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Evaluation of North Dakota's 4.75 mm NMAS Superpave Mixes for Thin Overlay Applications

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Presented by

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Motivation --- Need

- Correct surface defects (leveling)
- Create smooth riding surface
- Increase durability
- Improve skid resistance
- Reduce tire-pavement noise
- Provide economical surfacing alternative for low class roads -- LVRs

Objectives

- To evaluate the rutting resistance performance of the #4 mixes (APA)
- To evaluate the benefits/impacts of the #4 mixes as thin overlays or as maintenance application for low/medium volume hwys
- To provide utility for fine aggregate stockpiles and for natural sands

Material Selection

- Aggregates

  Northwood aggregate source

  - 60:40 Natural fines / Crushed fines
  - 50:50 Natural fines / Crushed fines

- Asphalt Binders

  - PG 64-28
  - PG 58-28

Aggregate Gradations for the 60:40 NF to CF Blend

Aggregate Description	Aggregate No.	Blend %	Sieve Size	Blend Gradation	Control Points Lower	Control Points Upper
Natural Fines	1	60	5/8"	100	100	100
Crushed Fines	2	40	1/2"	100	100	100
			3/8"	99.6	100	100
			#4	95.7	80	100
Sum of % =100			#8	80.4	65	100
			#16	61.6	40	80
			#30	42.8	25	65
			#50	22.8	7	40
Nominal Maximum Agg. Size = No. 4			#100	9.9	3	20
			#200	6.9	2	10

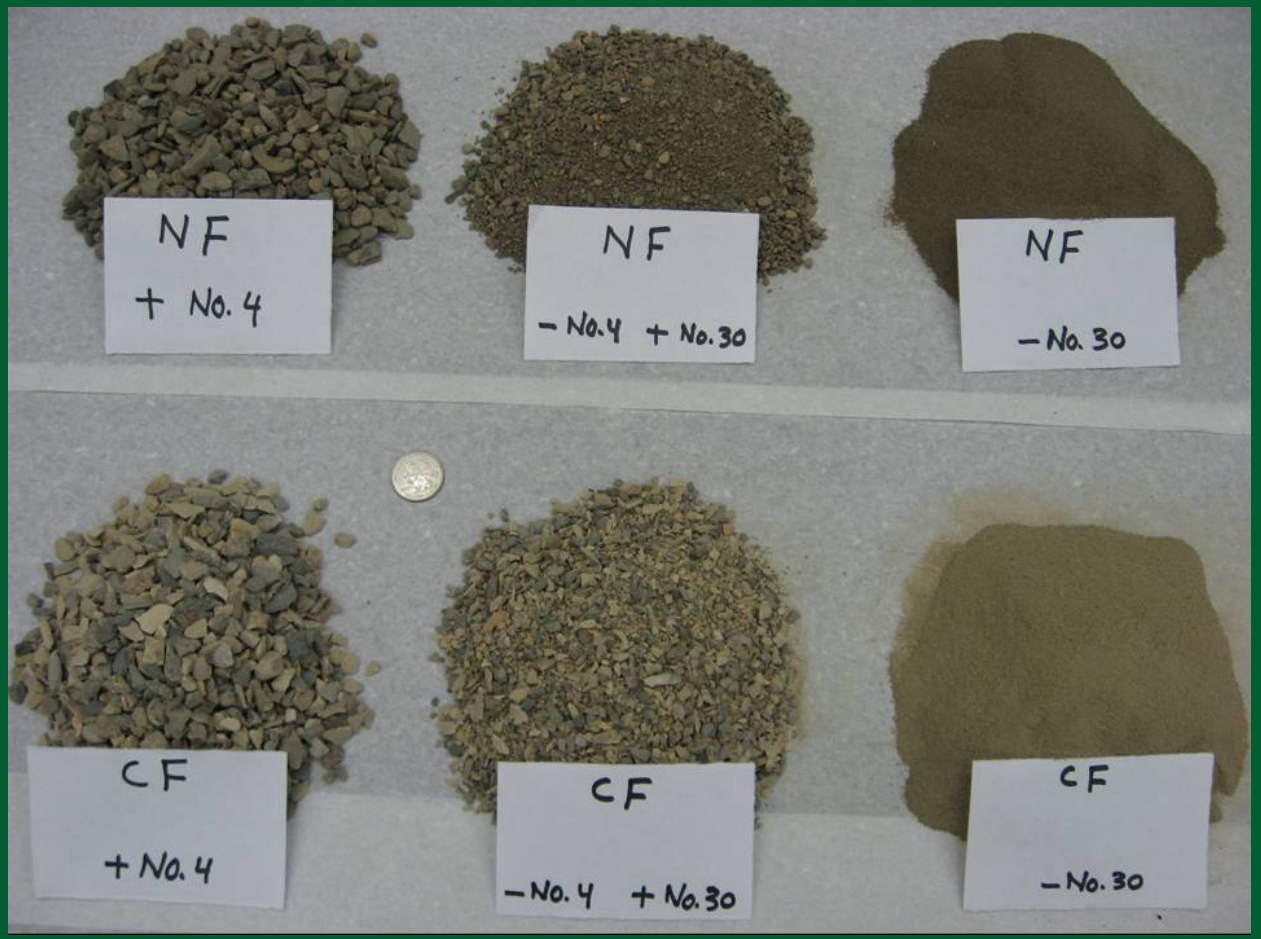
Aggregate Gradations for the 50:50 NF to CF Blend

