDWC mix
- 1900 tons placed and compacted to a 2-inch thickness in 2 days
- Core densities all between 2 to 4% air voids

Rt 87 Absecon Inlet Bridge – 2008 NAPA Quality in Construction Award Winner!

for Non-Typical Asphalt Project

Warm Mix Asphalt

What is Warm Mix Asphalt

Hot-Mix Asphalt 275-325°F

Warm-Mix Asphalt 220-275°F

Half-Warm Mix Asphalt 180-220°F

Cold Mix Asphalt 60°F

Different WMA Types

- Viscosity Reducers – These additives significantly reduce the viscosity of the binder at mixing and compaction temperatures.
  - Sasobit and Asphaltan B
- Foamed Asphalt – Produced by introducing moisture into the asphalt binder in the mix plant.
  - Zeolite, Low Energy Asphalt (LEA), ASTEC Double Barrel Green
- Emulsions - Use of an emulsion as the asphalt binder.
  - Evotherm
- Surfactants – Chemical product that increases the lubrication between aggregate particles during movement
  - Evotherm 3G, Rediset

Features & Benefits of WMA

- Better Workability of the Asphalt Mix Allows
  - Longer Haul Times
  - Extension of the Paving Season
  - Easier Handling of Stiff Mixes such as Polymer Modified, Rubber Asphalt Binder and high RAP Content.

Features & Benefits of WMA

- Reduction in Production Temperatures Reduces Emissions
  - Reduce Blue Smoke complaints
  - Reduce Recordable Emissions
- Reduction in Production Temperatures Reduces Energy Consumption
  - Depending on mix it may be possible to save 10 to 20% on energy costs.
    - Lower fuel consumption; lower electricity at pumps and conveyors due to reduce viscosity

Evotherm Test Section on I78 in NJ

Control Mix: 12M76 with 25% RAP

I-78 Warm Mix


SAFETY FIRST
REPORT
AGGRESSIVE
DRIVING
CELL # 77
222
EXTECH
°F
°C
LASER
BACKLIGHT

Recorded Emissions – Ohio Test Trials

Stack Emissions Tests

Mix Type	SO_2 lb/hr	NO_x lb/hr	CO lb/hr	VOC lb/hr
Conventional HMA	0.24	5.2	63.1	7.8
Evotherm WMA	0.37 (+54.2%)	5.1 (-1.9%)	50.3 (-20.2%)	20.2 (+159%)
Aspha-Min WMA	0.04 (-83.1%)	3.6 (-29.7%)	24.0 (-61.9%)	2.9 (-63.2%)
Sasobit WMA	0.04 (-83.1%)	4.1 (-21.3%)	23.2 (-63.2%)	3.8 (-50.9%)

SO_2 Sulfur Dioxide
NO_x Nitric Oxide
CO Carbon Monoxide
VOC Volatile Organic Compound

Recorded Emissions – Ohio Test Trials

Paver Emissions – NIOSH Method 5024 for Total Particulates (TP)

Evotherm WMA: 77% of Conventional HMA
Aspha-Min WMA: 67% of Conventional HMA
Sasobit WMA: 74% of Conventional HMA

NJDOT Warm Mix Asphalt

- Being used under “Pilot Project” conditions – still experimental
- Three field projects conducted to date
- Looking at 2 to 3 more this season (asphalt rubber applications)

High Performance Thin Overlay

HPTO

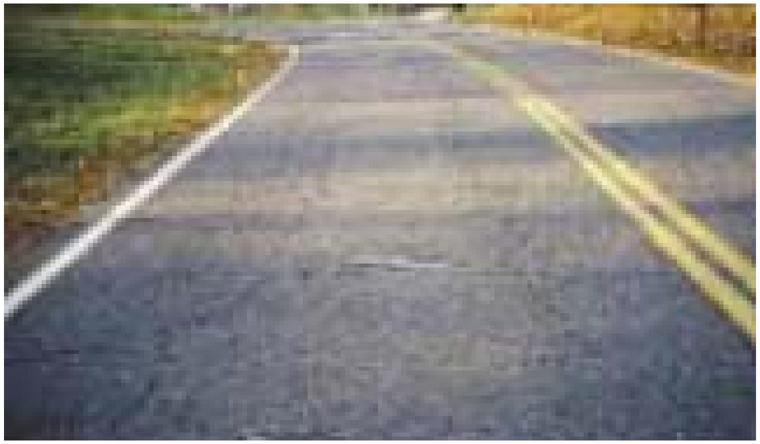
High Performance Thin-Overlay (HPTO)

- Focused Applications
  - Preventative Maintenance – NJDOT
    - Placed after signs of initial surface distress
    - Also potential use of “Shim” course on PCC prior to Wearing Course
  - Pavement Overlay – Locals/Municipalities
    - Place immediately on surface of pavements showing signs of surface distress with or without milling
      - **Low severity wheelpath alligator cracking (base issues)**
      - **Surface cracking with minimal rutting**

Potential Areas of Application

Minimal Rutting – low to moderate
surface cracking
No Full Depth Cracking!

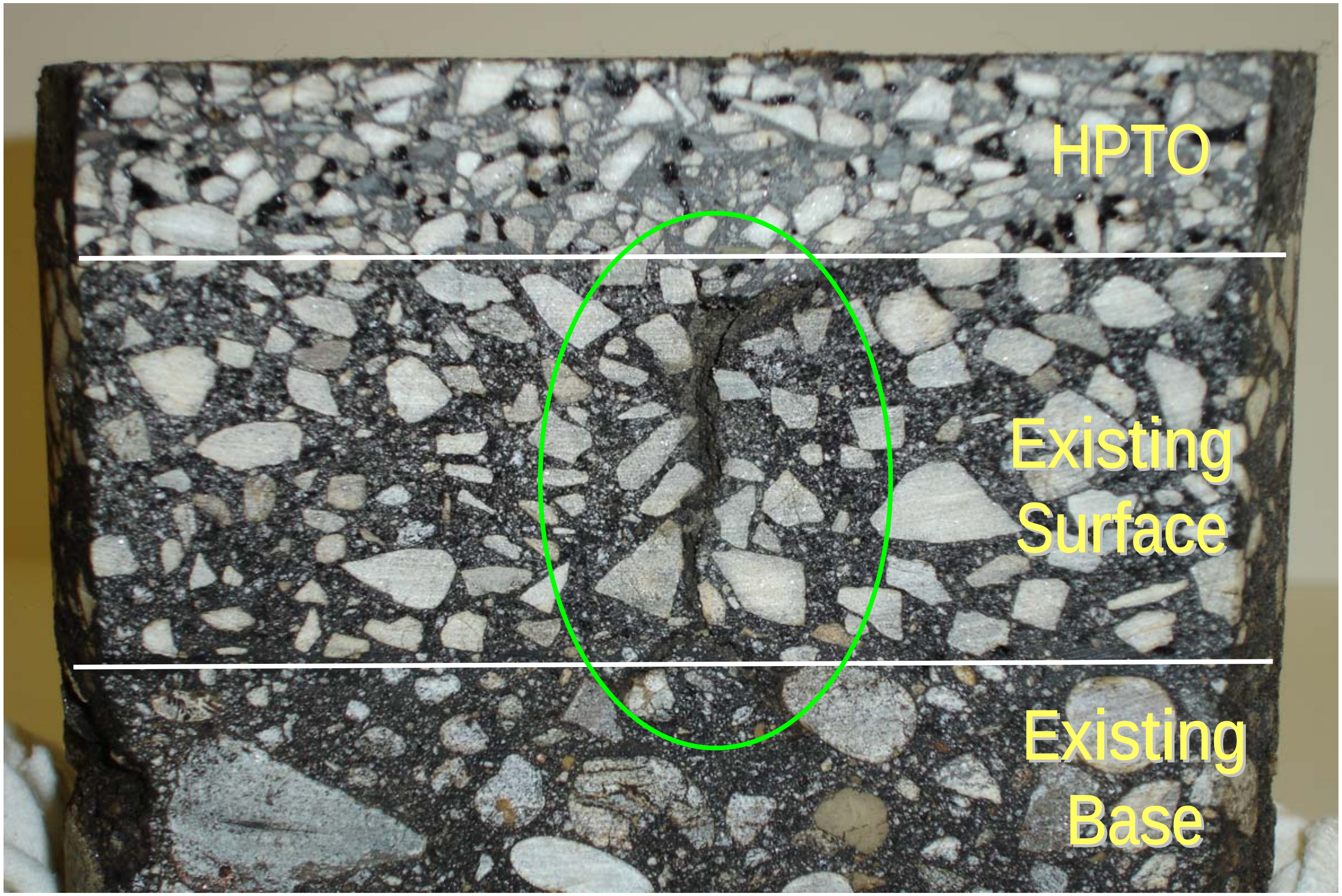
Low Severity Wheelpath



Low to Mod. Longitudinal
Cracking

Low to Mod. Transverse
Cracking

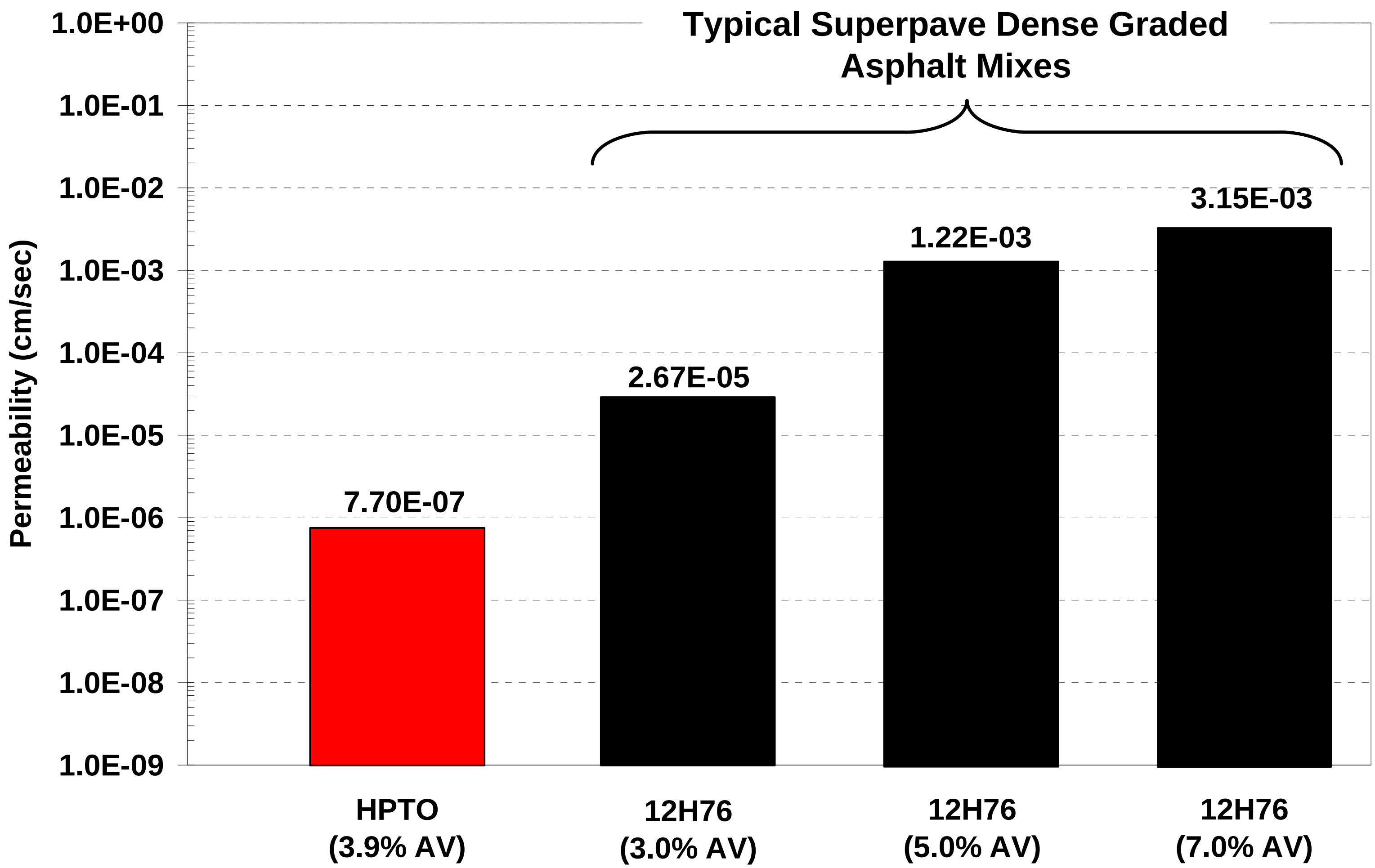
Direct Overlay – No Milling



High Performance Thin-Overlay

- Binder
  - Polymer-modified binder
    - PG76-22 (NJDOT Spec)
  - Minimum Asphalt Content = 6%
- Performance Specification
  - Utilize the Asphalt Pavement Analyzer (AASHTO TP 63) for stability (rutting) check
    - No check for fatigue – low air voids and higher asphalt content will control
    - Must supply for mix design verification and control (1st Lot and every other Lot after)

Typical Permeability Values



Surface (Skid) Friction, SN_{40}

Material Type	Skid Number
HPTO (New)	53
12.5mm SP (New)	51.6
12.5mm (4 Yrs)	54.3
19mm SP (4 Yrs)	55.7
19mm SP (5 Yrs)	47.7

HPTO Test Section – Paulsboro, NJ

NJDOT HPTO

- Still in experimental stage
- 2 projects using it as surface course
  - Evaluating general performance over next year or two
- Currently being used as better performing Leveling course

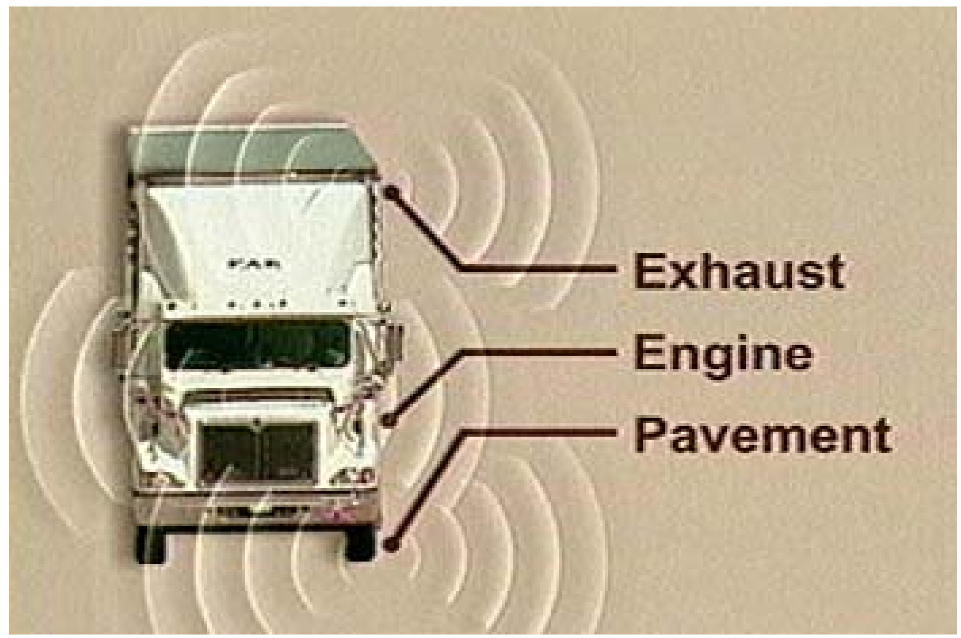
Quiet Pavements

Roadway Noise Generators

- Major noise generators:
  - engine,
  - exhaust system,
  - aerodynamic noise, and
  - tire/pavement interface noise.

- For $\geq$ 20 to 30 mph, pavement/tire noise dominates.

(Billera, et al., TRR 1601)



Approximate "Cross-over Speeds"

Vehicle Type	Cruising Speed	Accelerating Speed
Cars (< 1995)	18 to 25 mph	25 to 31 mph
Cars (> 1995)	10 to 15 mph	18 to 28 mph
Trucks (< 1995)	25 to 31 mph	31 to 35 mph
Trucks (> 1995)	18 to 25 mph	28 to 31 mph

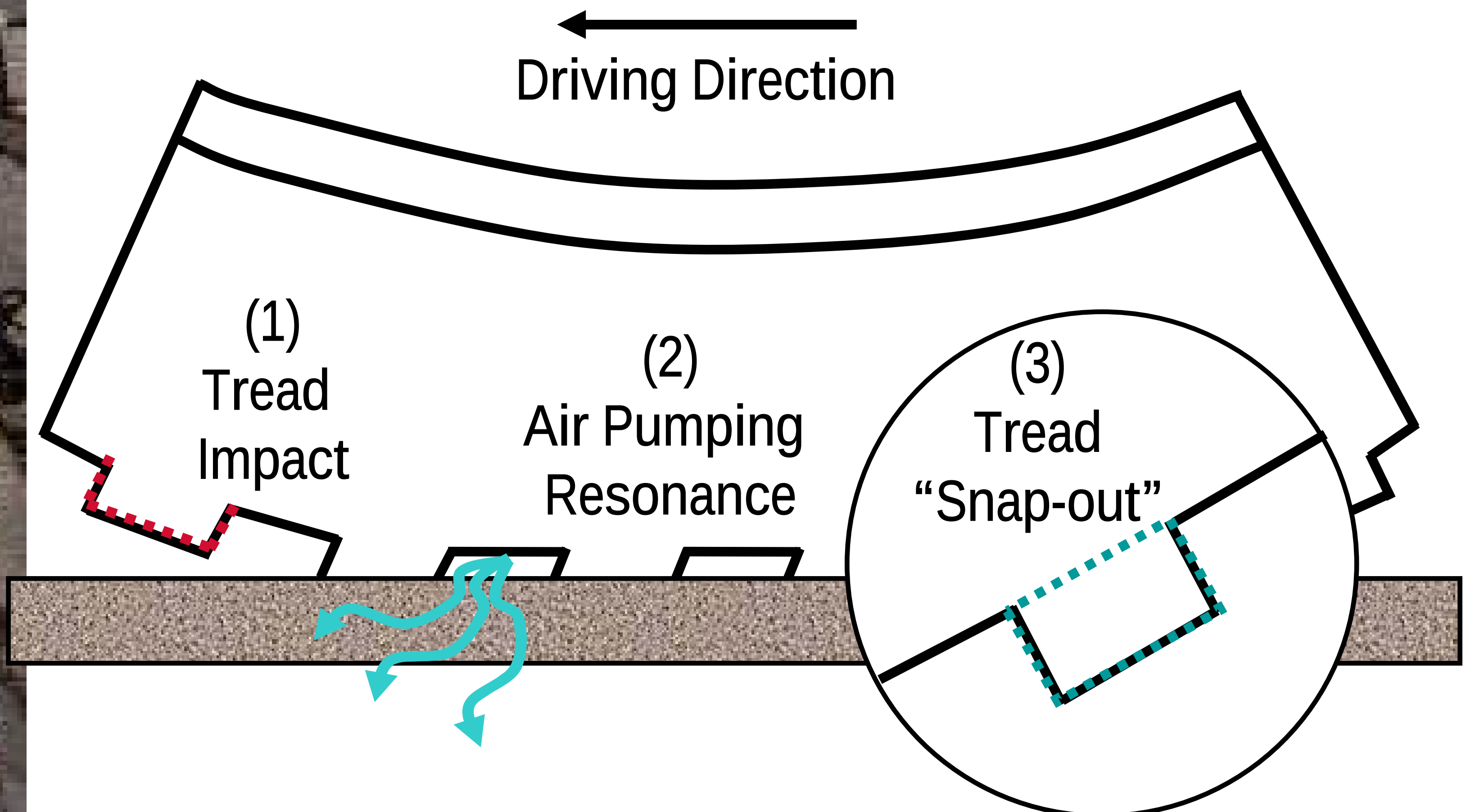
Pavement surface only effective when vehicle speeds are greater than "Cross-over Speeds"

To Put Noise in Perspective

- 1 dB(A) means a 12% decrease in noise
- 3 dB(A) means a 40% decrease in noise
- 6 dB(A) means a 200% decrease in noise

As a rule of thumb, the human hear can start to differentiate between two sound levels when they are different by more than 2 to 3 dB(A).

