Aggregate Blending for Friction Resistance

Indiana Mineral Aggregates Association
Winter Workshops
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Friction-Related Projects at NCSC

- *Identification of Laboratory Technique to Optimize Superpave HMA Surface Friction Characteristics* (completed)
- *Evaluation of Recycled Asphalt Pavement for Surface Mixtures* (draft final report in review)
- *Maximizing the Use of Local Materials in HMA Surfaces* (draft final report submitted)

Goals for Required Lab Method

- Test friction and texture
- Accelerate polishing
- Test asphalt mixtures, not aggregates only
- Ideal to be able to test in lab and field
- Led to identification of Dynamic Friction Tester and Circular Track Meter
- Needed a polisher to match
- Idea from NCAT, refined by NCSC

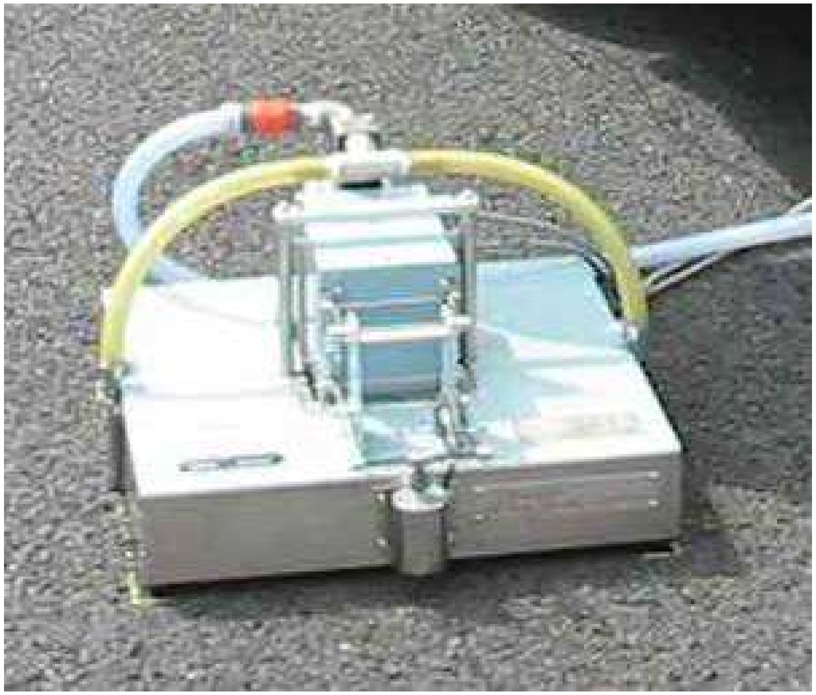
Background

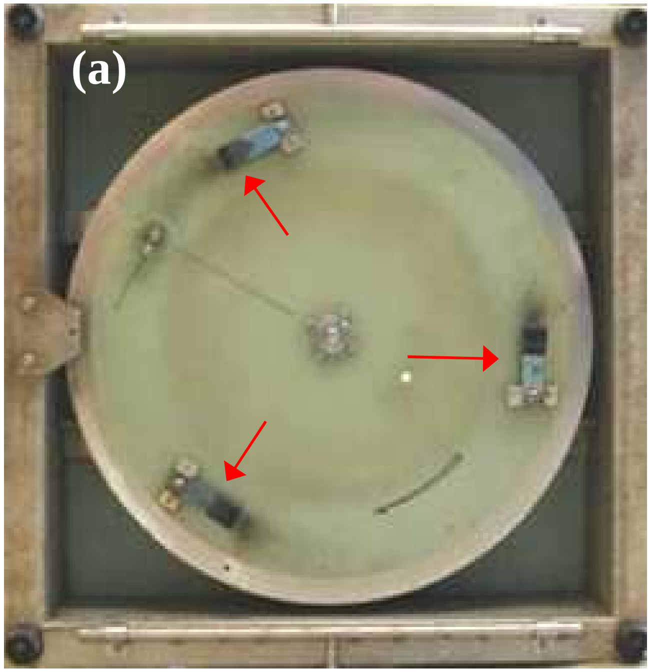
- Pavement friction is function of microtexture and macrotexture.
  - Microtexture – provided by aggregate surface
  - Macrotexture – determined by overall properties of the pavement surface (NMAS and gradation of aggregates, binder content, etc.)
- Friction at the tire-pavement interface is caused by:
  - Adhesion – between tire and surface (microtexture)
  - Hysteresis - deformation of tire around surface irregularities (macrotexture)

Designing for Pavement Friction

- Most states specify allowable surface aggregates by type based on historical usage and *aggregate* tests.
  - Useful, but do not consider macrotexture.
  - Need mixture test and specifications.
- Widely available aggregates are carbonates.
  - Tend to polish
- Polish resistant aggregates are not readily available and must be hauled in -- $$$.
- Coarser mix texture may reduce the need for high microtexture aggregates.