Aggregate	Aggregate	Blend	Sieve	Blend	Control Points	
Description	No.	%	Size	Gradation	Lower	Upper
Natural Fines	1	50	5/8"	100	100	100
Crushed Fines	2	50	1/2"	100	100	100
			3/8"	99.5	100	100
			#4	95.6	80	100
Sum of % =100			#8	79.0	65	100
			#16	59.2	40	80
			#30	40.9	25	65
			#50	22.1	7	40
Nominal Maximum Agg. Size = No. 4			#100	10.2	3	20
			#200	7.2	2	10

Aggregate Blend Properties

Blend Properties	%NF : %CF Blend	
	60:40 Blend	50:50 Blend
Fine Aggregate Angularity	40.5	41.7
Bulk SpG (G_{sb})	2.525	2.531
Apparent SpG (G_{sa})	2.718	2.723
Water Absorption (%)	2.812	2.791
Light Wt Particles (%)	1.1	1.1
Toughness (% Loss)	22.6	22.6

Aggregate Blend Properties



Mix Design
Superpave

- Mixes: 64(60:40), 64(50:50), 58(60:40), 58(50:50)
  - **Binder:** PG 58-28, PG 64-28
  - **Aggregate:** No. 4 NMAS (with 60:40 & 50:50 blends)
- Batching: (+ No. 4), (- No. 4 & + No. 30), (- No.30)
- Ndes: 75 gyrations
- Air Void Design: 6%
- Short Term Aging: 2 hours

Mix Design Considerations

- 6% air void design
- %Dust in the blends @ 6 to 8%
- %VMA between 16 and 18%
- FAA values of blends above 40
- The dust to effective asphalt content 0.9 - 2.2
- Volume of the effective asphalt ≤ 12
- APA rut depth about 9.5 mm (3/8 inch)

Voids Analysis @ Various AC Contents

Study Mix Designs	Properties @ Different AC Contents				
AC Content (%)	6.0	7.0	8.0	9.0	10.0
PG 64-28 Binder with 60:40 Aggregate Blend					
Bulk Specific Gravity of the Mix (Gmb)	2.230	2.251	2.273	2.290	
Percent Aggregate	94	93	92	91	
Theor. Maximum SpG of Mix (Gmm)	2.431	2.406	2.370	2.342	
Air Voids, Va (%)	8.3	6.5	4.1	2.2	
Voids in Mineral Agg. (VMA)	17.7	17.8	17.9	18.1	
Voids in Mineral Agg. Filled (VFA)	53.2	63.7	76.9	87.8	
PG 64-28 Binder with 50:50 Aggregate Blend					
Bulk Specific Gravity of the Mix (Gmb)	2.229	2.261	2.287	2.288	
Percent Aggregate	94	93	92	91	
Theor. Maximum SpG of Mix (Gmm)	2.445	2.411	2.362	2.338	
Air Voids, Va (%)	8.8	6.2	3.2	2.2	
Voids in Mineral Agg. (VMA)	17.7	17.4	17.4	18.2	
Voids in Mineral Agg. Filled (VFA)	50.3	64.2	81.6	88.2	