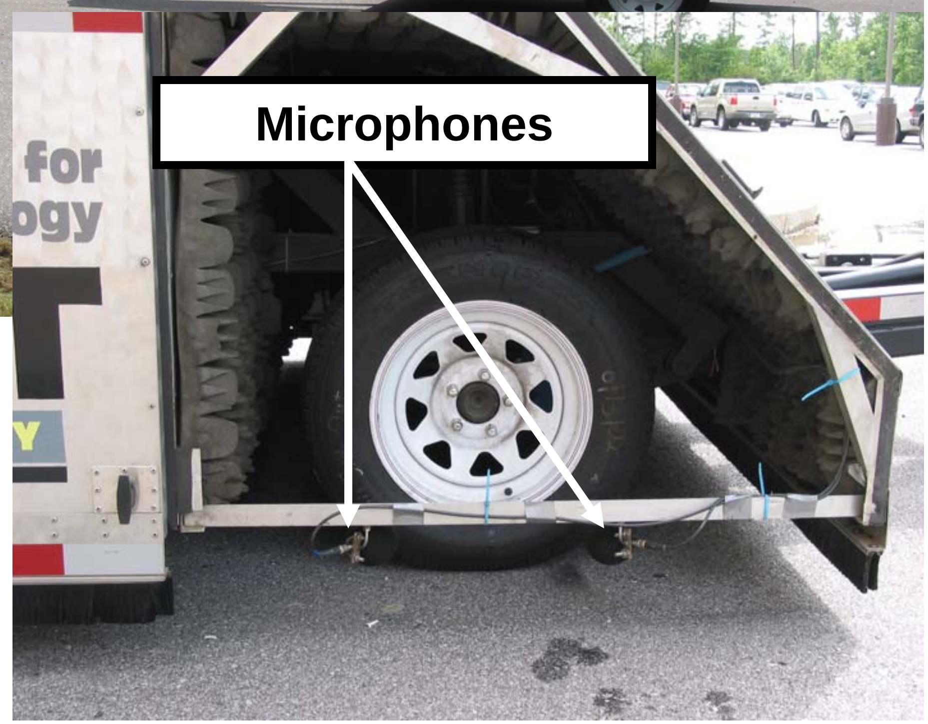
Three Main Mechanisms of Tire-Related Noise Generation



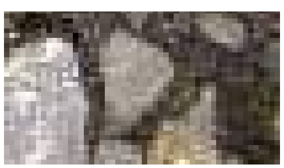
Different tire tread patterns will develop different noise levels

- Typically, the more aggressive, the more tire/pavement noise -

Meets ISO 11819-2



Close Proximity (CPX)

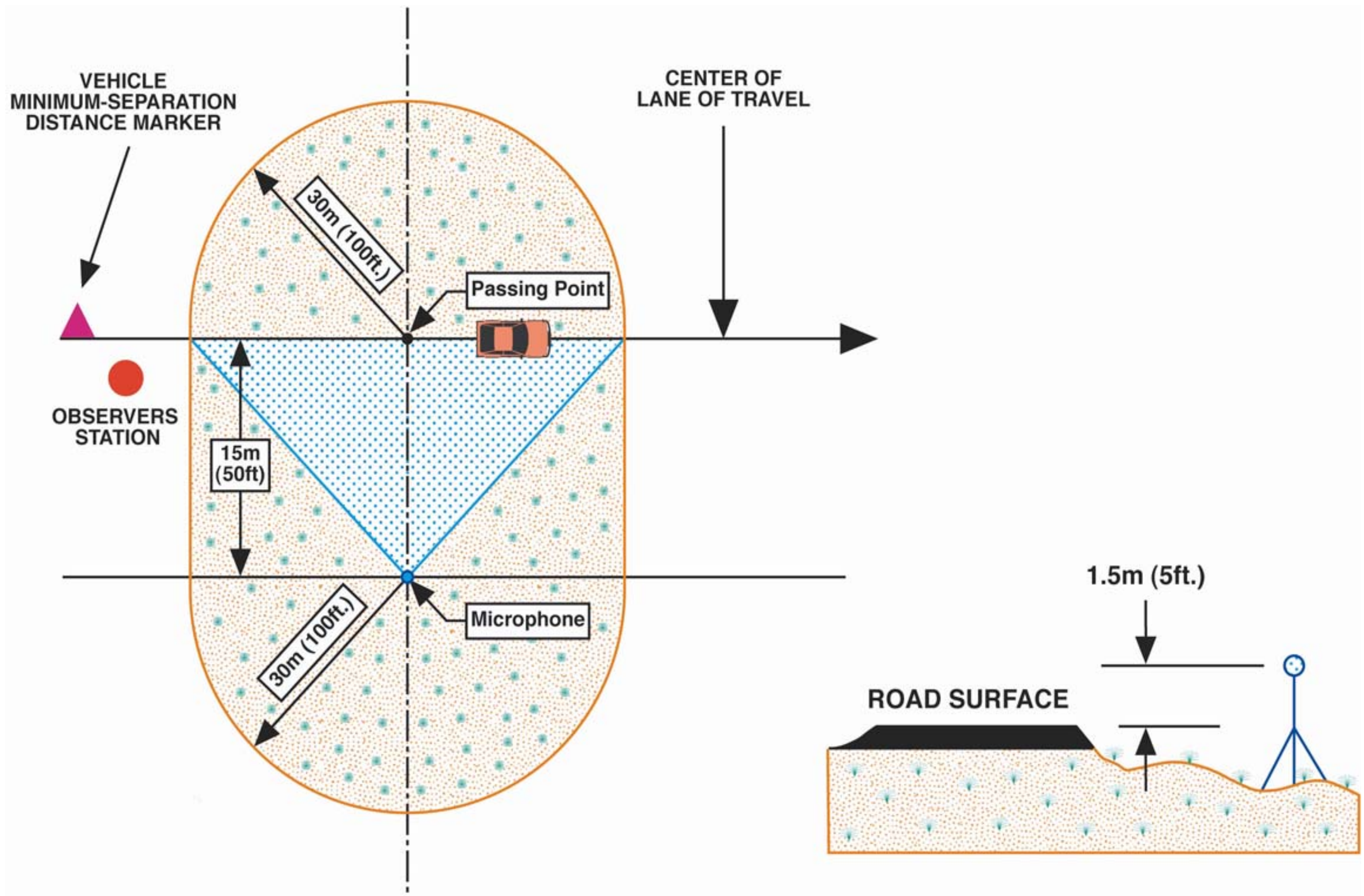


Sound-Intensity

Traditional Test Measurements - Wayside

- Statistical pass-by method
  - Based on measuring the noise level from a minimum of 180 single-vehicle passbys
  - Can compare pavements at different locations
  - Microphones generally set at 50 ft from roadway
- Controlled pass-by
  - Same as statistical pass-by but with limited number of vehicles
- Time-averaged method
  - Noise-level is measured continuously over a time period
  - Traffic counts & metrological data is needed

Wayside Measurements – Site Layout



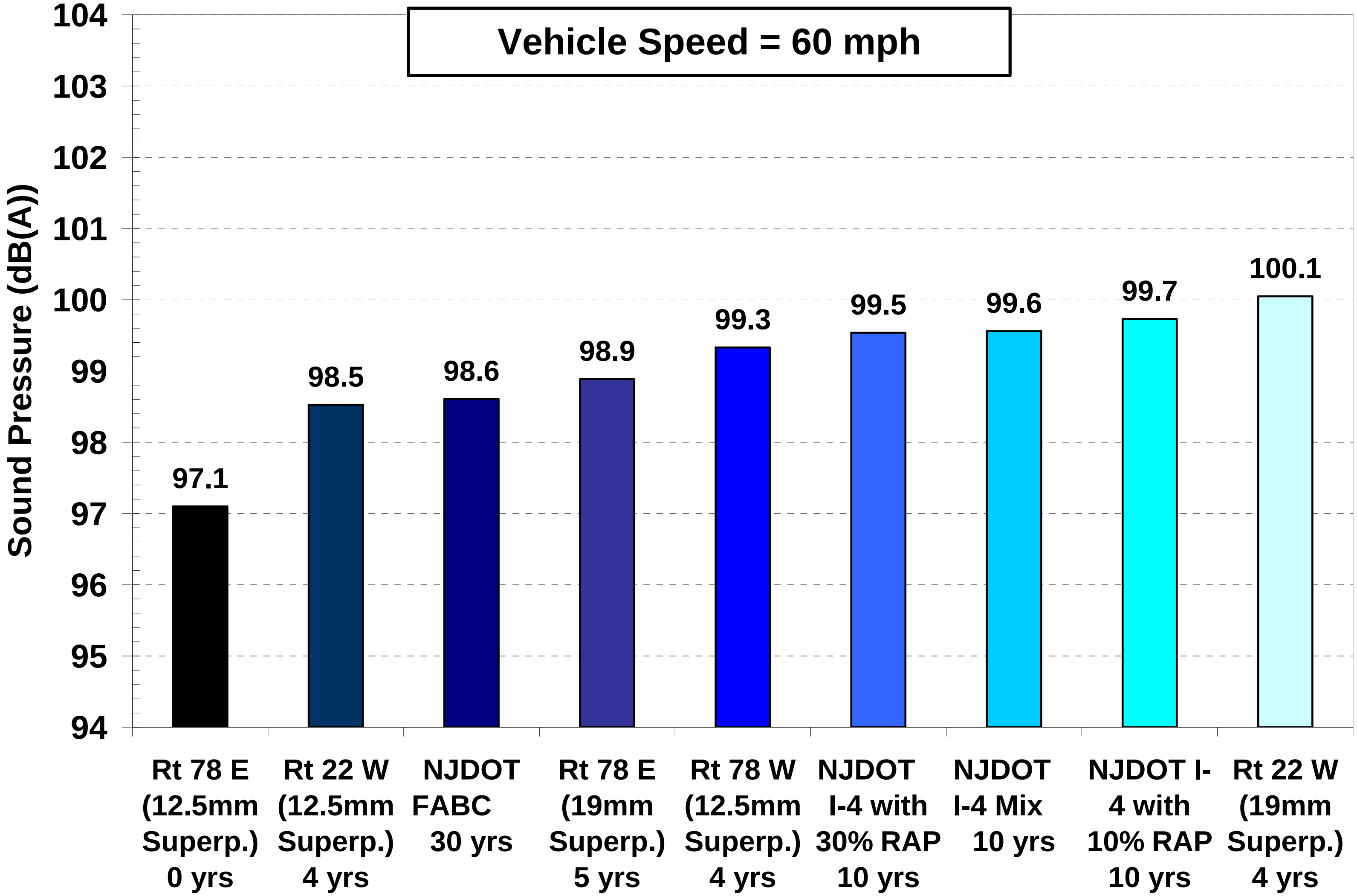
Difficult and Time Consuming to Achieve Proper Conditions

Pavement Noise Study (FHWA-NJDOT-2003-021)

- Measure Pavement/Tire Related Sound
  - Used Close Proximity Method
- Evaluate the effect of traffic speed
- Total of 42 pavement surfaces tested
  - HMA – OGFC, SMA, Novachip, Micro-surfacing Superpave (12.5 & 19mm), SHRP Sections
  - PCC – transverse tining, diamond grinding, no finish

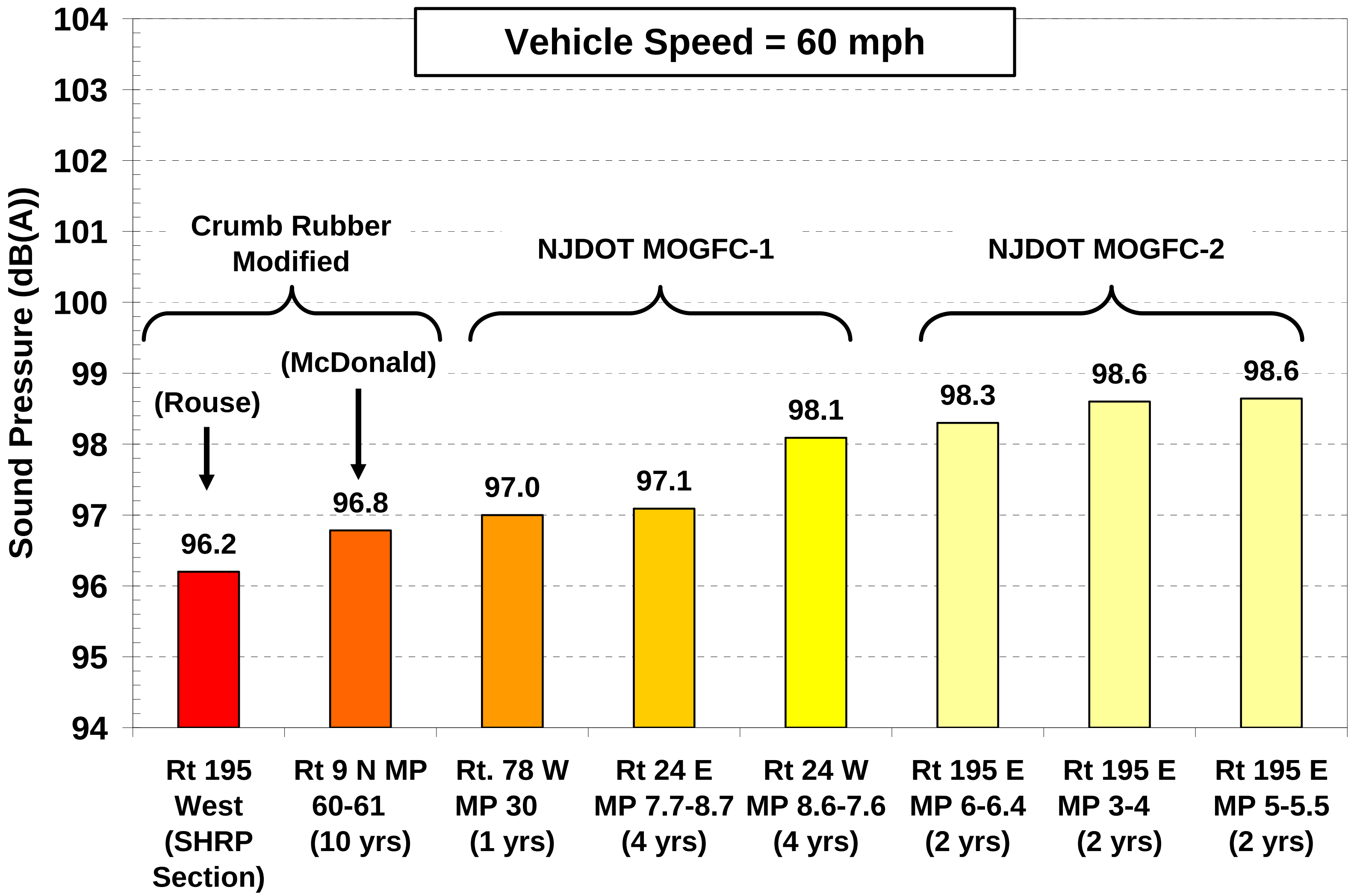
NEW JERSEY TEST SITES

DGA Pavement Surfaces



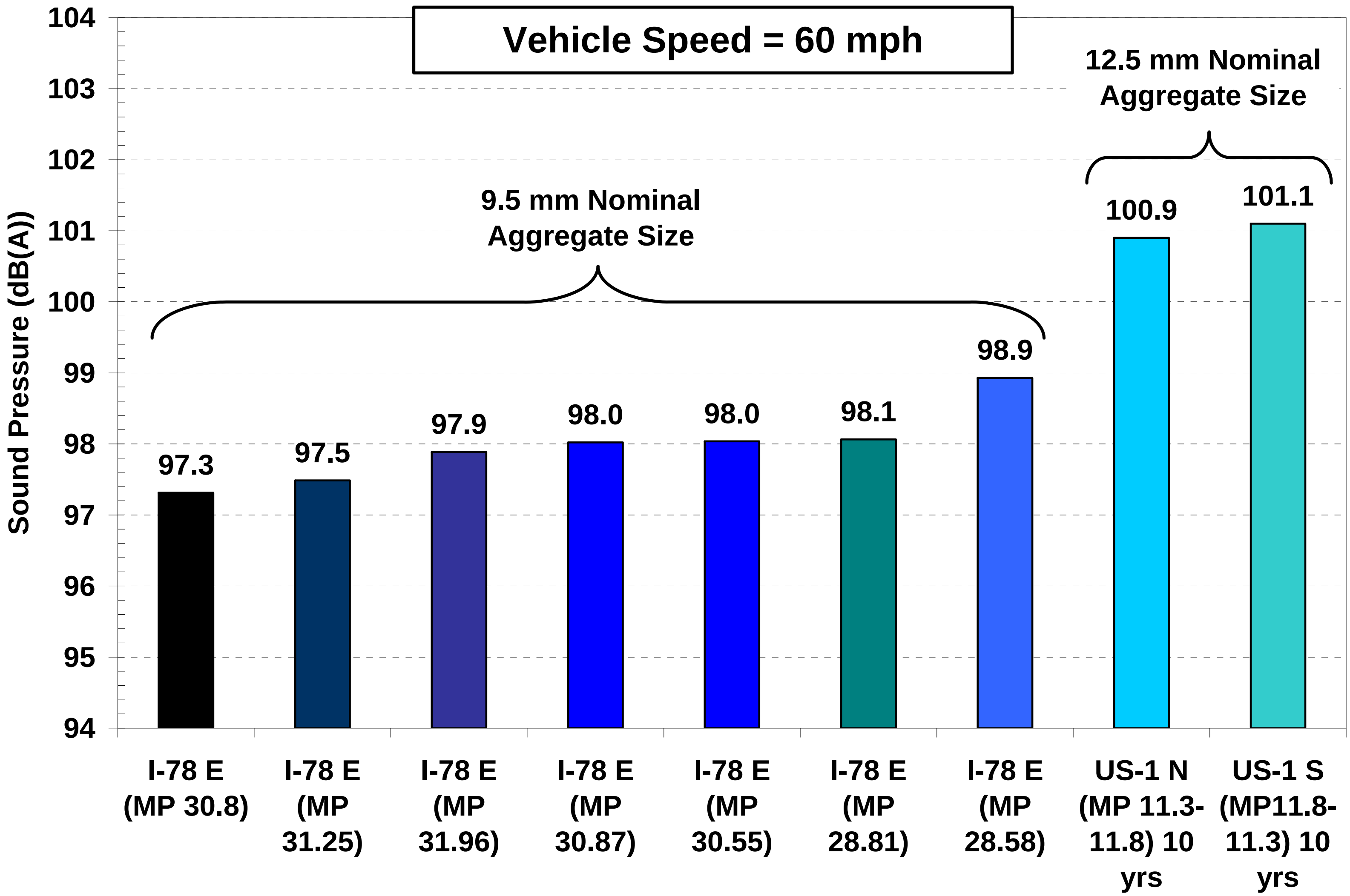
Noise increases with size and HMA aggregate