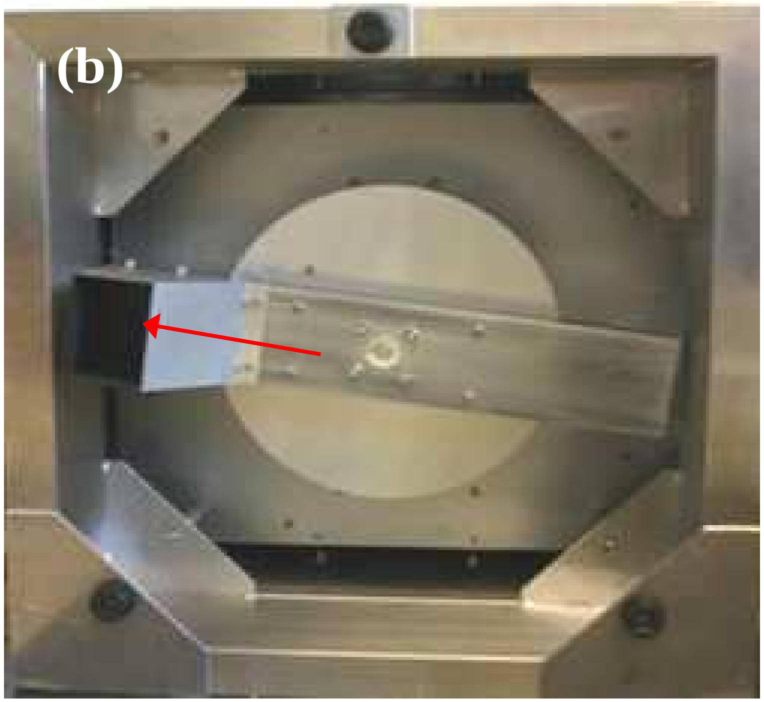
Dynamic Friction Tester (DFT)





DFT – dynamic friction at 20 km/h (DF20)

Circular Track Meter (CTM)