Voids Analysis @ Various AC Contents

Study Mix Designs	Properties @ Different AC Contents				
AC Content (%)	6.0	7.0	8.0	9.0	10.0
PG 58-28 Binder with 60:40 Aggregate Blend					
Bulk Specific Gravity of the Mix (Gmb)		2.259	2.279	2.286	2.267
Percent Aggregate		93	92	91	90
Theor. Maximum SpG of Mix (Gmm)		2.446	2.380	2.354	2.323
Air Voids, Va (%)		7.6	4.3	2.9	2.4
Voids in Mineral Agg. (VMA)		17.5	17.7	18.3	19.9
Voids in Mineral Agg. Filled (VFA)		56.3	75.9	84.1	87.8
PG 58-28 Binder with 50:50 Aggregate Blend					
Bulk Specific Gravity of the Mix (Gmb)	2.242	2.270	2.295	2.290	
Percent Aggregate	94	93	92	91	
Theor. Maximum SpG of Mix (Gmm)	2.446	2.411	2.380	2.348	
Air Voids, Va (%)	8.4	5.8	3.6	2.5	
Voids in Mineral Agg. (VMA)	17.2	17.1	17.1	18.2	
Voids in Mineral Agg. Filled (VFA)	51.5	65.9	79.1	86.4	

Mix Properties @ Design AC

Mix Properties	(64) 60:40	(64) 50:50	(58) 60:40	(58) 50:50	Spec's
Optimum AC (%)	7.2	7.1	7.5	7.0	< 8 Desired
Density (pcf)	140.7	141.3	141.6	141.6	
Air Voids (%)	6.0	6.0	6.0	6.0	6.0
VMA (%)	17.8	17.4	17.6	17.1	16.0-18.0
VFA (%)	66.3	65.9	66.1	65.9	65.0-78.0
%Gmm @ Ninitial	86.2	86.3	86.5	86.2	89.0 Max
%Gmm @ Nmaximum	95.2	96.3	94.5	95.4	98.0 Max
AC Film Thickness (m)	6.3	6.2	6.2	5.9	
Dust/Effective AC Ratio	1.3	1.4	1.4	1.5	0.9-2.2
Asphalt Absorption (%)	2.25	2.18	2.69	2.33	
Maximum SpG @ Ndes	2.399	2.409	2.414	2.414	
Effective (Gme)	2.672	2.674	2.703	2.684	