OGFC Surfaces



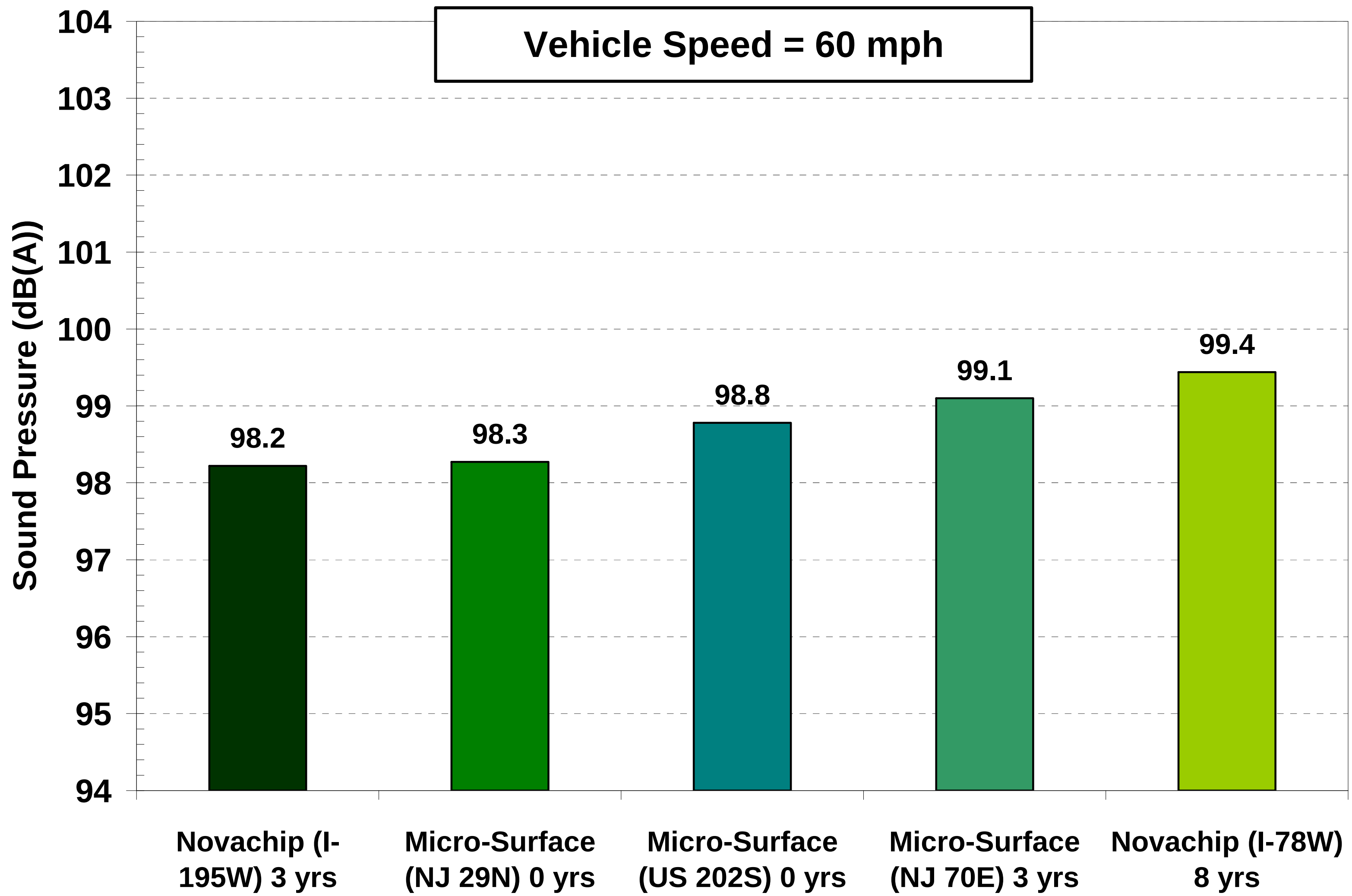
Finer OGFC with asphalt rubber quieter

SMA (Stone Mastic Asphalt) Surfaces



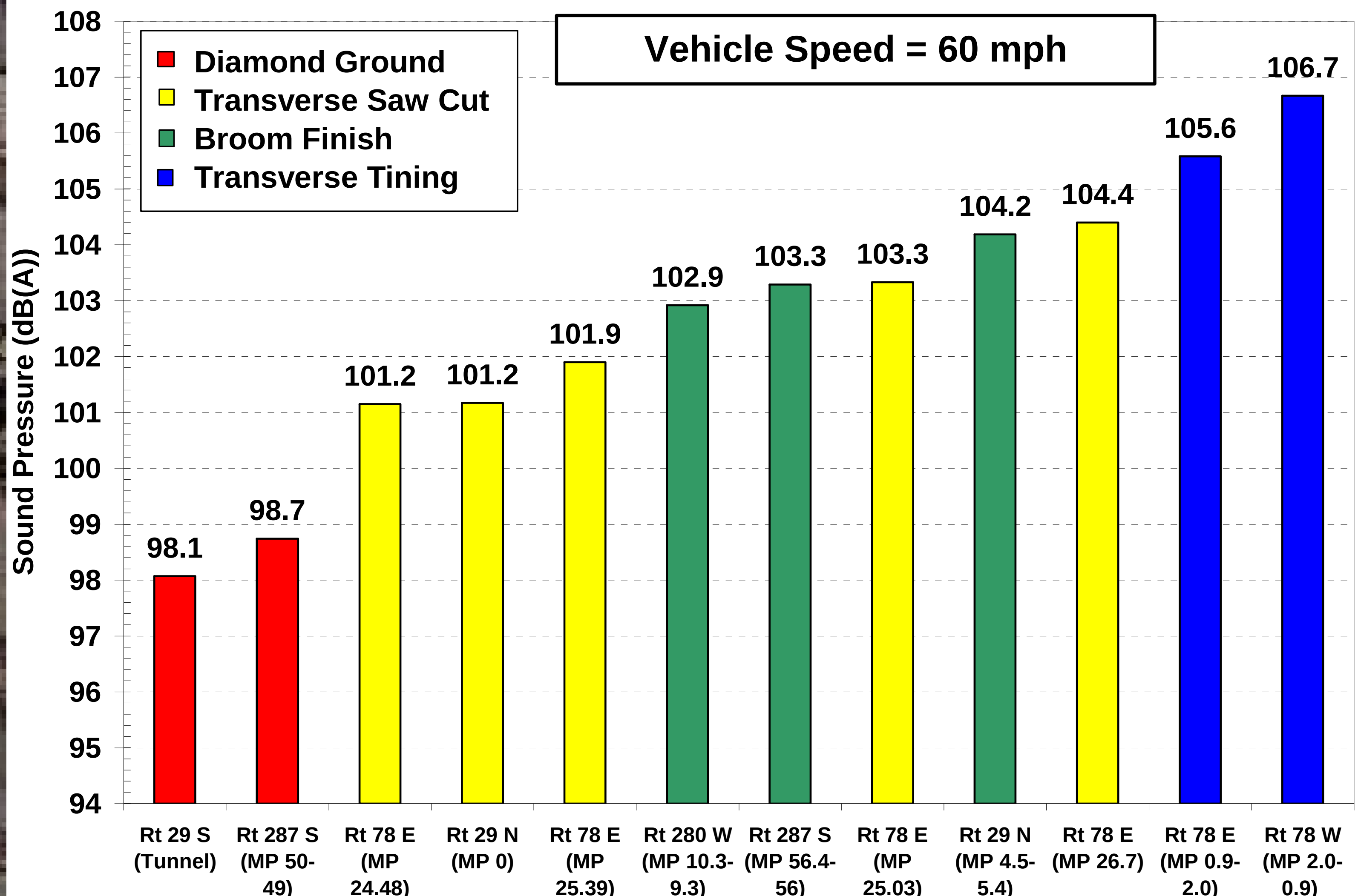
Noise increases with size and HMA aggregate

“Thin-Lift” Surface Treatments

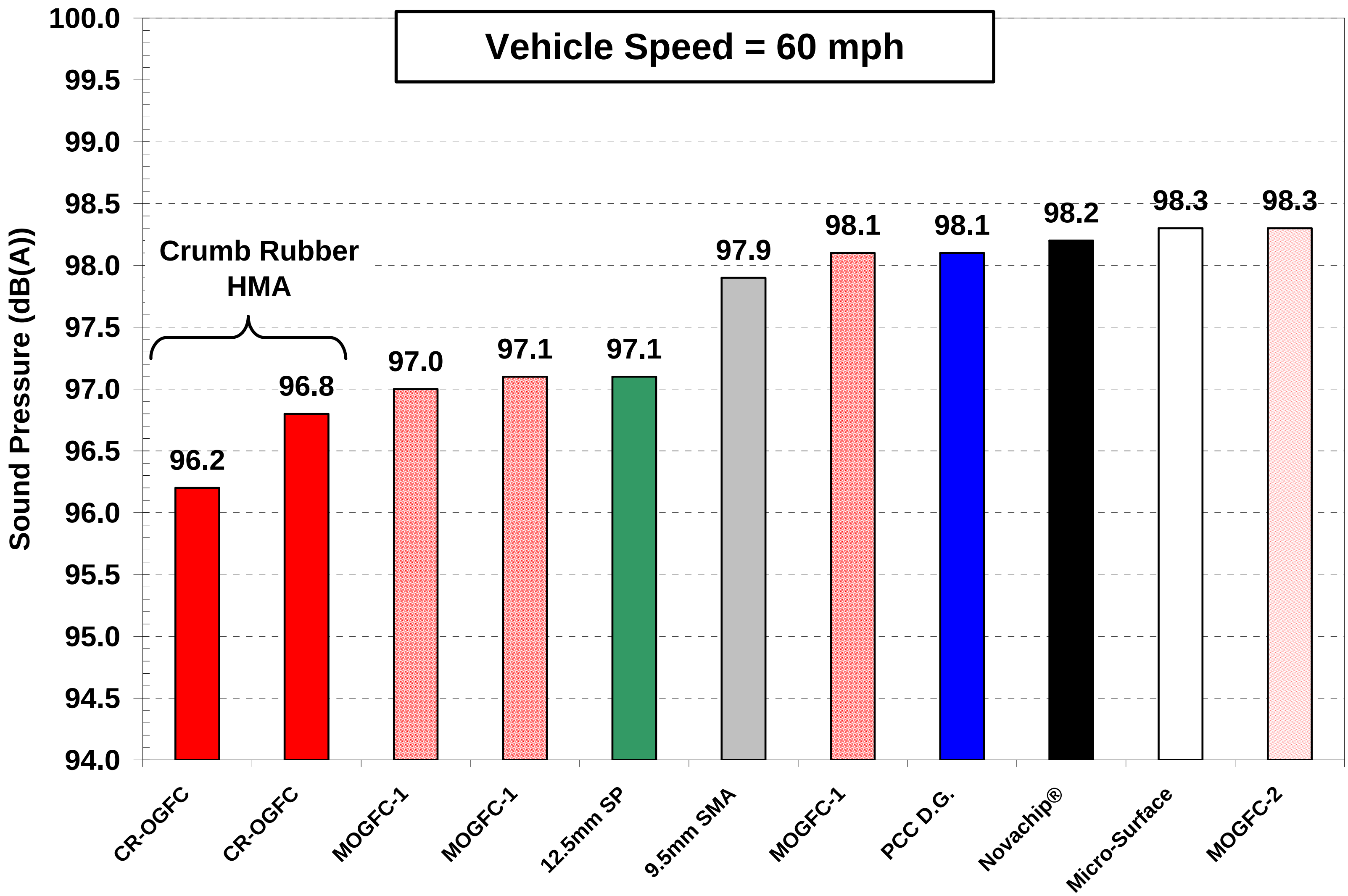


Noise increases as the pavement ages and stiffens

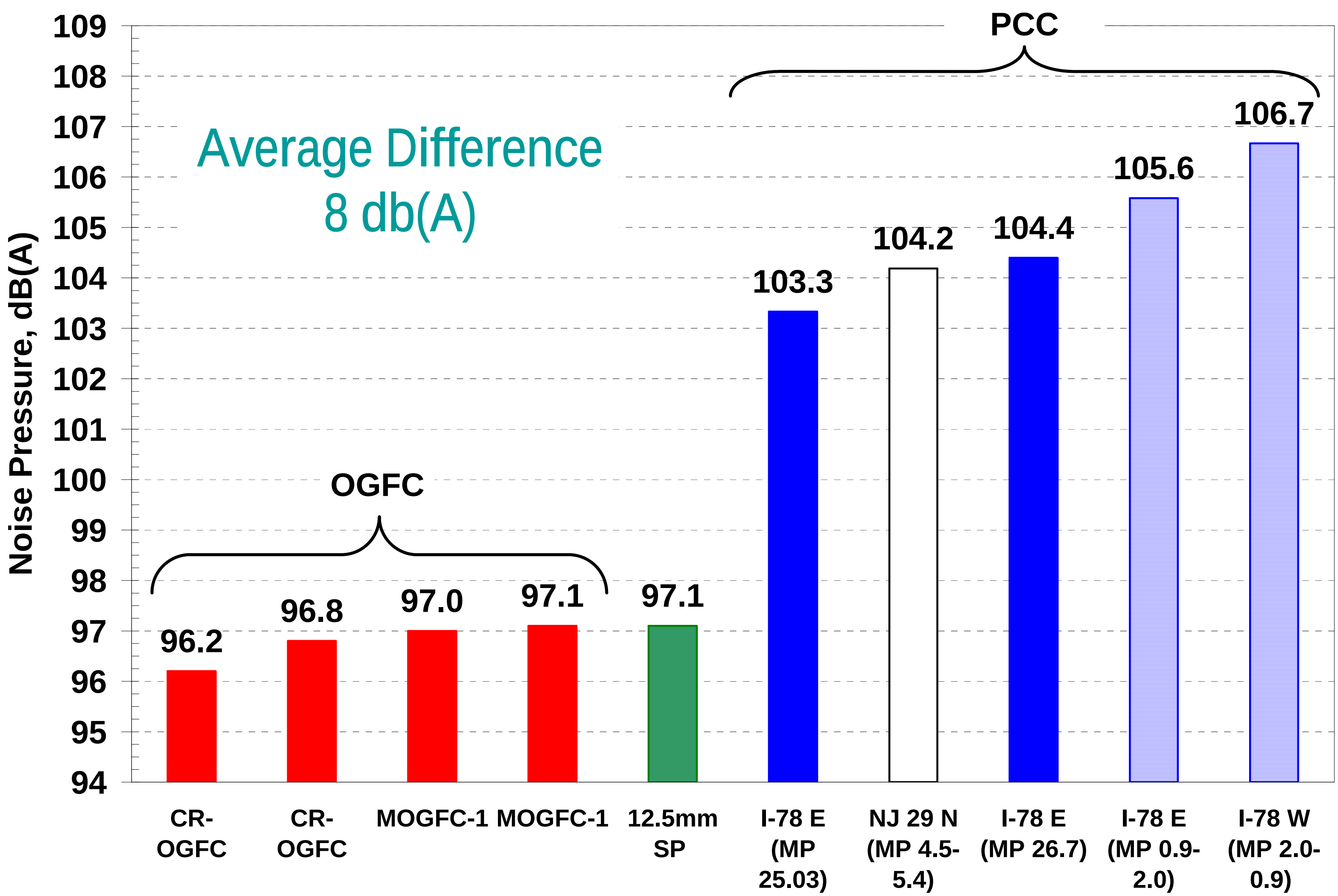
Concrete Surface Treatments



10 Quietest Pavement Surfaces Tested



Quietest to Loudest Comparison



NJ Compared to Average

- Based on 10 states (244 pavements)

Pavement Type	Noise (dB(A)) NJ	Noise (dB(A)) Average
DGA	99.1	97
OGFC (Coarse)	97.6	97
OGFC (Fine)	N.A.	93
SMA (9.5mm)	97.9	96
SMA (12.5mm)	101	96

Main Conclusions from NJ Research

- Different pavement surfaces generate various levels of noise
  - Finer graded HMA generated less noise
  - HMA lower than typical PCC (D.G. PCC similar)
  - Over 10 dB(A) difference from highest to lowest
    - OGFC vs Transverse Tined PCC
- Generated tire/pavement noise correlated to ride quality
  - Influenced by same macro-texture properties
    - Tire/pavement noise may influence a “users” perception of a “smooth ride” (based on RQI results – IRI was similar)
    - A SMOOTHER RIDE MEANS LESS NOISE!

Designing a Quiet Pavement

- Based on numerous field studies in Europe and United States
  - An open graded mix (OGFC) with more that 15% air voids and 90 to 100% passing the 3/8” sieve
    - Not suitable to use everywhere
  - Other fine graded HMA can also be utilized, but not as effective (9.5mm SMA, 9.5mm HMA)
  - European Concept (experimental) - using a two layer concept
    - ¾ inches of a fine graded OGFC
    - 1 ½ inches of a coarse graded OGFC

OGFC for Quiet Pavement - Restrictions

- OGFC should only be used on pavements with "free-flowing" traffic
  - No frequent stopping, intersections, sharp curves
  - Fast moving traffic "self cleans" OGFC
  - Winter maintenance may be issue – recommend using rock salt pre-wetted with calcium chloride
    - Typically uses twice application of Dense Graded HMA
- For areas of potential frequent stopping, better to use a fine-graded HMA or SMA
  - Will not clog
  - Easier for winter maintenance
  - Remember, only beneficial if traffic > 35 mph

Composite Pavement Issues

(HMA overlay PCC)

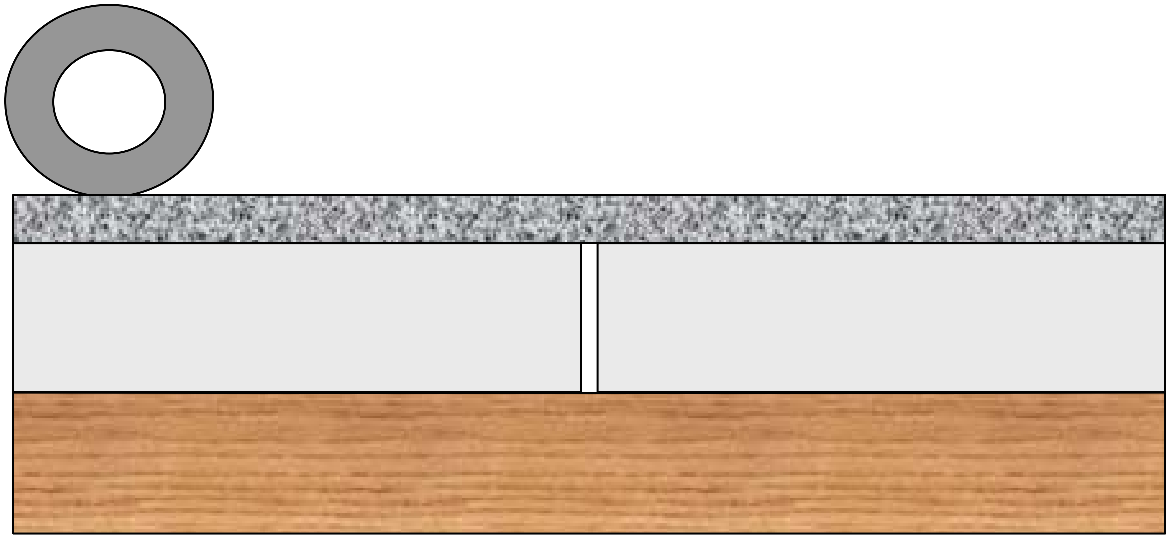
What? The Problem

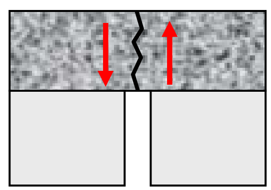
- **Superpave didn't address cracking in general, especially reflective cracking**
- **45% of NJDOT pavements are composite (HMA over PCC), with another 10% PCC to be overlaid!**
- **Conventional HMA overlays not addressing need**
- **Why is Reflective Cracking a Problem?**

Reflective Cracking - Mode 1

- Mode 1 Vertical Shear
  - – Poor load transfer
  - – Weak base or voids present
  - – Load Associated Problem