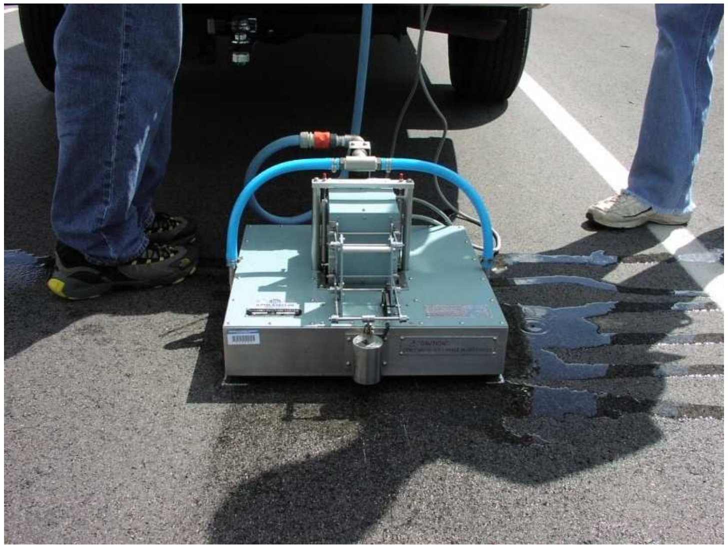


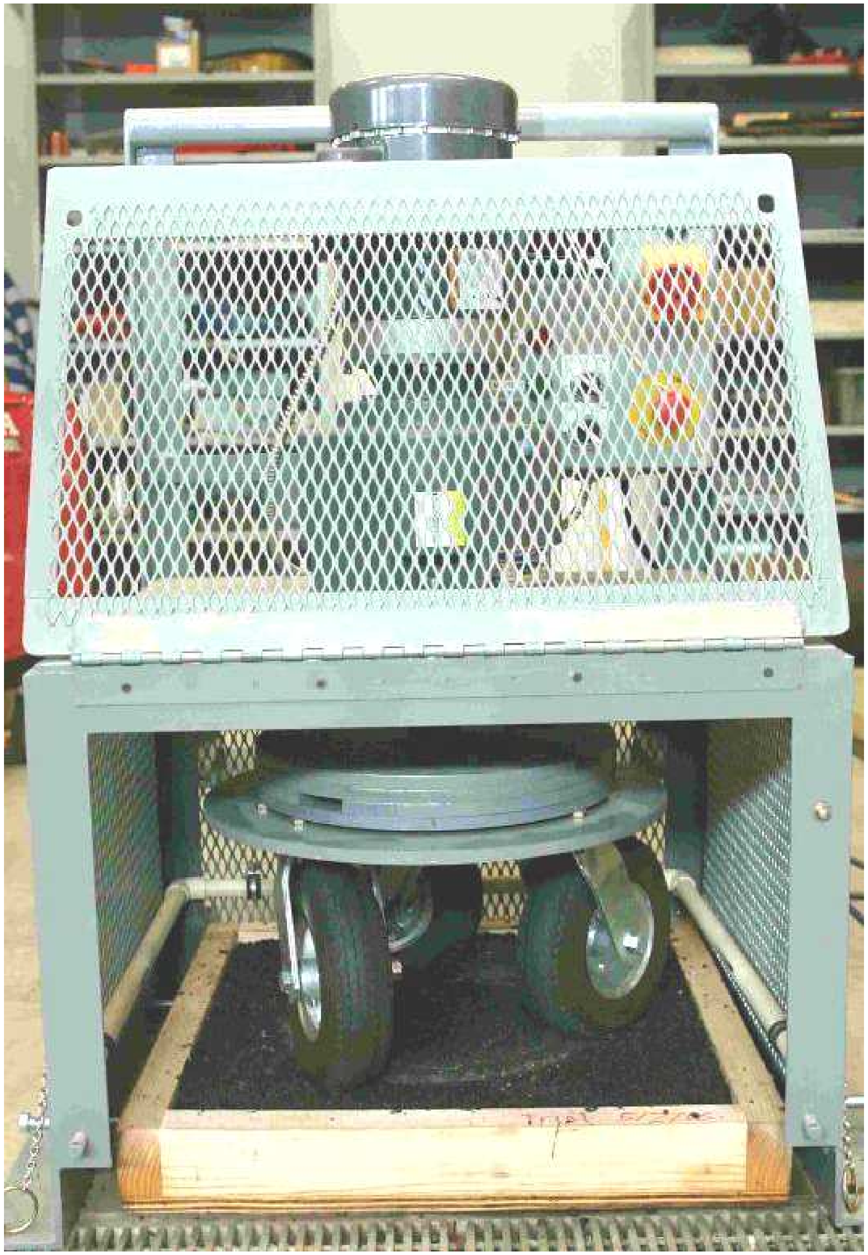
CTM – Mean Profile Depth, mm

International Friction Index

IFI ($F60$, S_p)

$$\begin{cases} F60 = 0.081 + 0.732 DF_{20} e^{\frac{-40}{Sp}} \\ S_p = 14.2 + 89.7 MPD \end{cases}$$