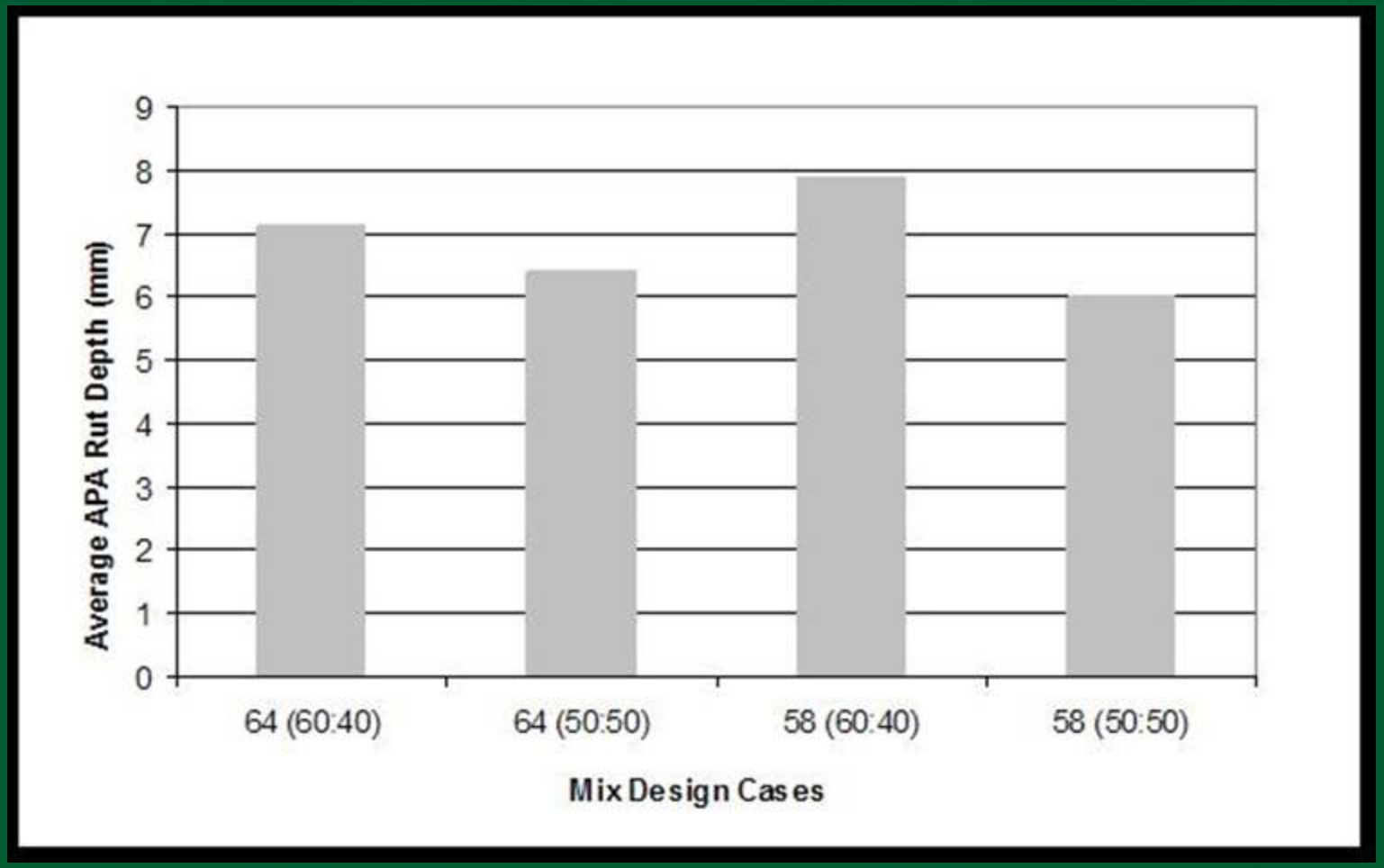
Performance Evaluation

- Volumetrics
- Evaluate resistance to rutting (APA)
  - Samples are 6-inch in dia & 3-inch thick
  - At 7% air voids
  - Dry sample testing @ 64ºC and 58ºC
  - Samples conditioned for 6 to 8 hours
  - 8,000 cycles
  - Rut depth criterion – 9.5 mm (3/8 inch)

APA Rut Resistance Results

Mix Design Cases	Left Side Depth (mm)		Right Side Depth (mm)		AVE (mm)
PG 64-28 & 60:40 Agg. Blend	*1*	*2*	*3*	*4*	7.1
	7.26	6.97	7.60	6.57	
PG 64-28 & 50:50 Agg. Blend	*5*	*6*	*7*	*8*	6.4
	6.20	6.92	6.16	6.46	
PG 58-28 & 60:40 Agg. Blend	*9*	*10*	*11*	*12*	7.9
	8.07	7.89	7.56	8.04	
PG 58-28 & 50:50 Agg. Blend	*13*	*14*	*15*	*16*	6.0
	6.49	6.19	5.29	5.90	

APA Rut Resistance Results



Rut Depth Comparisons

Rut Depth Comparisons
100:00 & 80:20 Blends

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Rut Comparisons: PG 64-28 & (60:40 & 100:00 Blends)

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Conclusions

- Rut depths for all mixture combinations were within the 9.5 mm specification
- 6% air void design works well with No. 4 mixes
- Mixes with higher Crushed Fines performed best
- Rut depth increases with higher %AC
- Rut depth increases with higher testing temp.

Conclusions

- Mixes with different PG grades (PG 64-28 & PG 58-28) were tested at **different temperatures**

  Need to be careful when doing comparisons

  - For 50:50 blends, %AC similar, mix with PG58-28 performed better (lower testing temp)
  - For 60:40 blends, %AC lower for PG64-28, mix with PG64-28 performed better (higher testing temp)

(1) %CF (Agg/Blending)	(2) %AC Volumetrics	(3) Testing Temperature

Recommendations

- The %AC should be kept low (preferably < 7.5%)
  - 6% AV design should be considered as the norm for No. 4 mixes
  - Dust proportion should be kept at 8% or higher
- % VMA should be maintained between 16 & 18%
- In future research, all mixes should be tested at the same temp (i.e. test temp for the lowest grade binder) ---

So results can be compared

Recommendations

- FAA for the blend >> 40
  - (preferably FAA > 40 for all aggregate sources)
- Use higher quality Natural Fines
  - FAA = 40+ * Water absorption < 2
  - Since natural fines with marginal quality produced successful mixes (50:50 & 60:40 blends), higher quality NF may allow for successful mixes with higher %NF
- Field trials are recommended

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Thank you

Questions?

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