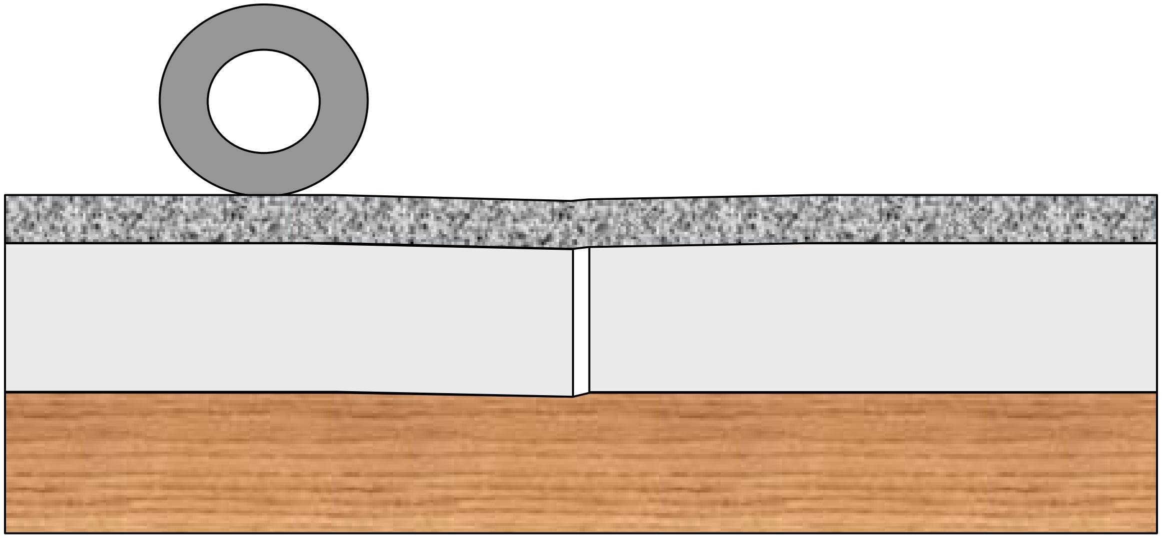
“Poor load transfer…”

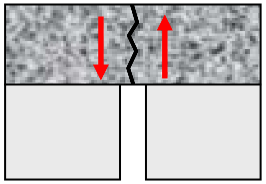




Mode 1: Vertical Shear Stress

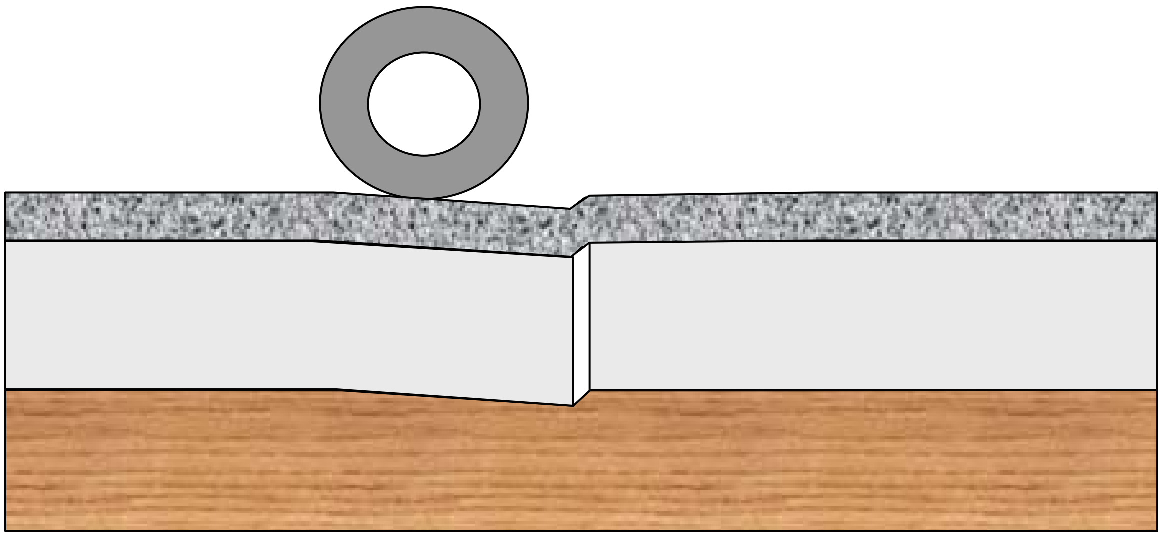
“Poor load transfer…”

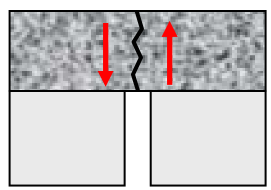




Mode 1: Vertical Shear Stress

“causes shear stresses in the overlay.”





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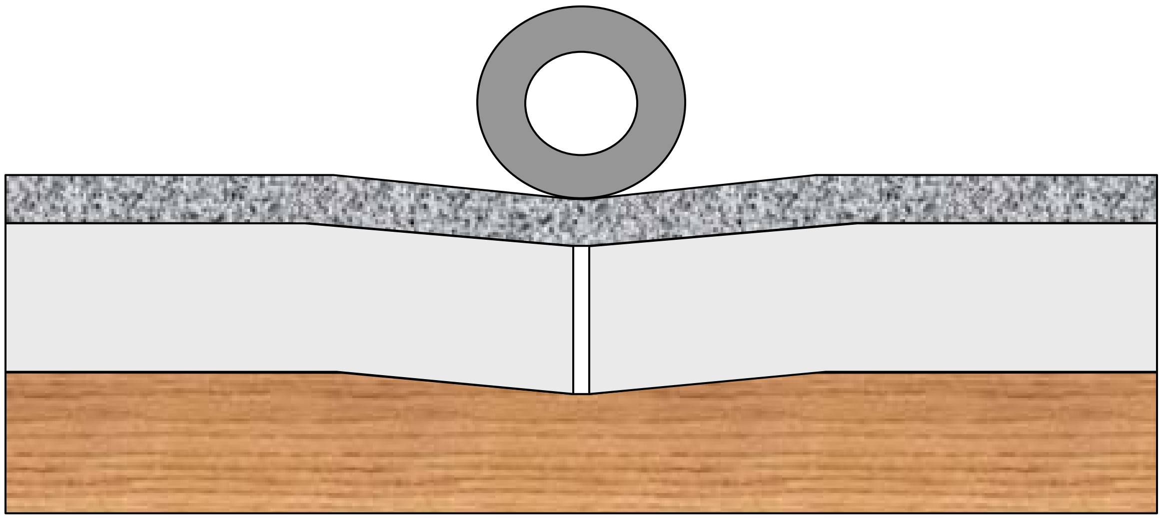

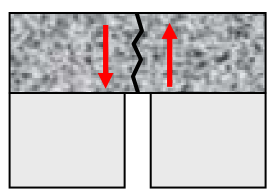

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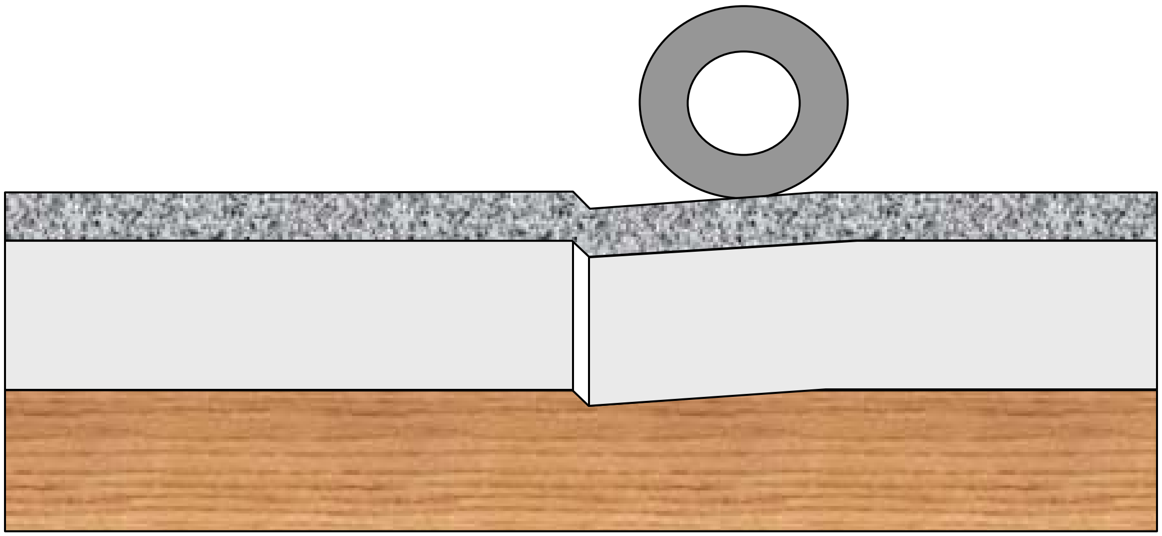

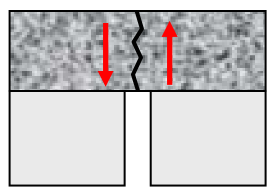

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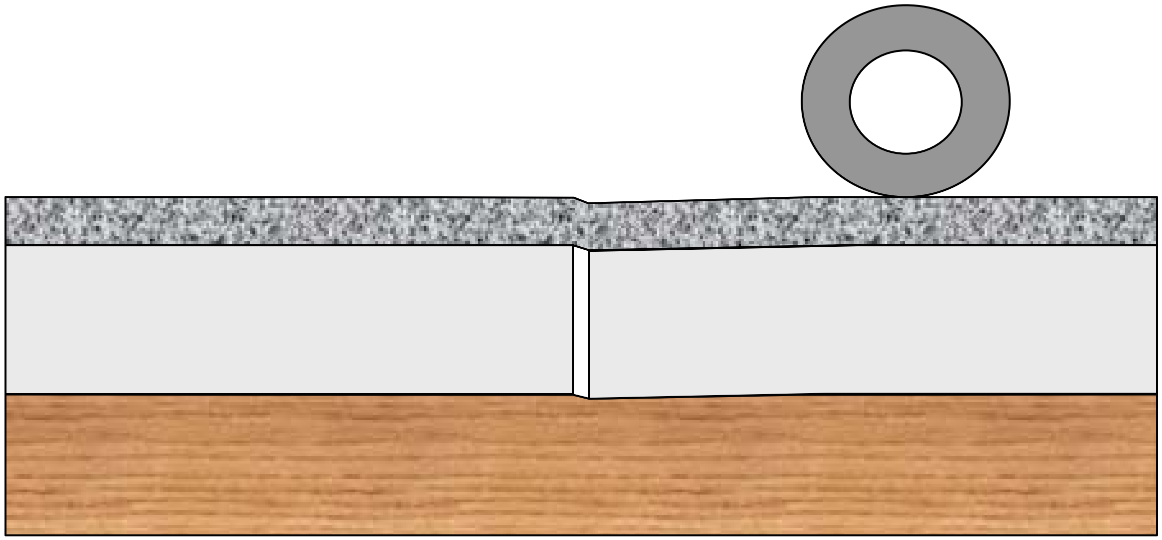

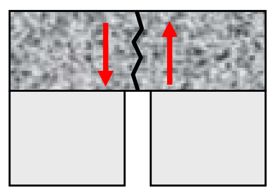

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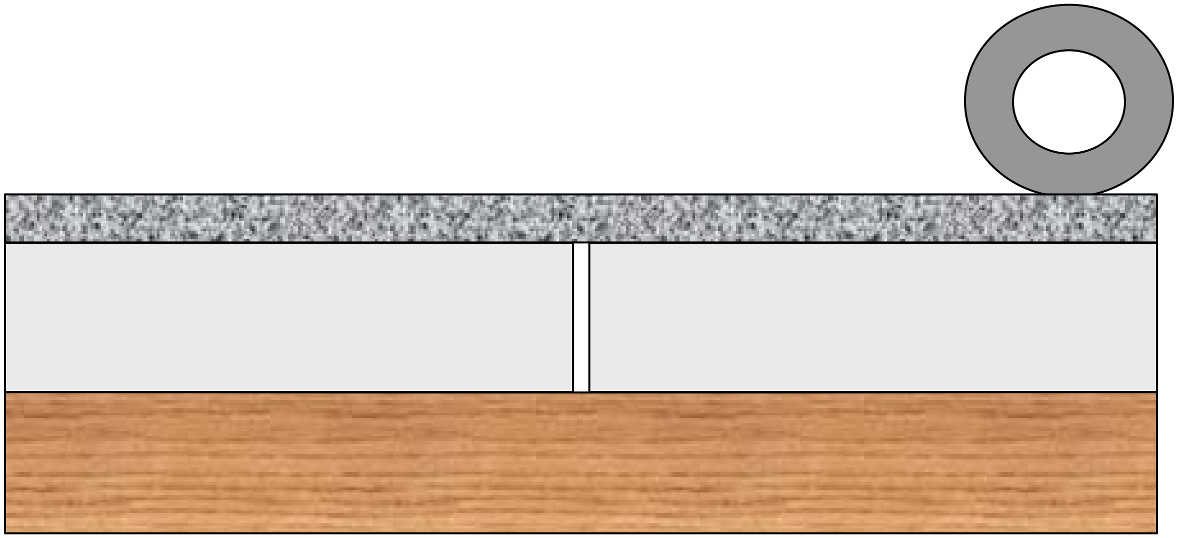
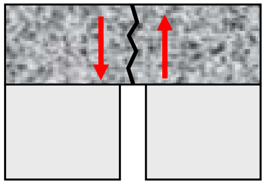
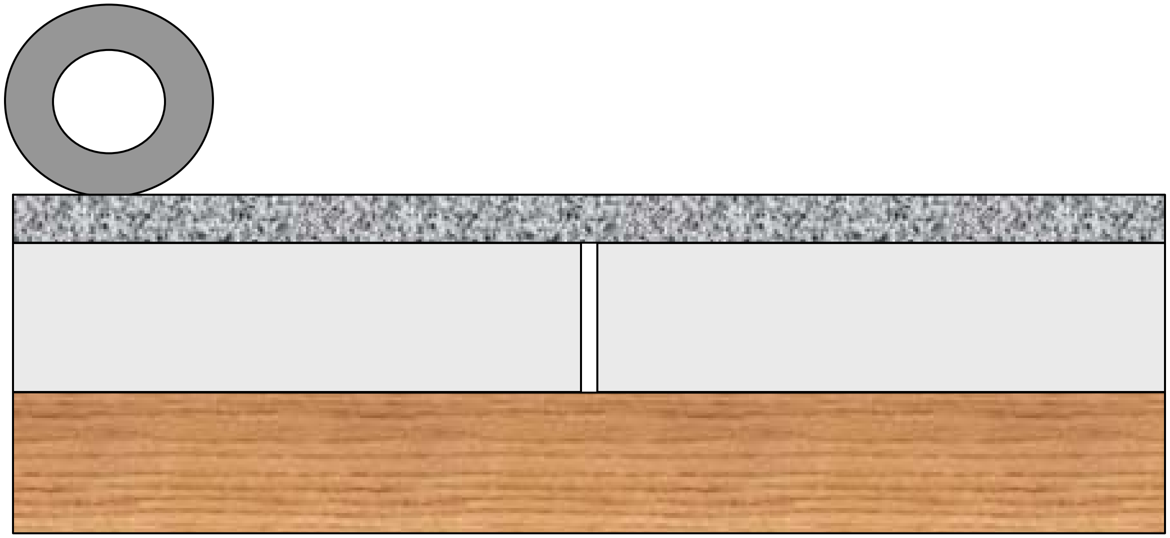
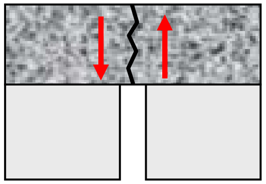




Mode 1: Vertical Shear Stress

“Over many repeated loads…”





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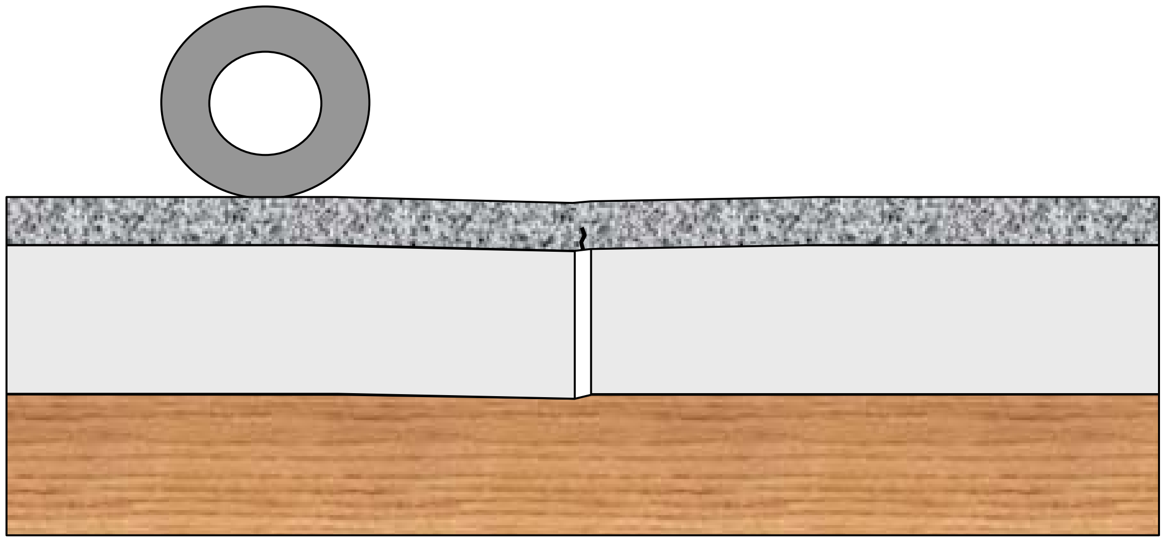

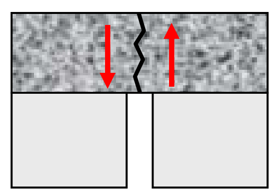

Mode 1: Vertical Shear Stress

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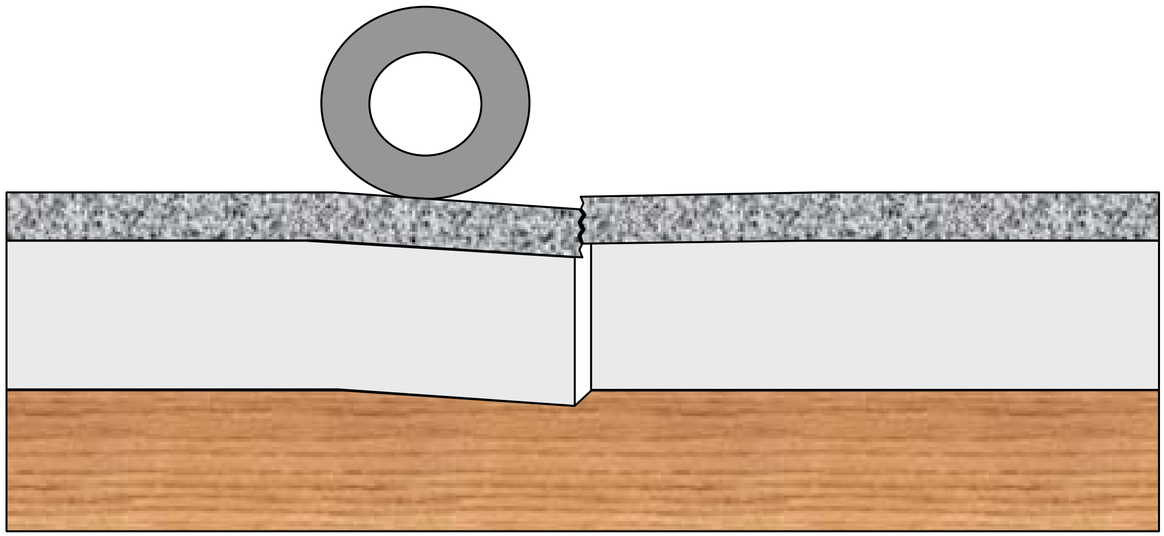