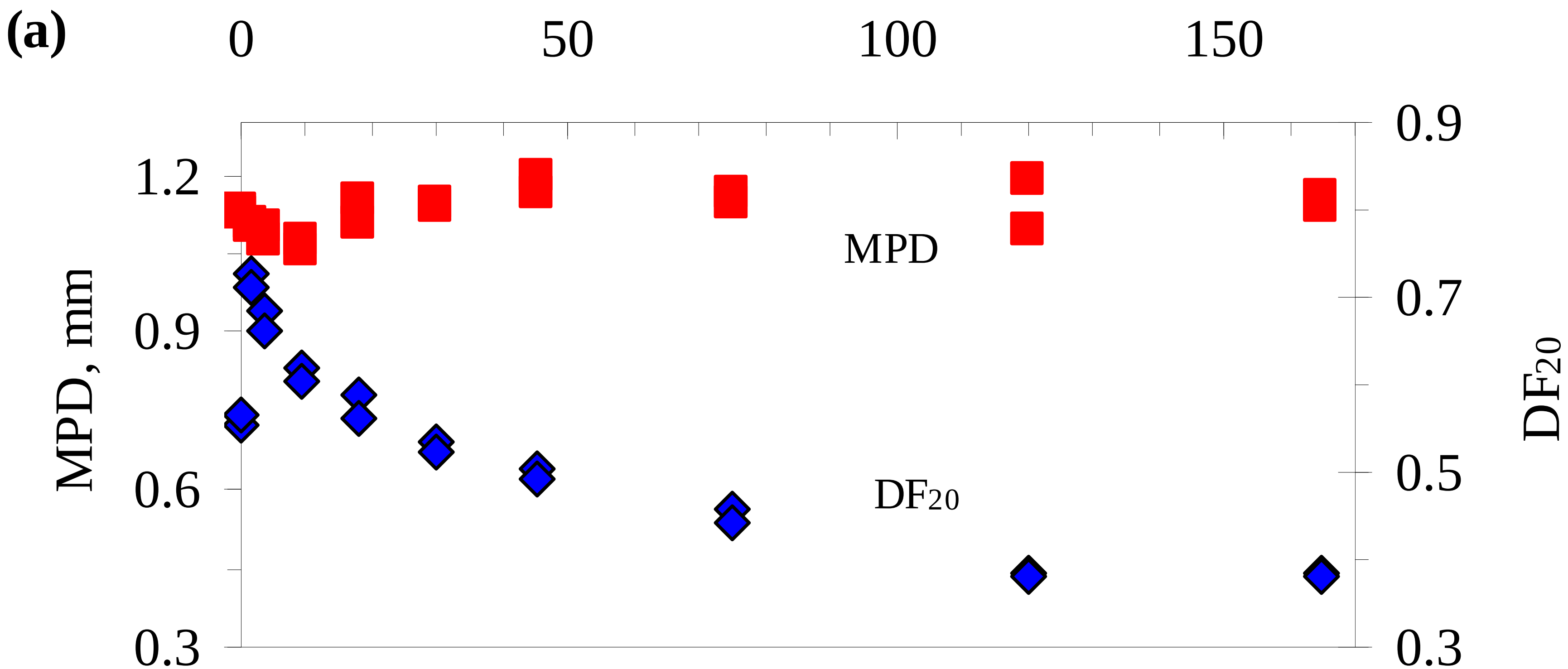




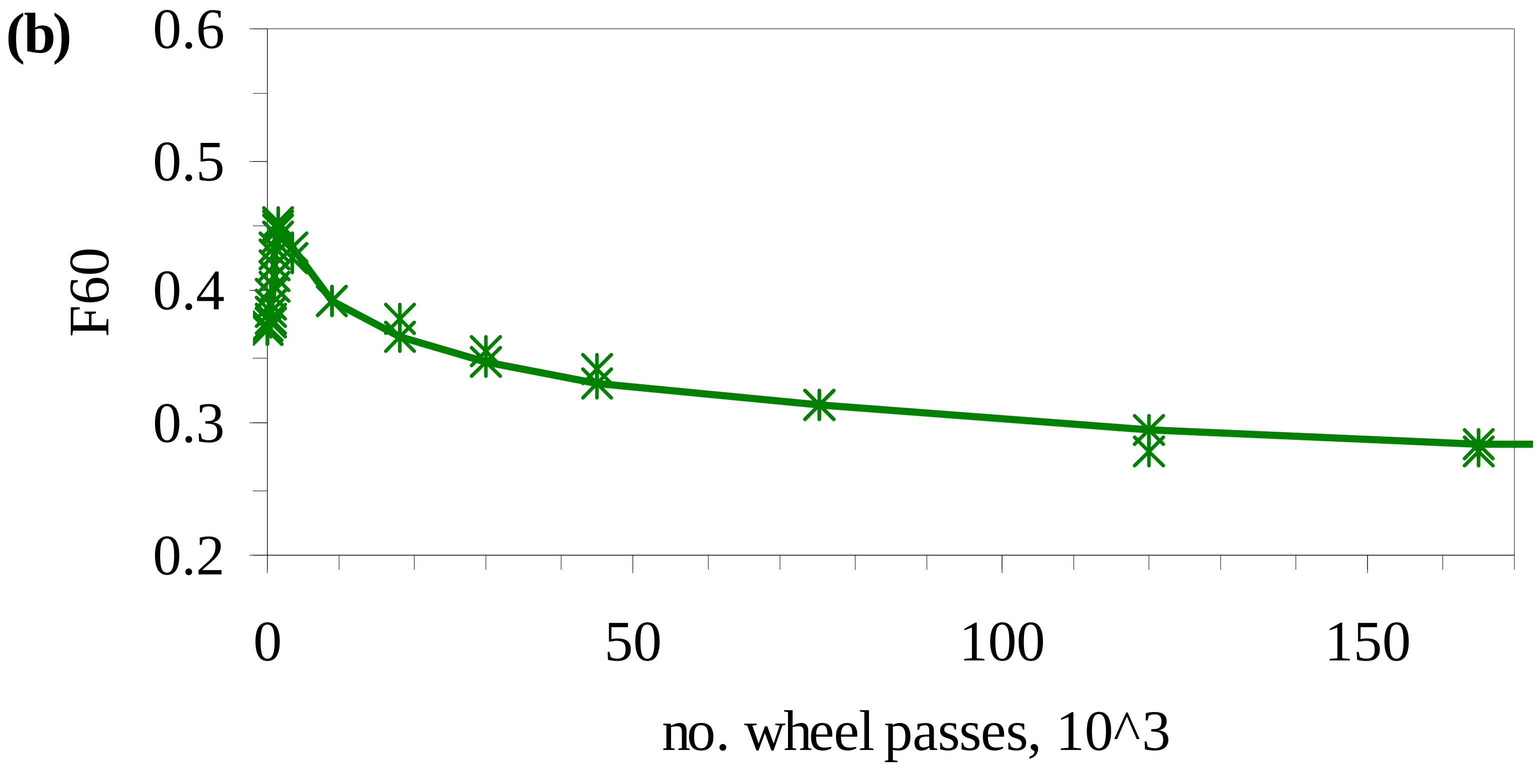
Circular Track Polishing Machine


(a)
(b)
(c)
(d)

Texture and Friction (DF20)



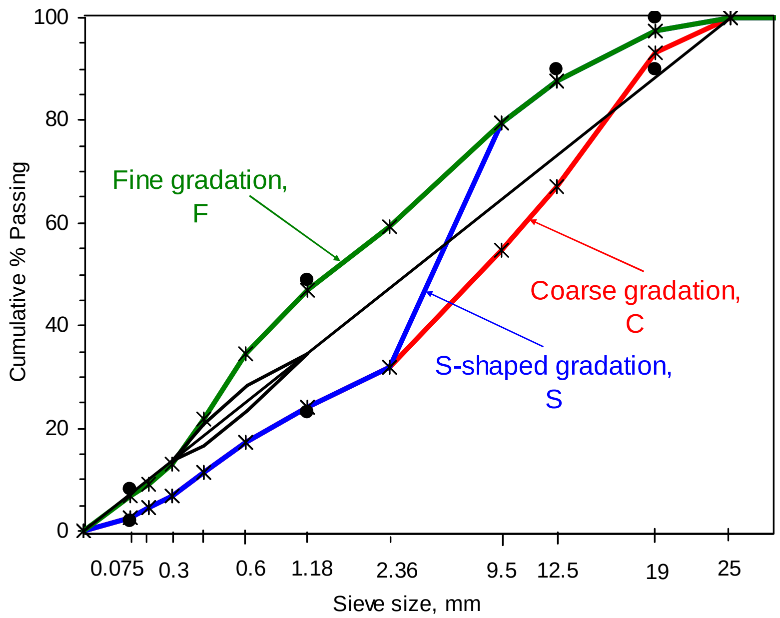
IFI (F60)



Identification of Laboratory Techniques to Optimize Superpave HMA Surface Friction Characteristics

- Assess/optimize combined micro- and macrotexture
  - Develop/modify lab device (and tests) to polish HMA
  - Evaluate influence of mix composition on friction
  - Develop model for friction prediction
- Funded by Indiana and Iowa DOTs

Experimental Design



- 3 Gradations – Fine, Coarse, S-shaped
- 2 Aggregate Sizes – 9.5 mm and 19 mm
- 2 Friction Aggregates – steel slag and quartzite
- 3 “Soft” Aggregates – hard and soft limestones, and dolomite
- 4 Friction Agg Contents – 10, 20, 40, 70%