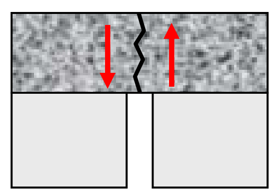

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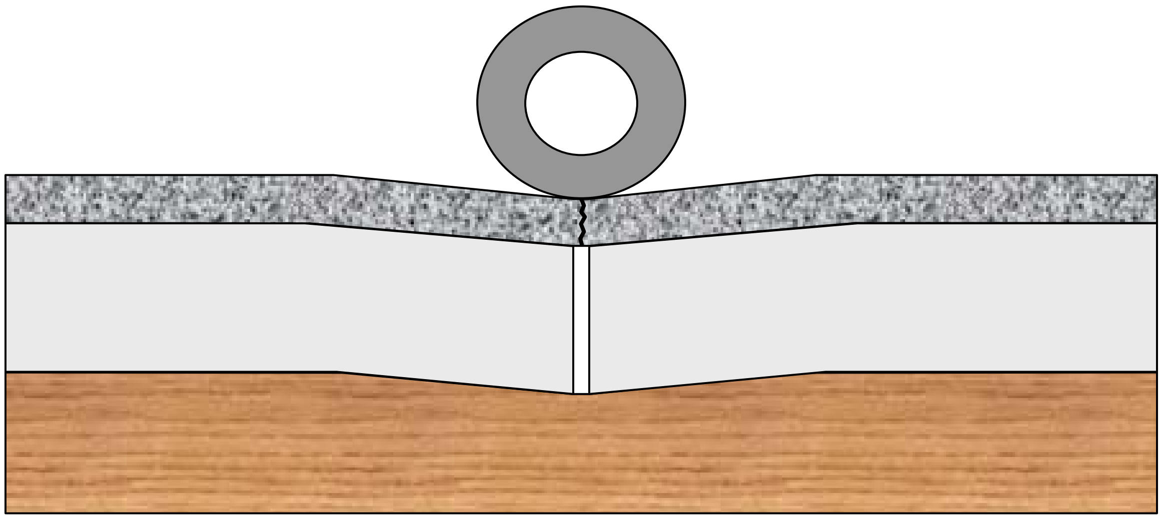

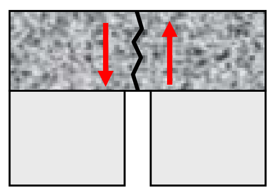

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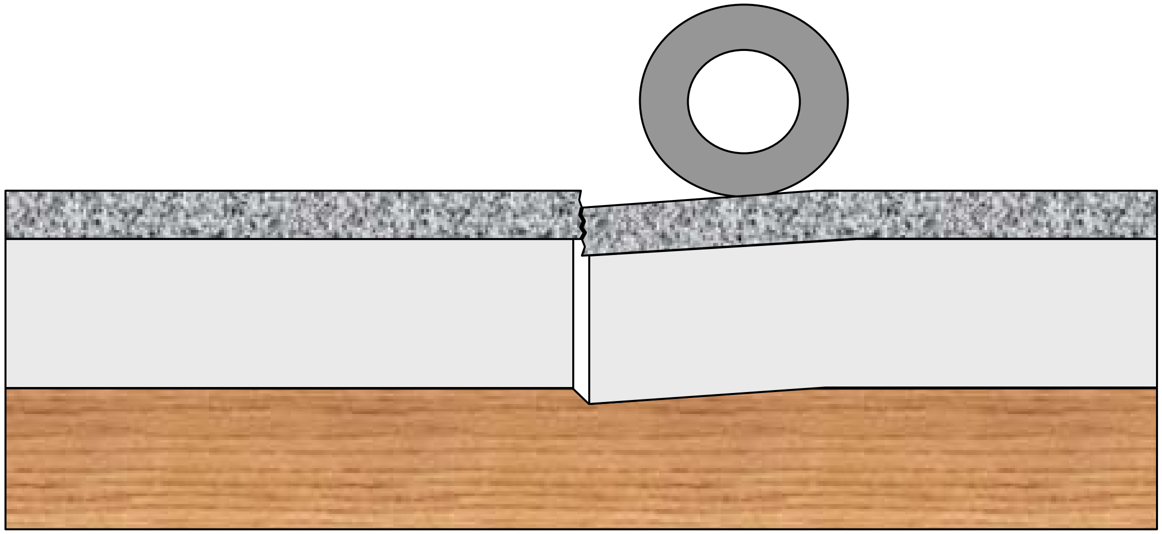

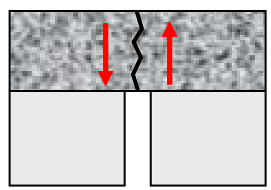

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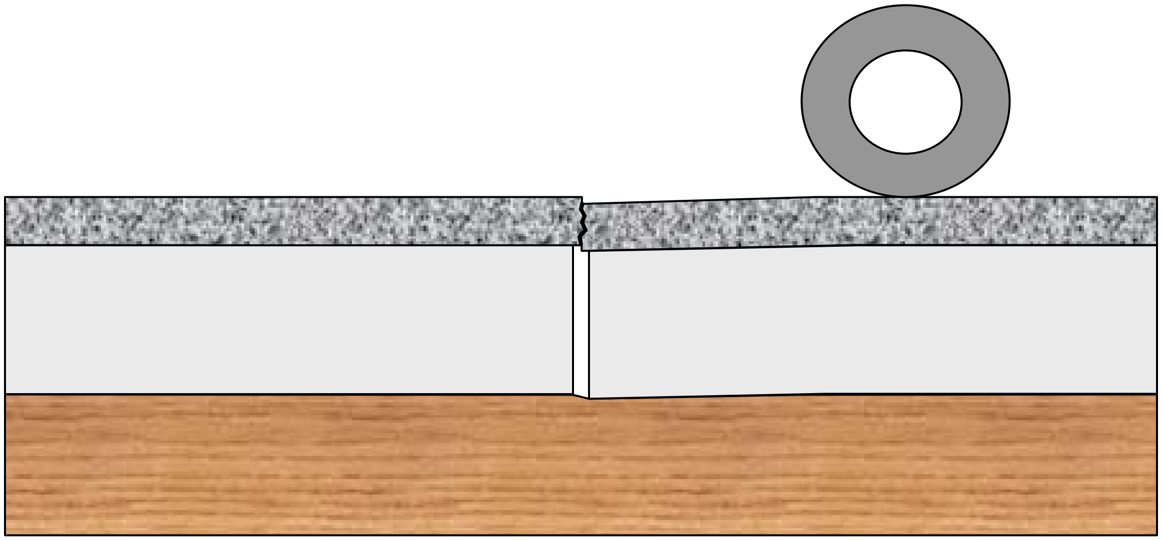

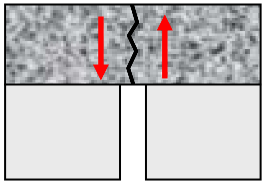

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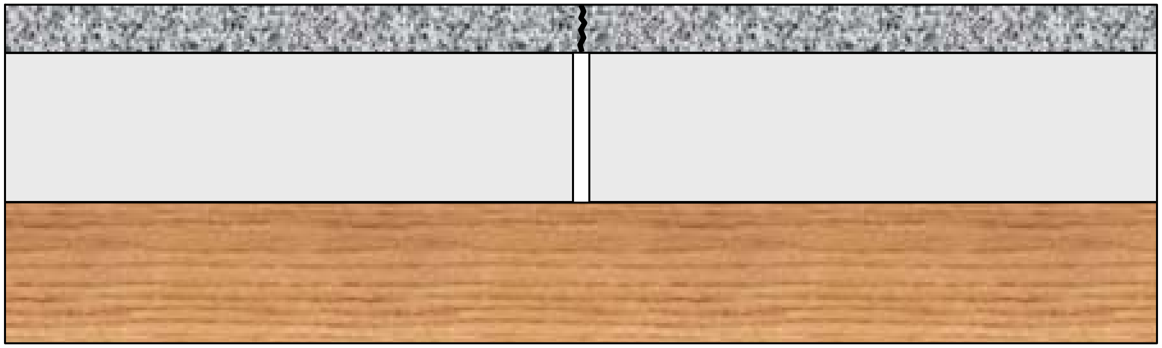
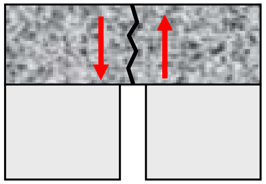


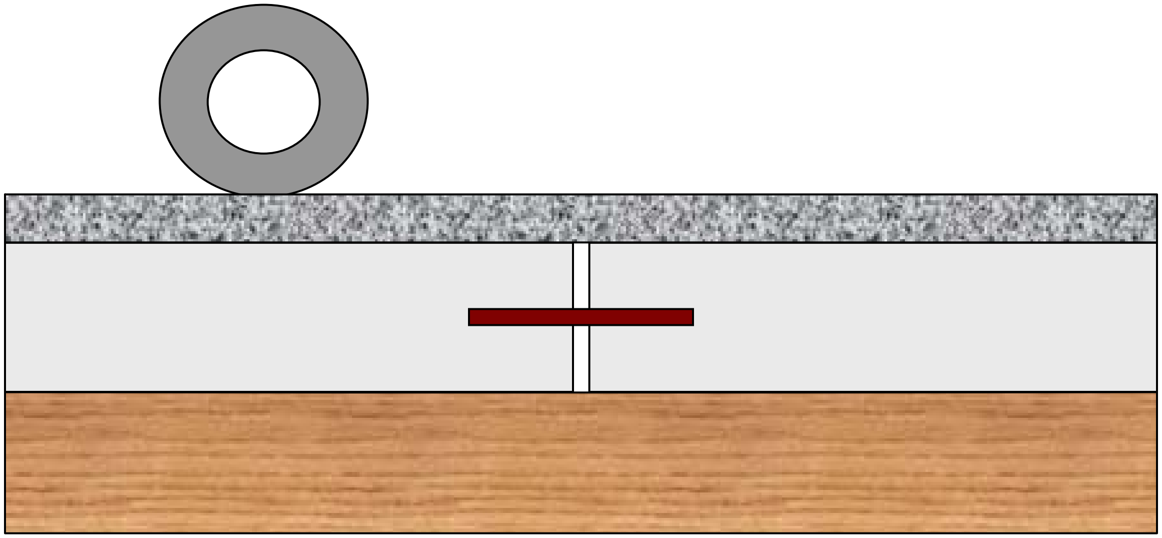


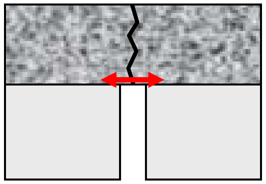
Mode 1: Vertical Shear Stress

Reflective Cracking - Mode 2

- Tensile stress at bottom of AC layer
  - Poor support
  - Weak base
  - Load Associated Problem

“Traffic loads at the joint…”





Mode 2: Horizontal Tensile Stress due to load

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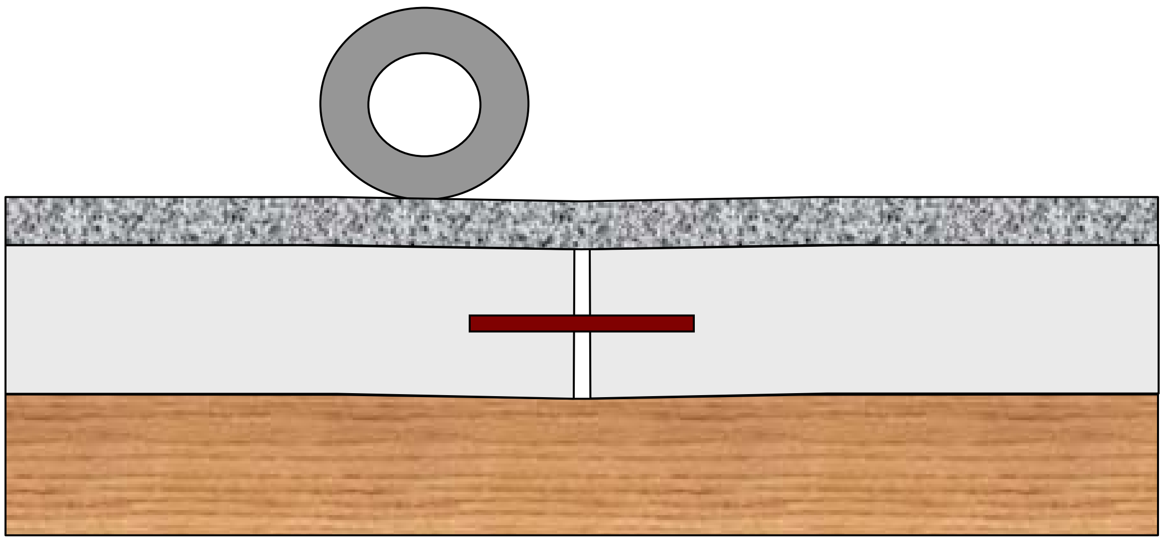

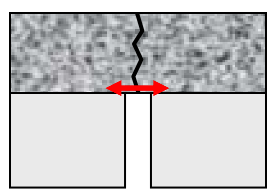

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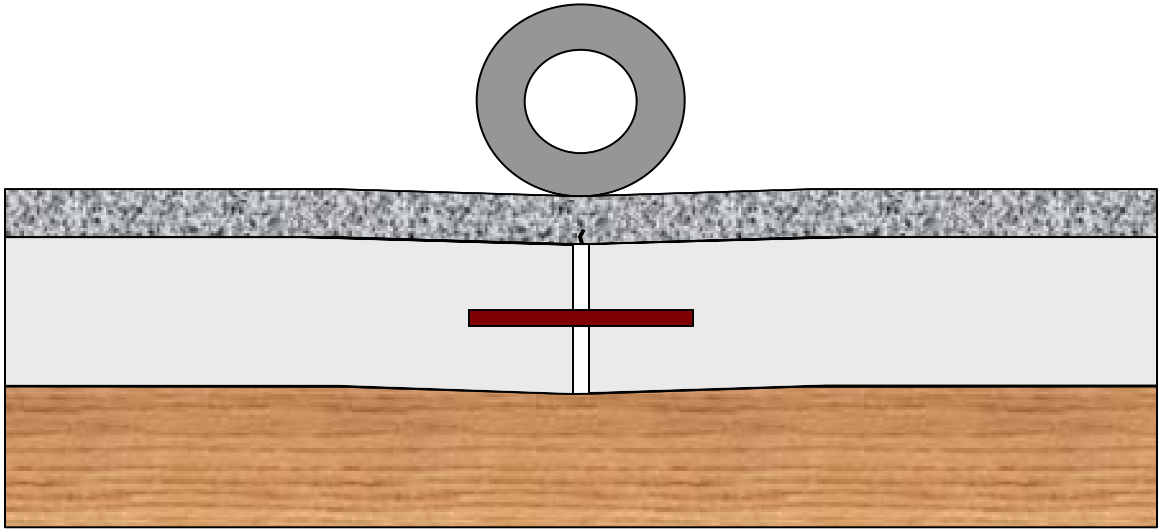

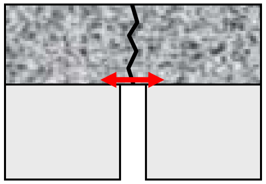

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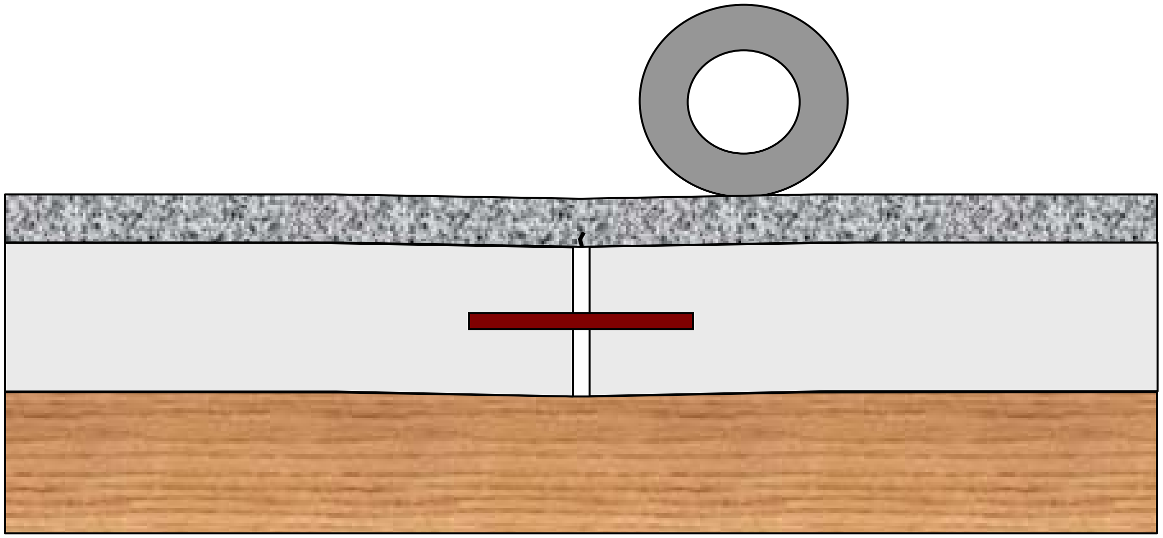

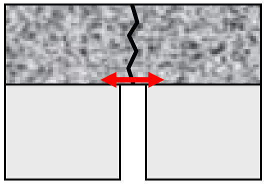

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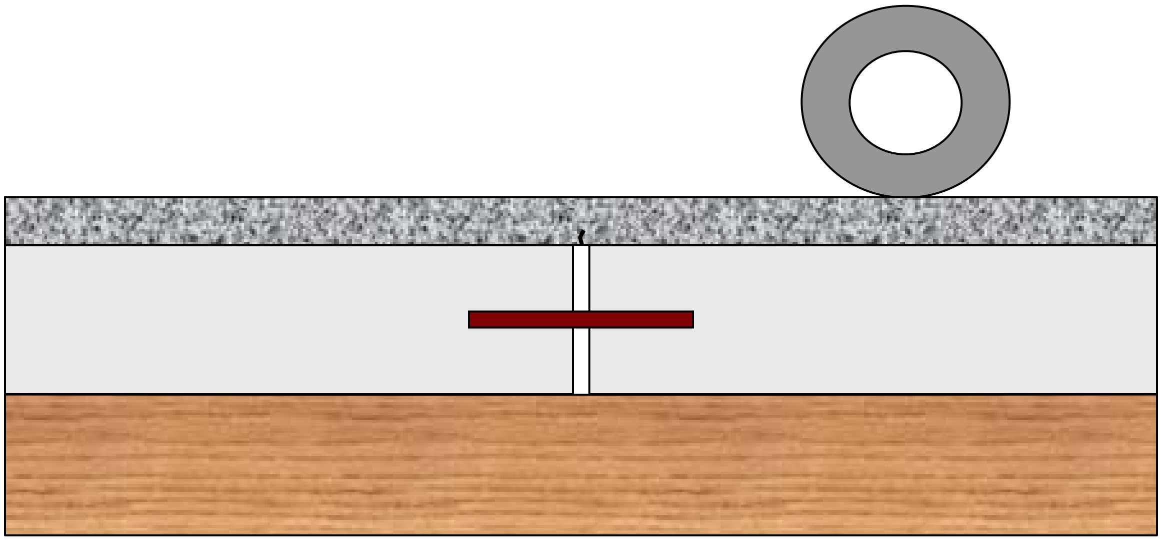
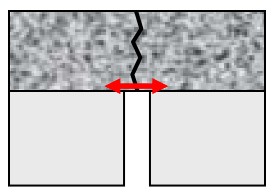
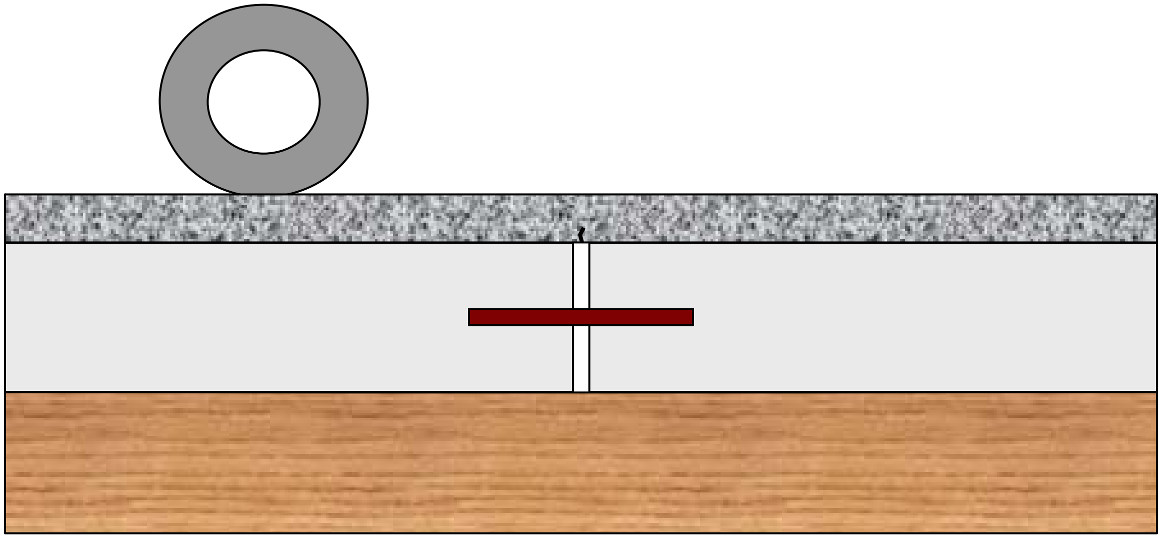
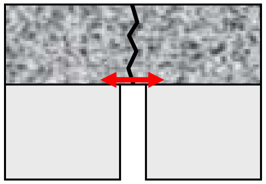




Mode 2: Horizontal Tensile Stress due to load

“Over many repeated loads…”





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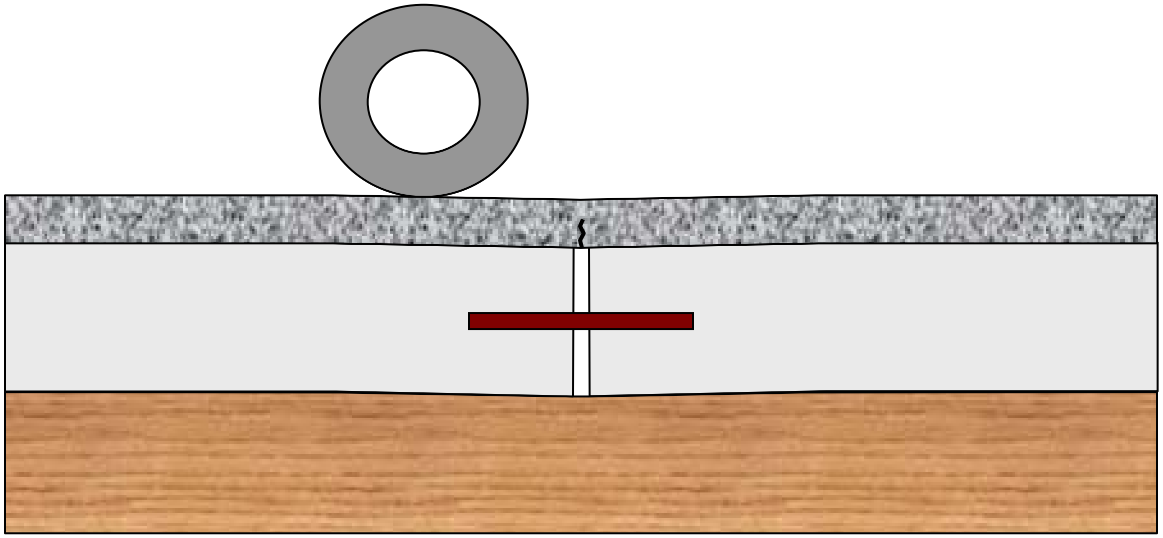

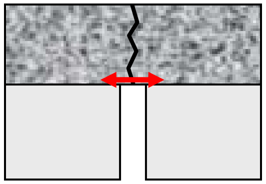

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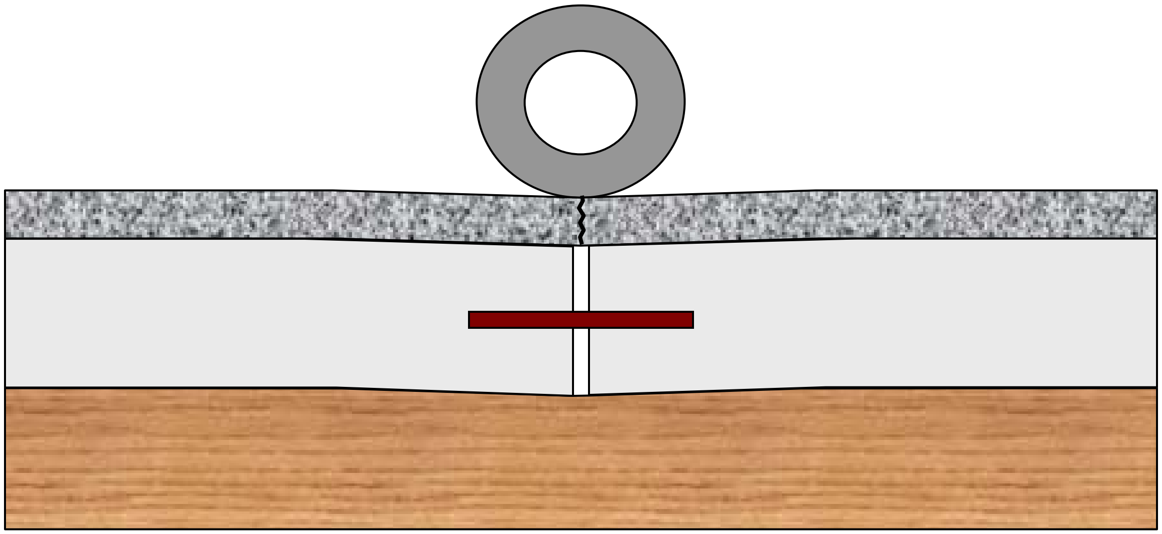

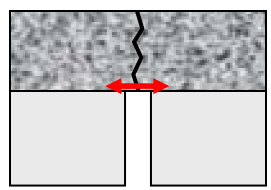

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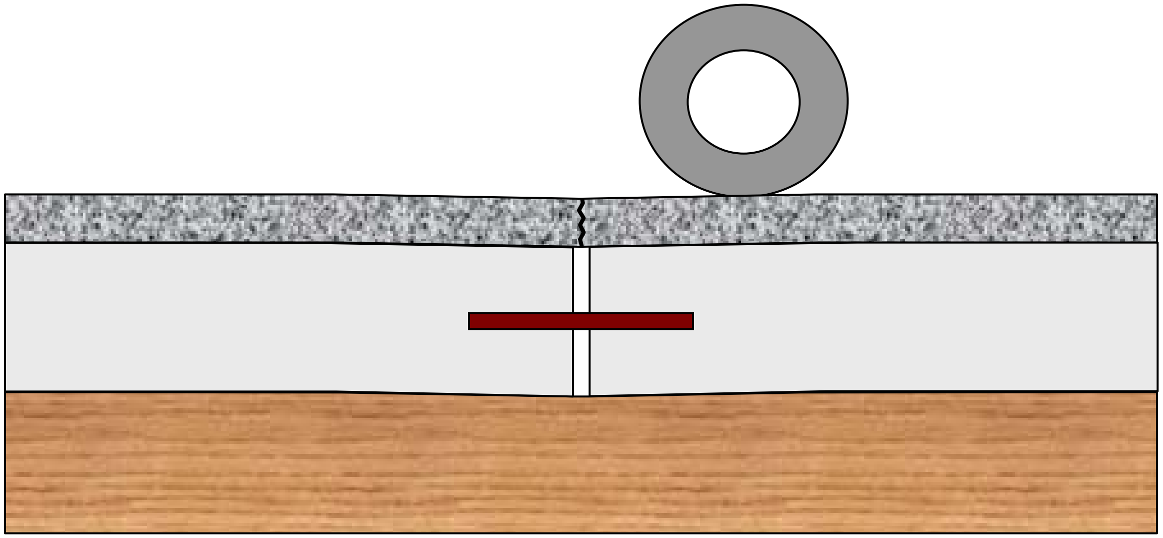

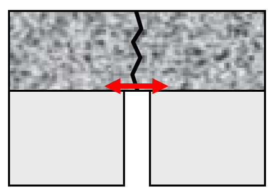

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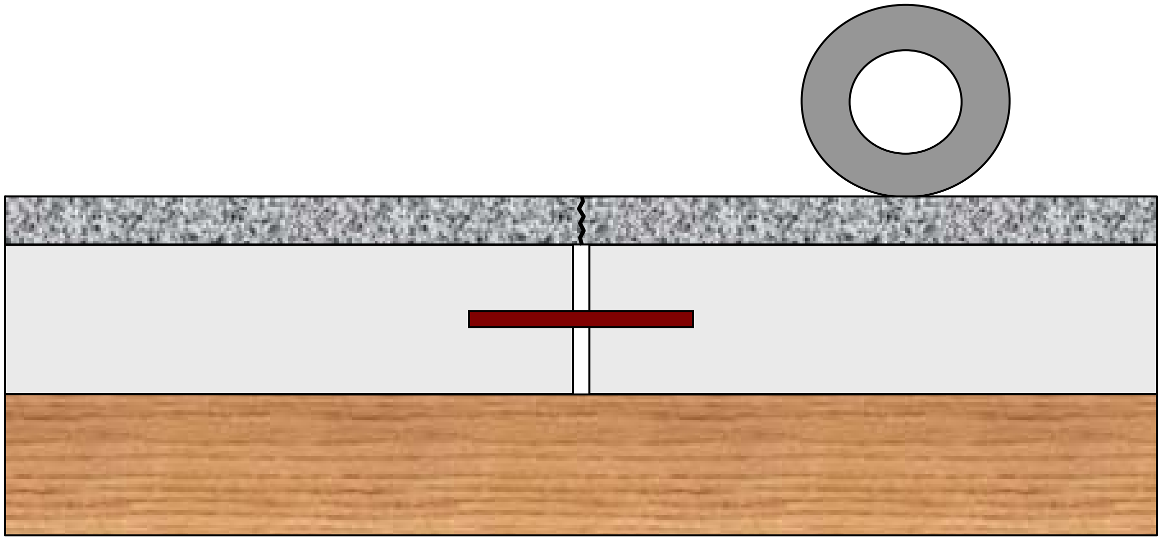

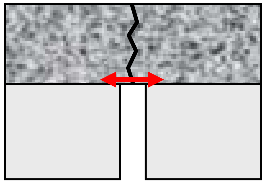

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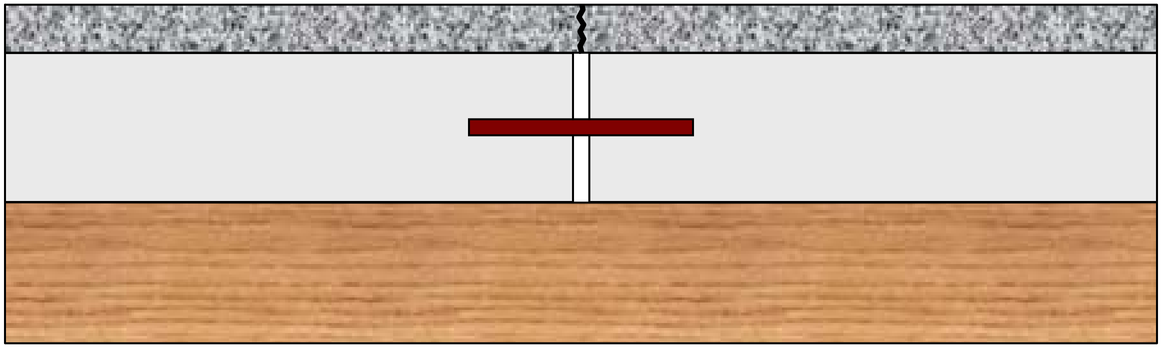
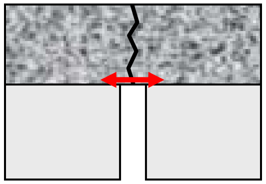


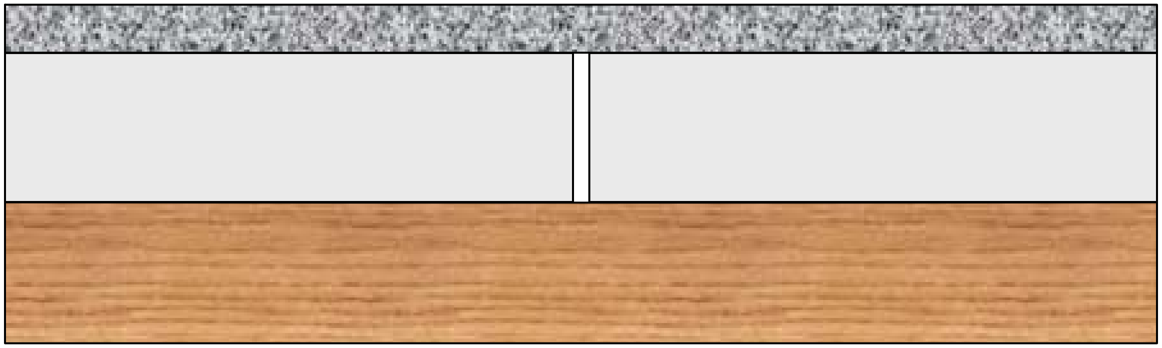


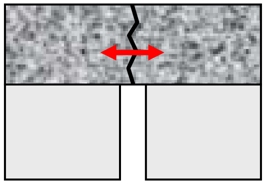
Mode 2: Horizontal Tensile Stress due to load

Reflective Cracking - Mode 3

- Horizontal Tensile Stress
  - Thermally Induced stresses
  - Magnitude depends on Slab length or Crack spacing

"Slab shrinkage under cooling temperature…"





Mode 3: Horizontal Tensile Stress due to climate

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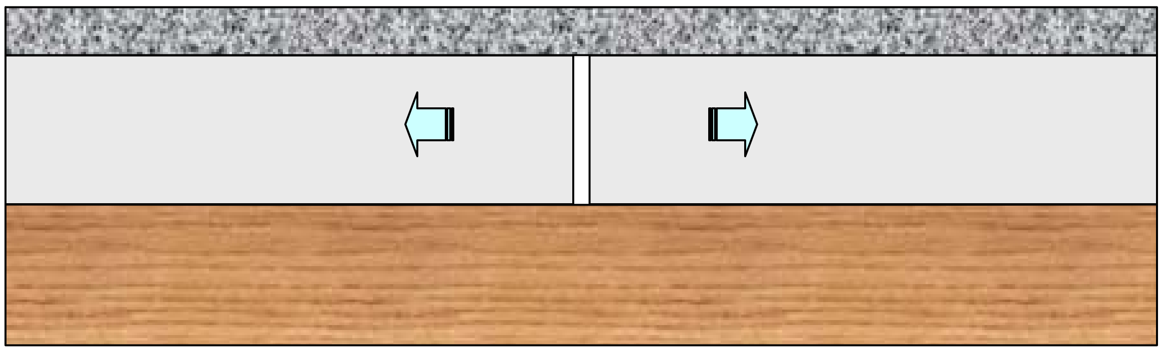

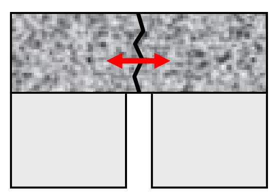

Mode 3: Horizontal Tensile Stress due to climate

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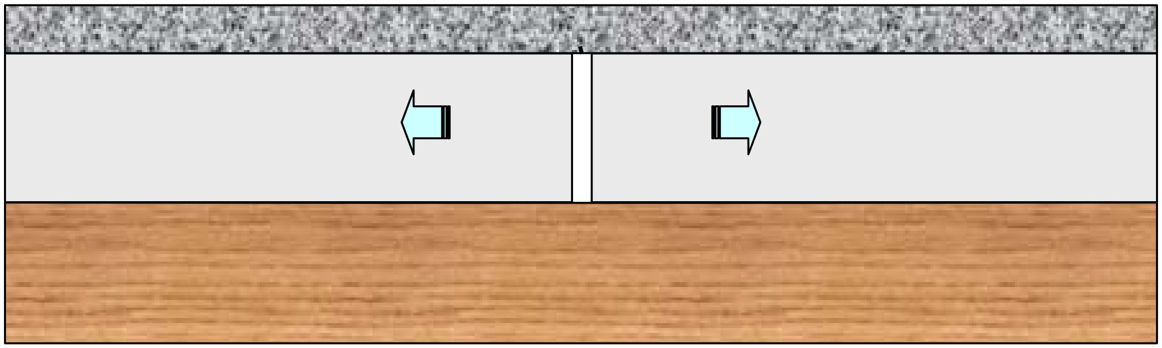
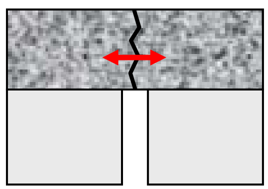
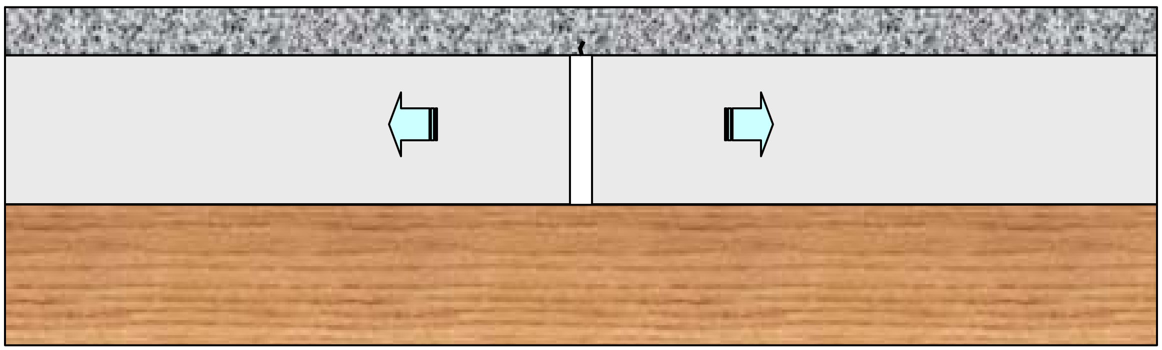
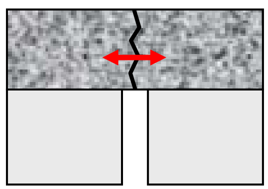




Mode 3: Horizontal Tensile Stress due to climate

“causes tensile stresses in the overlay.”