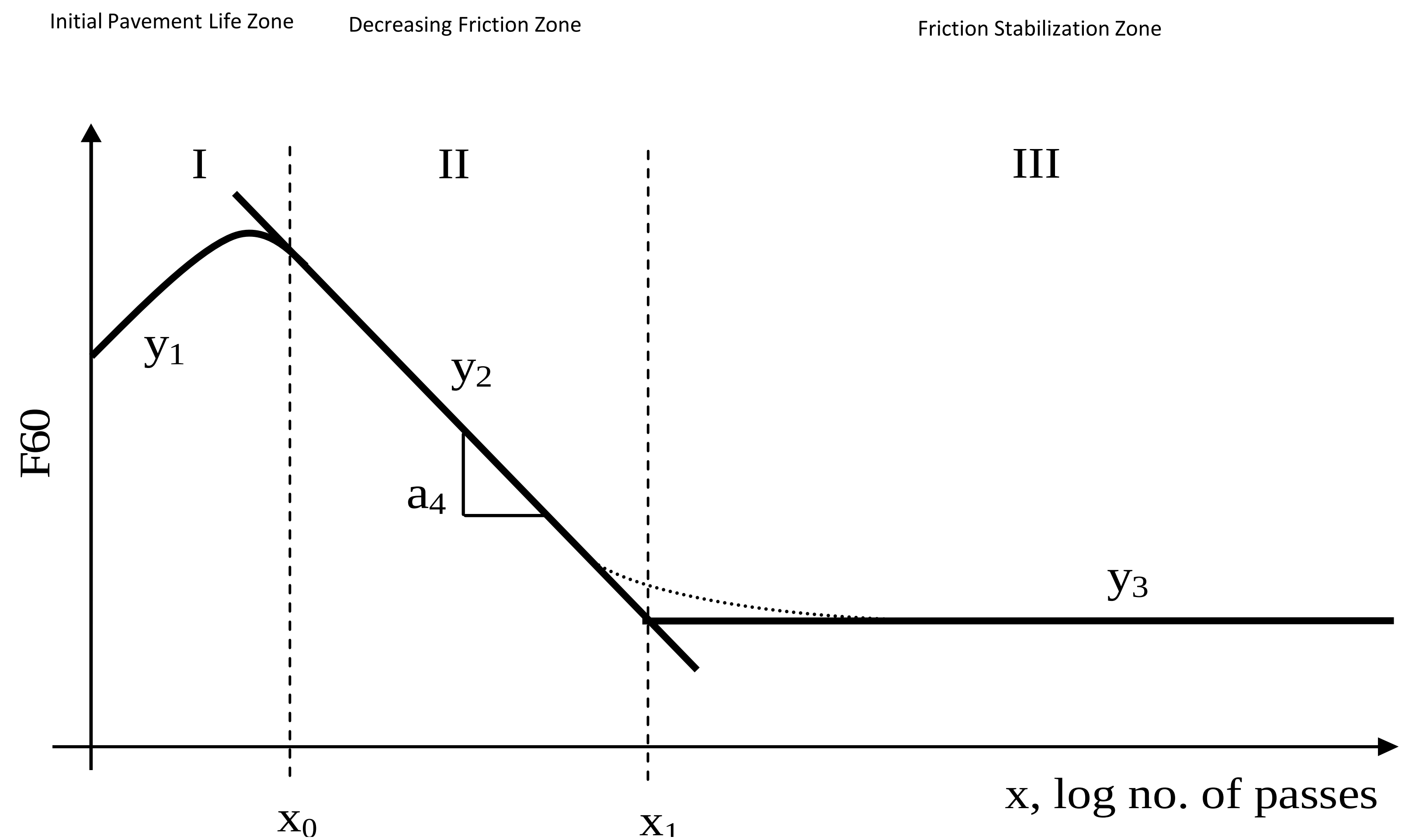
Key Findings

- Steel slag slightly more polish resistant than quartzite.
- Mixes with soft limestone polished more than hard limestone or dolomite.
- Increasing friction aggregate content improved polishing resistance.
- Friction aggregate content should be at least 20%.
- Larger NMAS mixes have higher friction.
- Fineness modulus of the aggregate blend appears to correlate with pavement macrotexture.

Key Findings

- S-Shaped gradation generally resulted in higher macrotexture.
- Frictional properties can be improved by using polish resistant aggregate blends or by increasing macrotexture (FM).
- A model for describing the change in friction parameters under traffic/ polishing was developed.
- The lab procedures are very promising tools.

Polishing Model



Calculate F60 (IFI Value) per E1960. See AAPT 2009, Kowalski et al.