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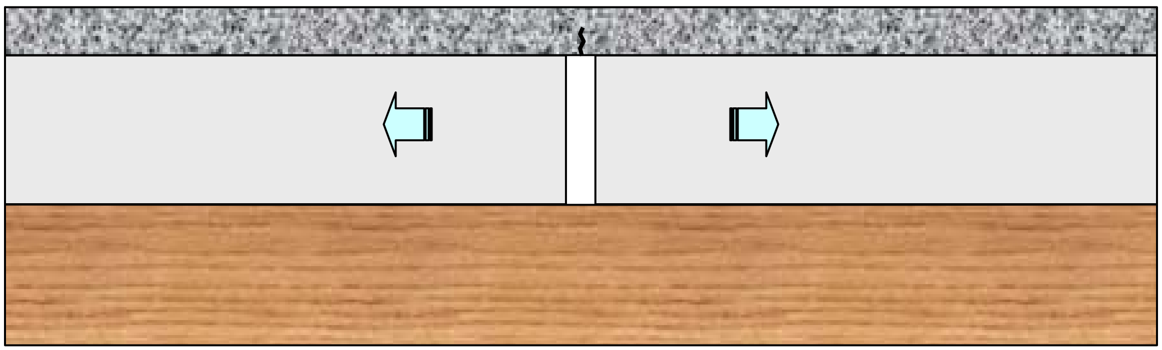

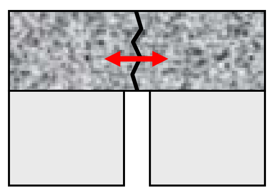

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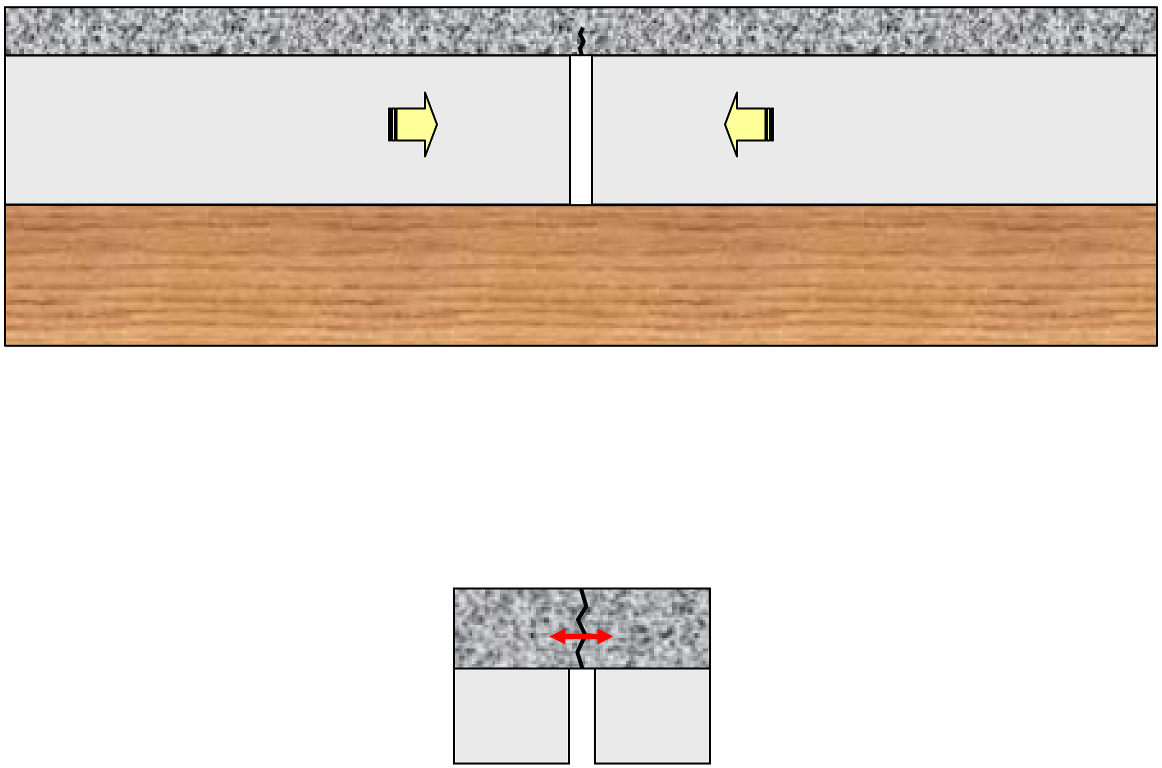

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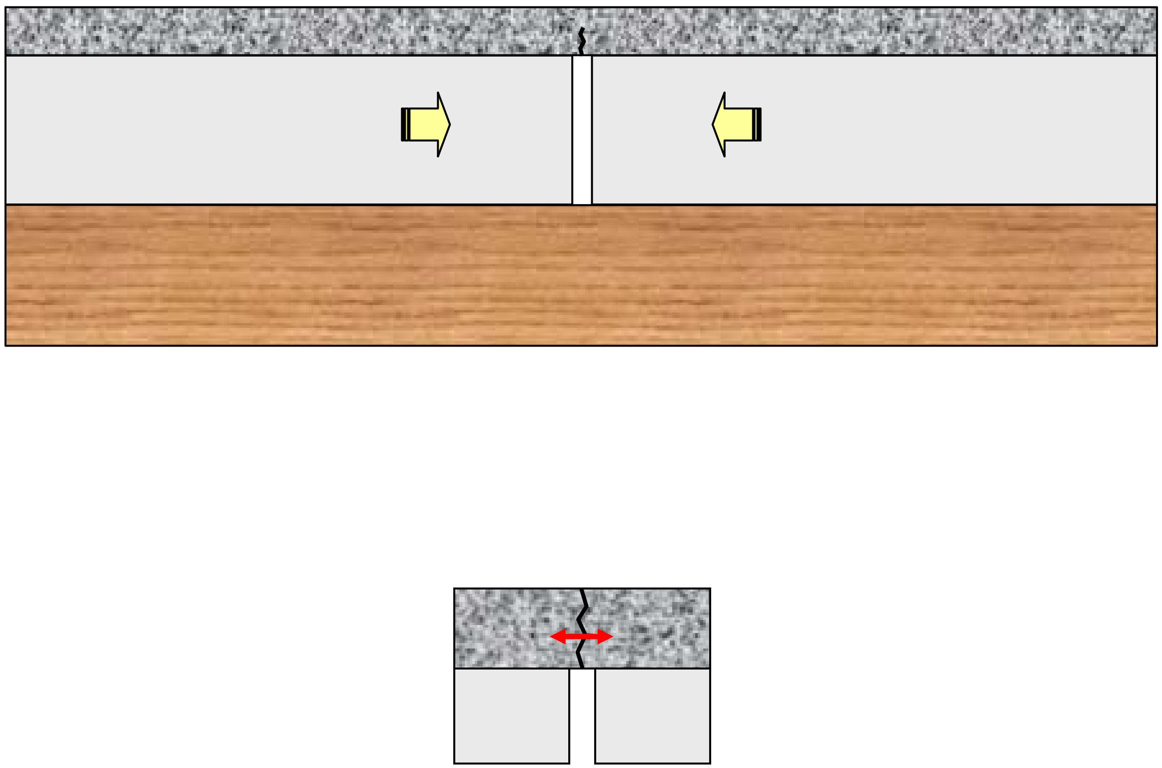

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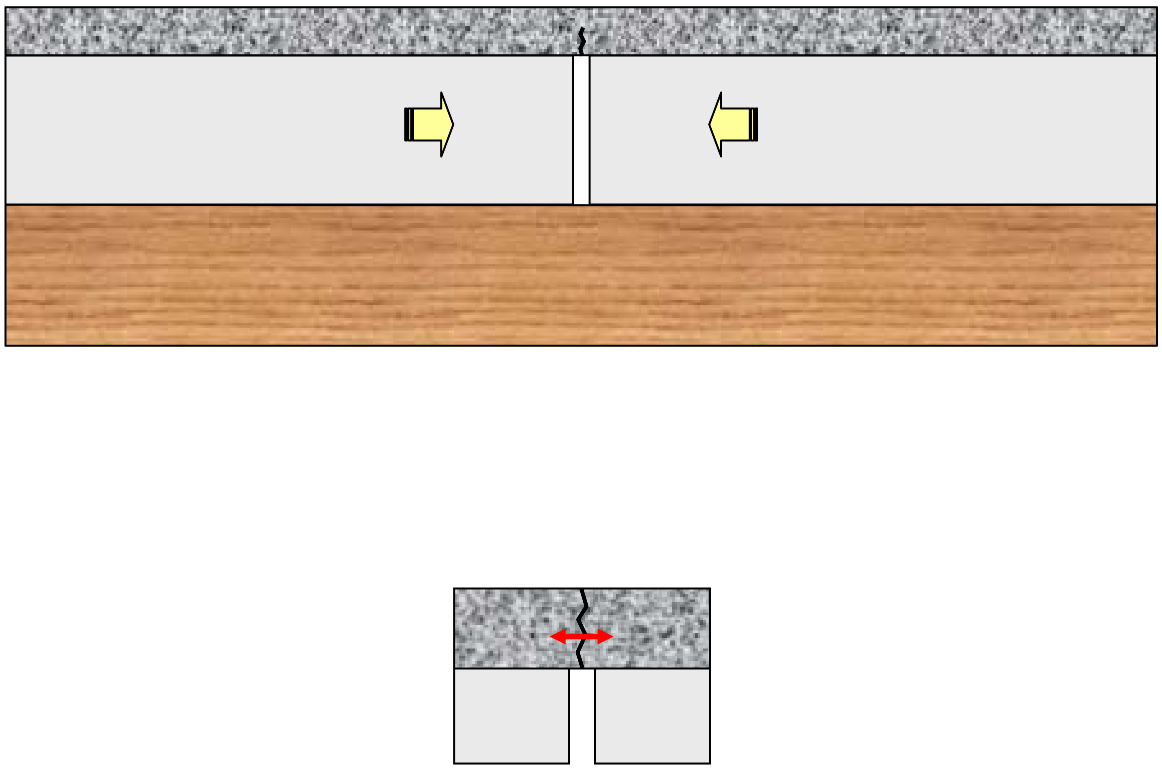
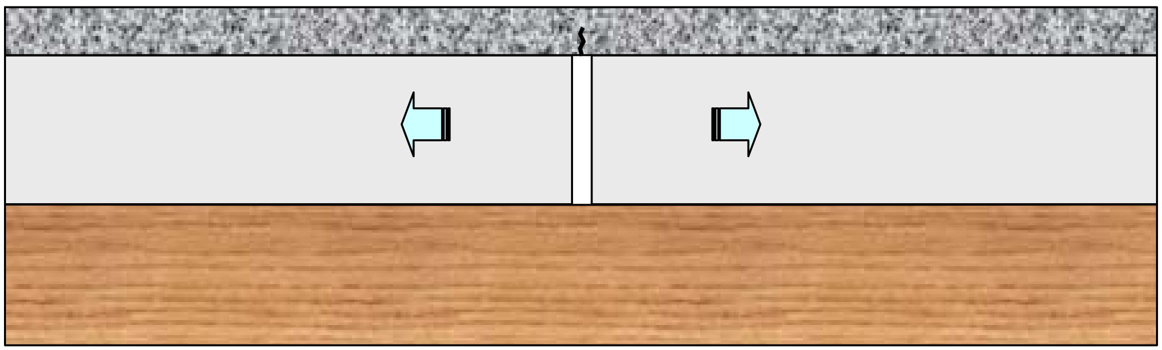
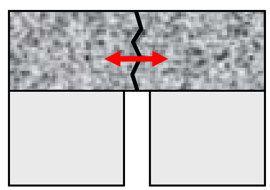


Mode 3: Horizontal Tensile Stress due to climate

“Over many cycles…”





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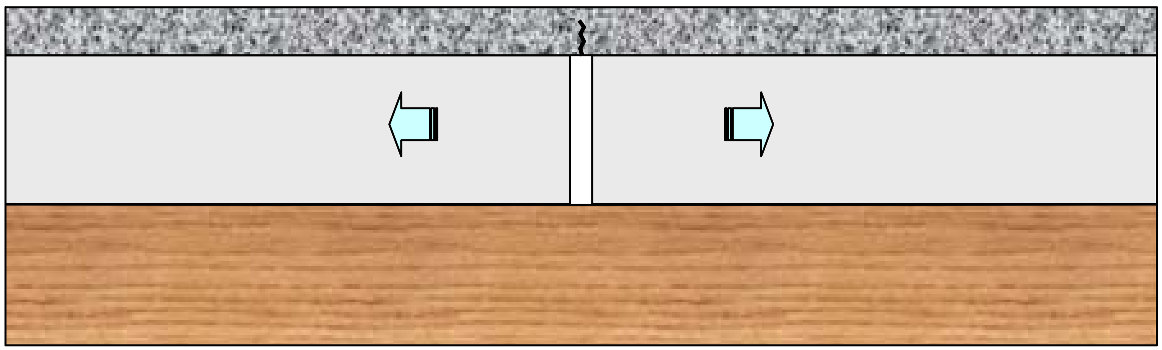

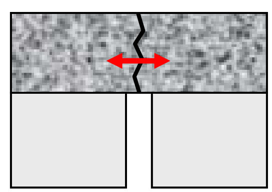

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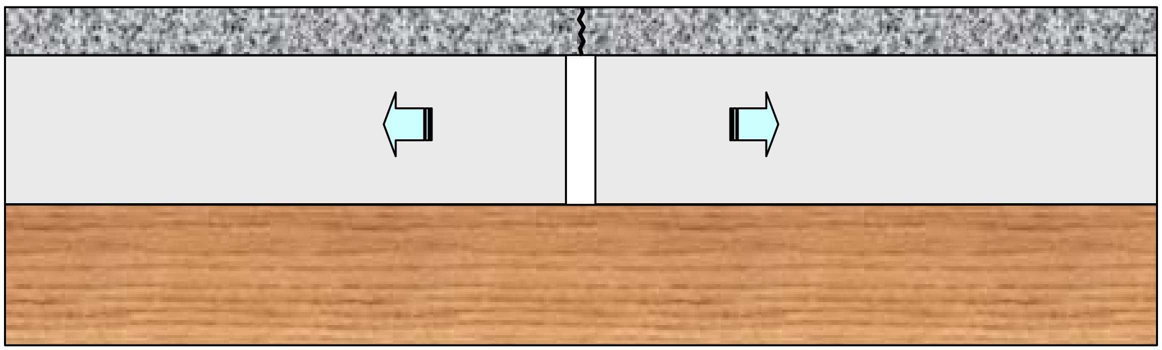

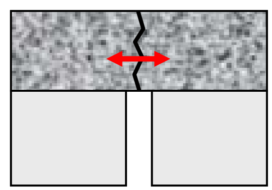

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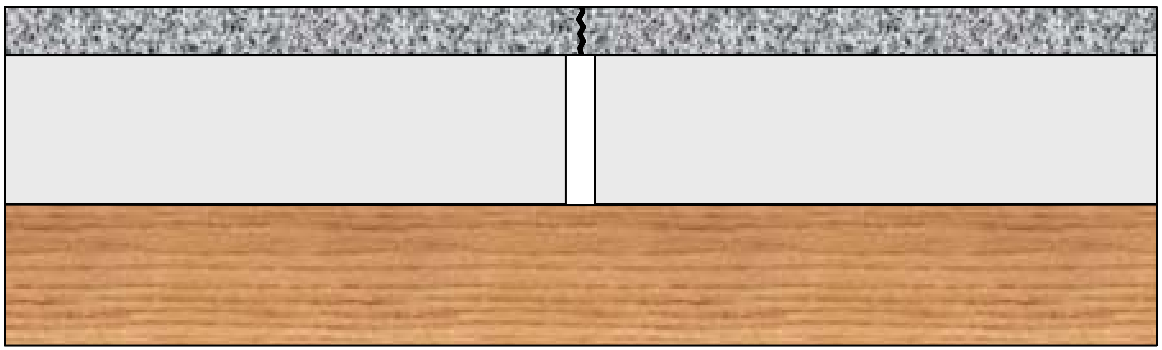
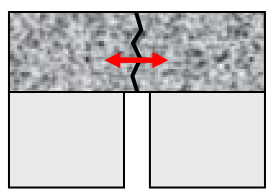


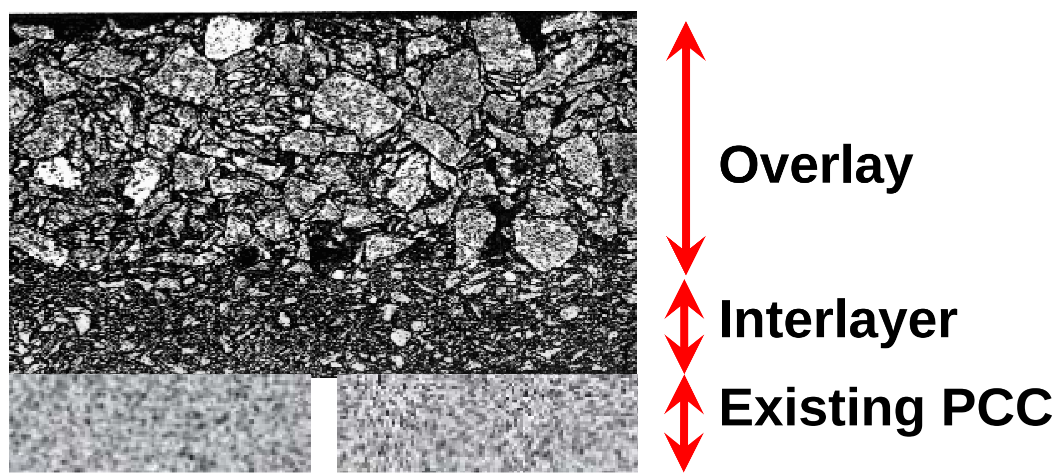


Mode 3: Horizontal Tensile Stress due to climate

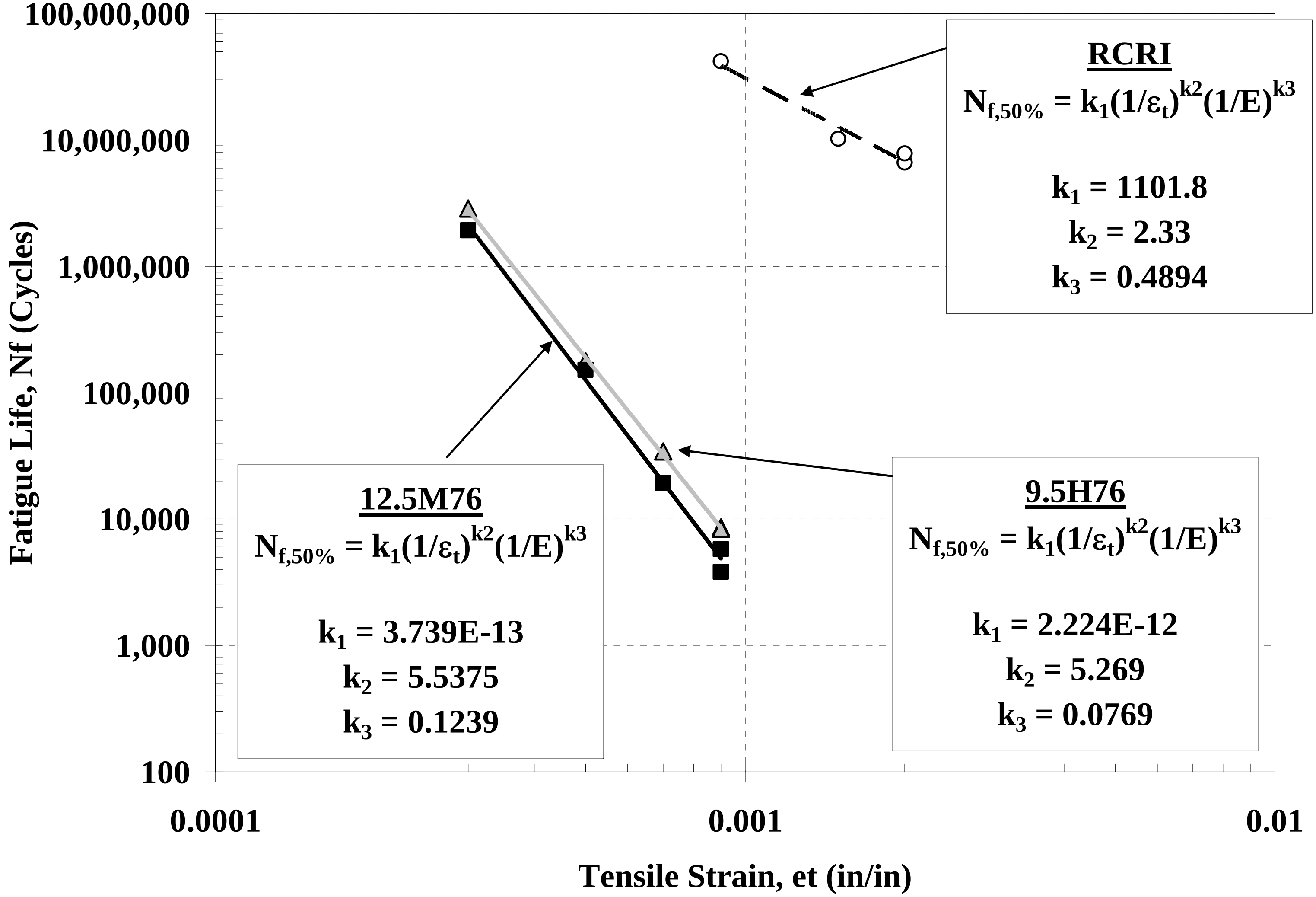
The Solution

Reflective Crack Relief Mixtures

- RCRI and RBL
  - Thin (1”) fine aggregate HMA
  - Highly elastic binder – modified on low PG side as well (-28^{o}C and lower)
  - Asphalt-rich, impermeable layer to keep moisture away from PCC and supporting materials