Evaluation of Recycled Asphalt Pavement for Surface Mixtures

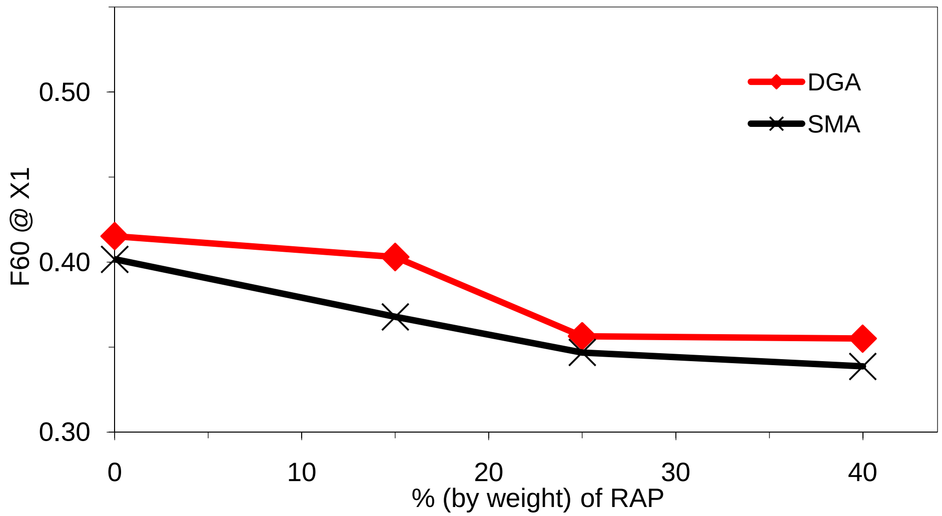
- RAP not used to full extent in surfaces
  - Unknown aggregates
- Determine threshold level of RAP that has minimal effect or method to test aggregates in the RAP

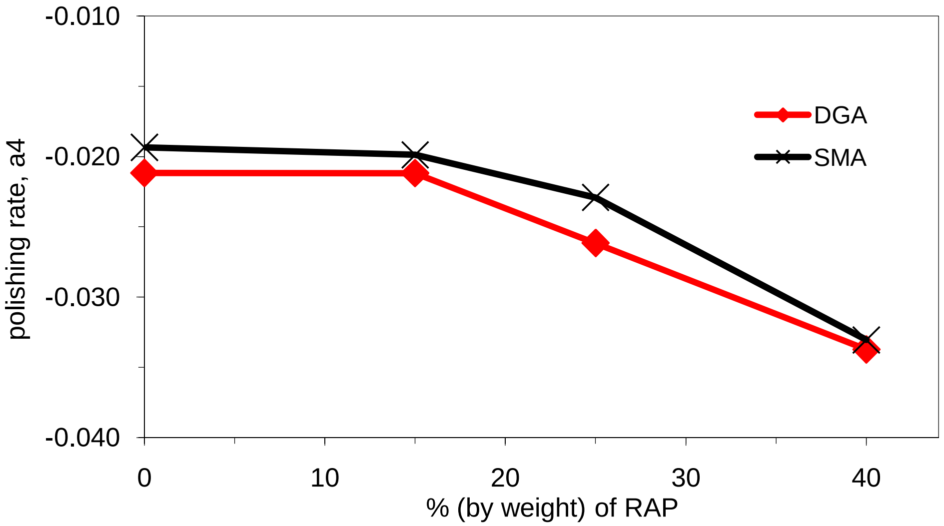
Experimental Design

- Mix Type – HMA and SMA
- Lab Fabricated “Worst Case” RAP
- RAP Content – 0, 15, 25, 40%
- Friction Aggregate – Steel Slag and ACBF Slag

➢ Field testing of 8 existing surfaces (15-25% RAP)

Use of the Model





Preliminary Findings and Recommendations

- Report not officially accepted yet.
- Adding small quantities of poor quality RAP had little effect on friction.
- Adding higher amounts of RAP had an effect on friction.
- When blended with high quality friction aggregates, performance was still acceptable at 25% RAP.
- Adding more RAP without changing binder grade increased critical cracking temperature.

Preliminary Findings and Recommendations

- Field friction testing suggests 15% RAP is acceptable and higher RAP contents are possible for medium volume roadways.
- Recommended limit of 20% RAP by binder replacement for Category 3 and 4 roadways.
  - Further field testing for Category 5.
  - On case by case basis, consider higher RAP contents when RAP aggregates can be known.

Disclaimer

- The views expressed here are those of the presenter and do not represent the views of the sponsor!

Maximizing the Use of Local Materials in HMA Surfaces

Objective – explore opportunities to allow the use of more local materials in HMA in place of “imported” fine and coarse aggregates

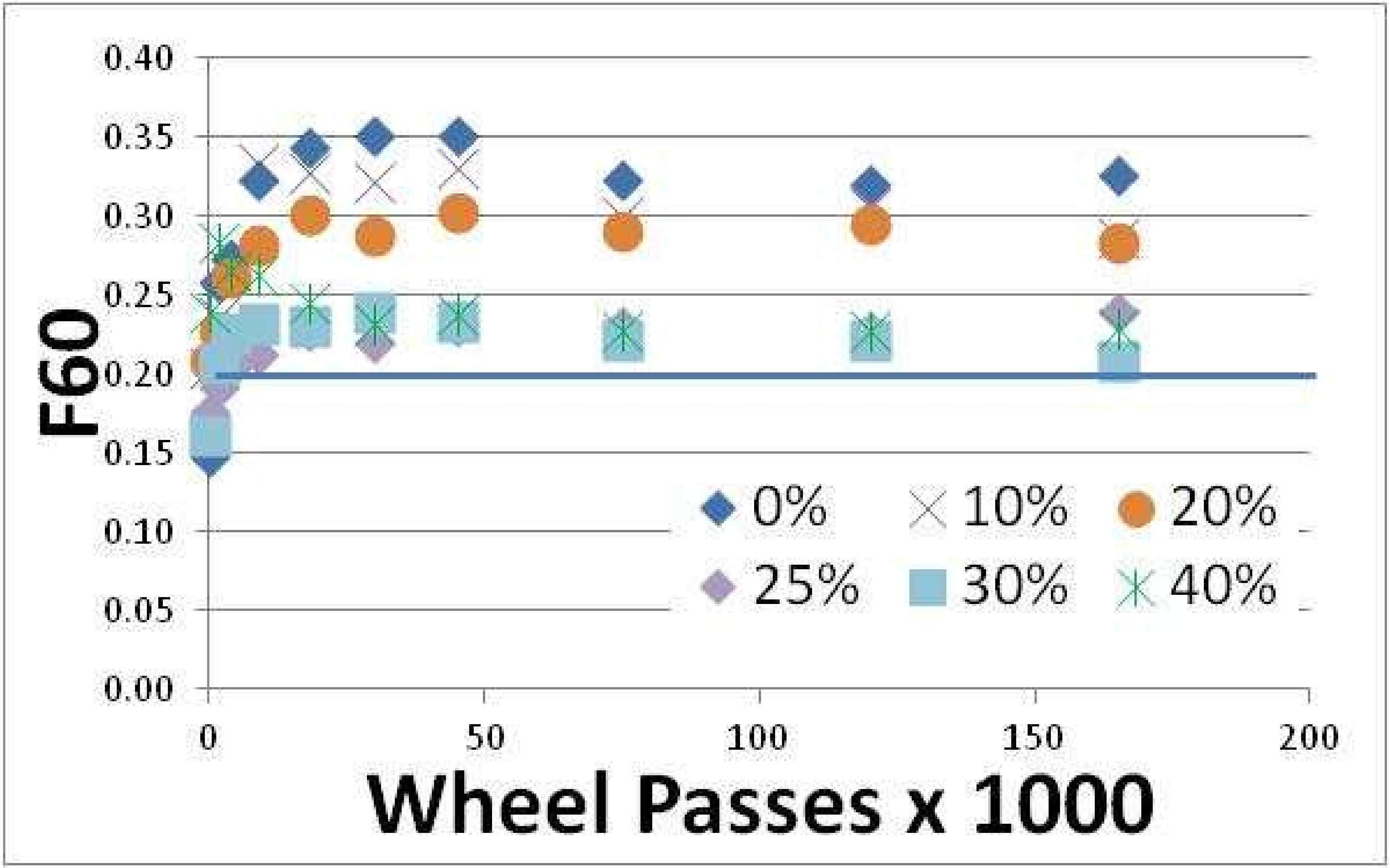
Draft final report will be submitted this afternoon.

Very preliminary results.

Experimental Design

- Local coarse aggregate content – up to 40% blended with the same 3 high quality aggs
- Local fine aggregate content – up to 20% (with steel slag, ACBF slag and sandstone CA)
- HMA and SMA mixes

OMM selected aggregates for testing.



F60
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
50
100
150
200
Wheel Passes x 1000
0%
10%
20%
25%
30%
40%

Preliminary Findings

- Adding polish susceptible agg caused decrease in surface friction in HMA and SMA.
- But friction was still acceptable at up to around 20% local agg.
- Fine aggregate data was somewhat erratic.
- Appears fine agg up to 20% was small negative effect on friction.
- Other considerations besides friction.

Potential Cost Savings

Substituting local agg for steel slag could save:

- $1.50 to 2 per ton of hot mix (fine aggregate)
- $3 to 4 per ton of hot mix (coarse agg)
- $4.50 to 6 per ton of hot mix (both)
- Up to 10% of cost of mix
- $3000 to 4000 per lane mile of surface mix

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Upcoming Event!

- North Central Asphalt User Producer Group Technical Conference
- Hyatt Regency, Indianapolis
- February 15-16, 2012

Questions???

NCAUPG Technical Conference
Hyatt Regency, Indianapolis
February 15-16, 2012

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