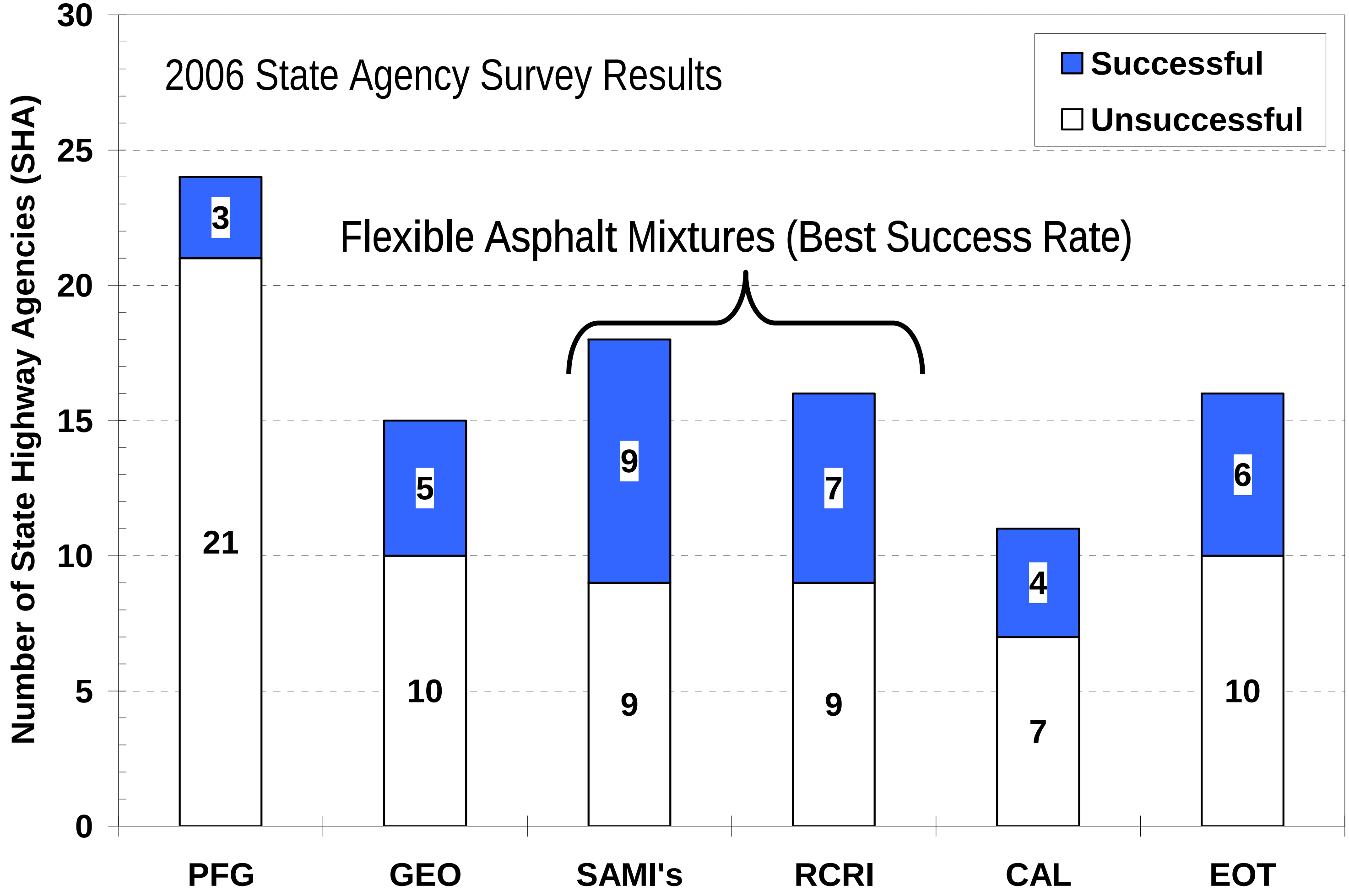


Fatigue Life Comparisons



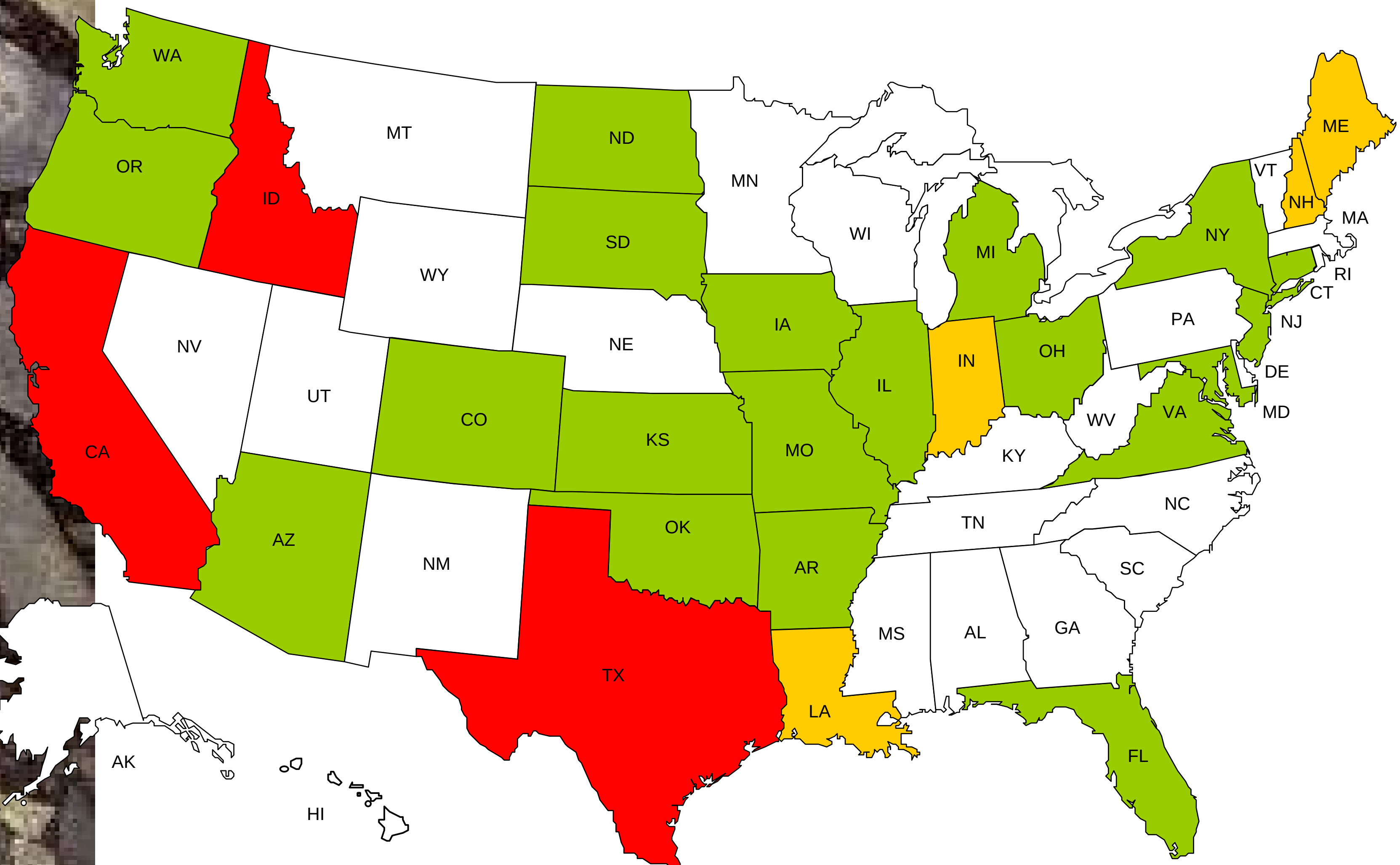
Successful* Mitigation Methods

(Bennert and Maher, TRB 2007)



*Greater than 4 Years Before Cracking Observed

Paving Fabrics to Mitigate Reflective Cracking



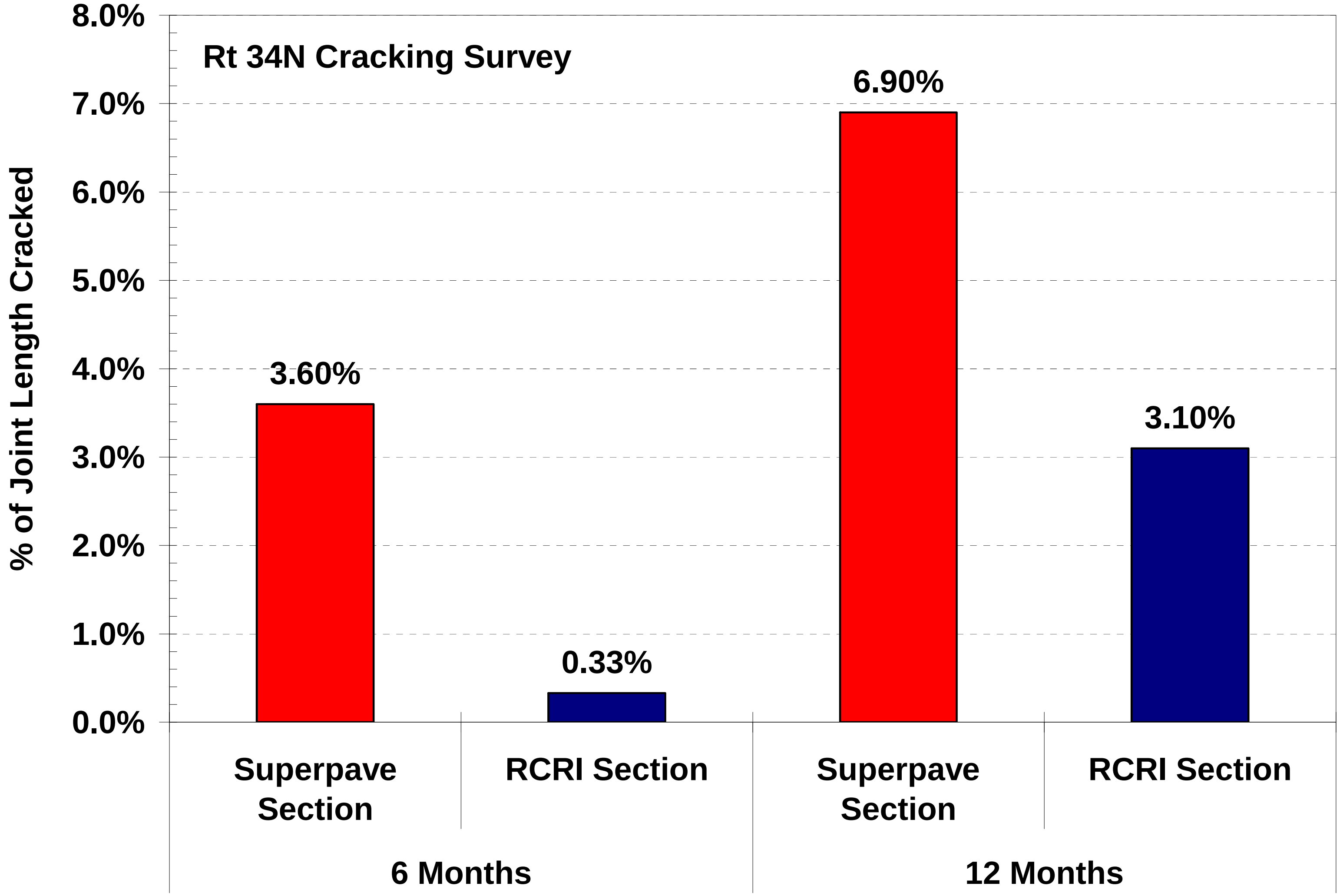
* Successful is defined as greater than
4 years before cracking occurs

Successful*
Unsuccessful
Never Tried

Quick Note on Paving Fabrics

- Work well for HMA pavements when additional structural support needed
  - i.e. – can not increase pavement thickness but need more support
- Due to horizontal movement of PCC, fabrics stretch and HMA still cracks
  - Not recommended for PCC/Composite pavements

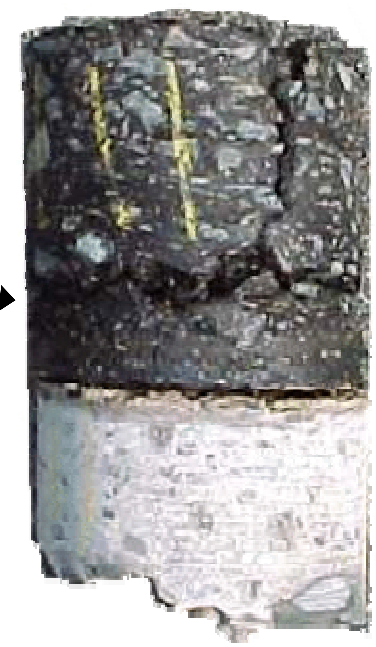
RCRI Test Section (Rt 34N)



Why do we still get cracking with a “crack relief interlayer”?

"Crack Jumping"

- Occurs in HMA materials that overlay highly elastic stress absorbing interlayers
  - No cracking in RCRI – crack initiates above RCRI
  - Issues with stiffness/fatigue compatibility
- The interlayers only absorb a percentage of the vertical stress/strain, not eliminate it
  - At specified thickness, it almost completely eliminates the horizontal



1.5” of 12M76

5 Cycles

0.5” of RCRI: 1.5” of 12M76

278 Cycles

1.0” of RCRI: 0.5” 12M76

> 2,800 Cycles

0.035” Opening
15^{o}C (59^{o}F)

Current Methodology for Composite Pavements

- Rutgers University developed an analytical method to predict the performance of asphalt mixtures on composite pavements
  - “Deflection Spectra Approach”
  - Takes into account both horizontal and vertical movements
  - Realistic asphalt mixture response (over 15 mixtures sampled from field and tested)
- Developed simplified Excel Spreadsheet to optimize HMA mixture selection
- NJDOT evaluating now – still “Experimental”

Example #1: 4” Thick HMA; 15 ft PCC Slab Length

NJDOT HMA Overlay Selection Program

Step 1 - Determing appropriate HMA material to be placed directly over PCC to limit cracking due to horizontal deflection

	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M64
Horizontal Fatigue Life (Cycles)	*76168*	*15927*	*18047*	*20939*	*9295*	*672*	*2259*
	PASS	PASS	PASS	PASS	PASS	FAIL	PASS

CTE (in/in/C)	1.15E-05
HMA Overlay Thickness (in)	4
PCC Slab Length (in)	180
Temp at Bottom of HMA (°F)	50

Step 2 - Determine Appropriate HMA Material to be placed directly over PCC to limit cracking due to vertical deflection

	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
Vertical Fatigue Life (Years)	*1750.2*	*23.4*	*19.2*	*15.4*	*2.1*	*0.6*	*5.6*
	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL

ESAL's per Year	1.50E+05
FWD Vertical Deflection at 18 Kips (mils)	8
-OR-	
PCC Condition (Good, Avg, Poor)	Good

Step 3 - Determine Optimum HMA Overlay

	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
Vertical Fatigue Life (Years)	*4266.7*	*121.9*	*102.1*	*150.5*	*13.2*	*2.4*	*47.1*
	PASS	PASS	PASS	PASS	PASS	FAIL	PASS

Requested Design Life to Limit Cracking (Years)	10

Summary Matrix

Select optimum PCC overlay and Select HMA Overlay

	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
PCC Overlay (Horizontal)	PASS	PASS	PASS	PASS	PASS	FAIL	
PCC Overlay (Vertical)	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL
HMA Overlay	PASS	PASS	PASS	PASS	PASS	FAIL	PASS

Example #2: 4” Thick HMA; 78 ft PCC Slab Length

NJDOT HMA Overlay Selection Program

Step 1 - Determing appropriate HMA material to be placed directly over PCC to limit cracking due to horizontal deflection

Horizontal Fatigue Life (Cycles)	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M64
	1378	*287*	*198*	*166*	*21*	*24*	*7*
	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

CTE (in/in/C)	1.15E-05
HMA Overlay Thickness (in)	4
PCC Slab Length (in)	936
Temp at Bottom of HMA (°F)	50

Step 2 - Determine Appropriate HMA Material to be placed directly over PCC to limit cracking due to vertical deflection

Vertical Fatigue Life (Years)	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
	1750.2	*23.4*	*19.2*	*15.4*	*2.1*	*0.6*	*5.6*
	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL

ESAL's per Year	1.50E+05
FWD Vertical Deflection at 18 Kips (mils)	8
-OR-	
PCC Condition (Good, Avg, Poor)	Good

Step 3 - Determine Optimum HMA Overlay

Vertical Fatigue Life (Years)	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
	4266.7	*121.9*	*102.1*	*150.5*	*13.2*	*2.4*	*47.1*
	PASS	PASS	PASS	PASS	PASS	FAIL	PASS

Requested Design Life to Limit Cracking (Years)	10

Summary Matrix

Select optimum PCC overlay and Select HMA Overlay

	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
PCC Overlay (Horizontal)	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	
PCC Overlay (Vertical)	PASS	PASS	PASS	PASS	FAIL	FAIL	FAIL
HMA Overlay	PASS	PASS	PASS	PASS	PASS	FAIL	PASS

Example #3: 4” Thick HMA; 15 ft PCC Slab Length

NJDOT HMA Overlay Selection Program

Step 1 - Determing appropriate HMA material to be placed directly over PCC to limit cracking due to horizontal deflection

Horizontal Fatigue Life (Cycles)	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M64
	76168	*15927*	*18047*	*20939*	*9295*	*672*	*2259*
	PASS	PASS	PASS	PASS	PASS	FAIL	PASS

CTE (in/in/C)	1.15E-05
HMA Overlay Thickness (in)	4
PCC Slab Length (in)	180
Temp at Bottom of HMA (°F)	50

Step 2 - Determine Appropriate HMA Material to be placed directly over PCC to limit cracking due to vertical deflection

Vertical Fatigue Life (Years)	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
	381.5	*1.4*	*1.1*	*0.3*	*0.1*	*0.1*	*0.1*
	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

ESAL's per Year	1.50E+05
FWD Vertical Deflection at 18 Kips (mils)	16
-OR-	
PCC Condition (Good, Avg, Poor)	Poor

Step 3 - Determine Optimum HMA Overlay

Vertical Fatigue Life (Years)	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
	930.0	*7.2*	*5.8*	*3.1*	*0.5*	*0.2*	*1.2*
	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

Requested Design Life to Limit Cracking (Years)	10

Summary Matrix

Select optimum PCC overlay and Select HMA Overlay

	Strata	RBL	HPTO	9.5mm SMA (76-22)	9.5H76	12H76	12M76
PCC Overlay (Horizontal)	PASS	PASS	PASS	PASS	PASS	FAIL	
PCC Overlay (Vertical)	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
HMA Overlay	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL