Minnesota Department of Transportation

Memo

Office of Materials
1400 Gervais Avenue, Mail Stop 645
Maplewood, MN 55109

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TO: File: Research on RAP Activation and Blending

FROM: Mark Watson
Research Project Engineer

DATE: 4 November, 2009

SUBJECT: Blending of RAP with Virgin Aggregates (No add AC)

Introduction:
This memo describes the RAP mixing experiment which consisted of blending different proportions of RAP with virgin aggregate at different temperatures and no additional liquid AC.

The experiment took place the morning of Wednesday, November 4, 2009 at the Crane Creek Asphalt (A division of Mathy Construction) Plant No. 84 shown in Figure 1 and located at 680 NW 24th St in Faribault Mn. This three tier batch mix plant is equipped with 6 virgin aggregate belt feed bins and 1 RAP belt feed bin. The mixing unit is a twin pugmill type with ≤ ¾" clearance from the walls and timer controls for wet and dry mixing.

Figure 1. Crane Creek Asphalt Plant No. 84, Faribault, Mn.

The RAP was sampled from millings obtained from TH 60 and blended with four types of virgin aggregates as shown in Table 1.

Table 1. RAP and Virgin Aggregate Properties

Pit	Source of Material	TOTAL Sp. G	Minus #4	
			% Passing	Sp. G
66110	NELSON ¾" ROCK	2.712	3	2.712
19123	CASTLE ROCK ½" X #4	2.675	3	2.675
19123	CASTLE ROCK MAN SAND	2.627	25	2.627
66110	NELSON NAT SAND	2.612	23	2.612
	TH 60 MILLINGS	2.663	18	2.663

The virgin aggregate and RAP were blended in a single batch as shown in **Error! Reference source not found.**. Various plant temperatures, measured at the point of discharge and RAP contents that were used are shown in Table 2. Note that temperature was also measured at the point of sampling.

Figure 2. Batch Size

Table 2. Blending Iterations

Run No.	Plant Temp (°F)	RAP Content (%)	Dwell Time (Sec.)	Sample Temp. (°F)
1	420	10	30	320 (Front) - 344 (Back)
2	490	24	30	290 – 300
3 (1st 1/2)	400	24	30	230 (Front)
3.5 (2nd 1/2)	375	24	30	225 (Back)

Figure 3. Iteration (Run) No 1.

Figure 4. Iteration (Run) No 2.

Figure 5. Iteration (Run) No 3.

Samples:

- 3, 5 gal. steel pails of each iteration (run no.)
- 2, 5 gal pails of virgin aggregate material (Castle Rock + Nelson Sand)
- 1, 5 gal pail of Nelson ¾" Rock

- 2, 5 gal pails of RAP material (TH 60 Millings)
- 2, sealed plastic bags of RAP material (TH 60 Millings)
- 1 sealed plastic bag of crushed millings (Not used in the mixing experiment)

Figure 6. From LT to RT Iteration (Run) 3, 2 and 1.

Observations:

- Recycled binder clumped around fines and formed ‘balls’
- RAP binder appeared to activate in all iterations
- Higher concentrations of RAP yielded noticeably more binder activation
- Higher temperatures yielded greater activation (blending) of the recycled binder

BITUMINOUS PLANT MIX DESIGN REPORT
Minnesota Department of Transportation
District 6 Materials Lab
2900 48th Street NW
Rochester, MN 55903
Phone: 507-286-7586
Fax: 507-285-7112

06-2009-141
Date: 8/11/2009

THIS MIX DESIGN REPORT IS NOT VALID UNTIL PLANT NO. INDICATED BELOW IS CERTIFIED.

ENGINEER KYLE LAKE	FOR TH 60
PROJECT NUMBER SP 6606-34	
CONTRACTOR SIGN.	

SPEC	2360 AFT
SPEC YEAR	2009
MIX TYPE	SPWEB340
AC GRADE	PG 58-28

THIS MIXTURE HAS BEEN REVIEWED FOR VOLUMETRIC PROPERTIES ONLY, IT DOES NOT ASSURE THAT FIELD PLACEMENT AND COMPACTION REQUIREMENTS HAVE BEEN MET.

PLANT NO. 6-2784 - 2009A JOB MIX FORMULA

Begin With Test Number

SP	WE	301
- -	- -	- - -

AFT Properties

Pbe	4.8
SA	28.9
Adj. AFT	8.7

Sieve Size (mm)	(in.)	Composite Formula	Broad Band		For Information Only Virgin Formula
25.0	(1)				
19.0	(3/4)	100	100	100	
12.5	(1/2)	87	85	100	
9.5	(3/8)	79	35	80	
4.75	(#4)	69	30	80	
2.36	(#8)	57	25	65	
1.18	(#16)	45			
0.600	(#30)	33			
0.300	(#50)	15			
0.150	(#100)	6			
0.075	(#200)	4.3	2.0	7.0	
Spec. Voids		4.0	3.0	5.0	
	% AC	5.6 (TOTAL)	5.2		%AC (NEW)

PERCENT PASSING

Total AC = 5.6
Add AC = 4.4
4.1 add

TM # 6-2009-21 Indicates a Gyratory Density of 148.3 (lbs/ft3) at 60 Design Gyrations
Use of anti-strip required: No

	Pit	Source of Material	Total Sp. G	Minus #4 % Passing	Minus #4 Sp. G
25 %	66110	NELSON 3/4" ROCK	2.712	3 %	2.712
25 %	19123	CASTLE ROCK MAN SAND	2.627	25 %	2.627
25 %	66110	NELSON NAT. SAND	2.612	23 %	2.612
25 %		TH 60 MILLINGS	2.663	18 %	2.663
%				%	
%		Dust out		%	
%				%	
%				%	
		Mix Aggregate Specific Gravity at the Listed Percentages =	**2.653**		**2.634**

FOR LAB INFORMATION ONLY: LAB COMPACTION TEMP. RANGE = 288-295 °F
Remarks ADDITIONAL QUALITIES TO BE TAKEN AT TIME OF PRODUCTION!

Mix Design Reviewed by:

Mix Design Specialist
06-2009-141 Ver. 1

cc: Dist Mat'ls Eng. - Tom Meath
Contractor - MATHY/CCA #2
KYLE LAKE

BITUMINOUS PLANT MIX DESIGN REPORT

Minnesota Department of Transportation
District 6 Materials Lab
2900 48th Street NW
Rochester, MN 55903
Phone: 507-286-7586
Fax: 507-285-7112

 # 06-2009-138

Date: 8/10/2009

THIS MIX DESIGN REPORT IS NOT VALID UNTIL PLANT NO. INDICATED BELOW IS CERTIFIED.

ENGINEER CHAD CASEY	FOR TH 60
PROJECT NUMBER SP 6607-42	
CONTRACTOR SIGN.	

THIS MIXTURE HAS BEEN REVIEWED FOR VOLUMETRIC PROPERTIES ONLY, IT DOES NOT ASSURE THAT FIELD PLACEMENT AND COMPACTION REQUIREMENTS HAVE BEEN MET.

SPEC	2360 AFT
SPEC YEAR	2009
MIX TYPE	SPWEB440
AC GRADE	PG 64-34

PLANT NO. **6-2784** - **2009A** JOB MIX FORMULA

Begin With Test Number

SP	WE	401
- -	- -	- - -

AFT Properties

Pbe	4.6
SA	27.7
Adj. AFT	8.5

Total AC = 5.2 %
Add AC = 4.7 %

Sieve Size (mm) (In.)	Composite Formula	Broad Band		For Information Only Virgin Formula (PERCENT PASSING)
25.0 (1)				
19.0 (3/4)	100	100	100	
12.5 (1/2)	95	85	100	
9.5 (3/8)	82	35	90	
4.75 (#4)	68	30	80	
2.36 (#8)	55	25	65	
1.18 (#16)	42			
0.600 (#30)	33			
0.300 (#50)	15			
0.150 (#100)	7			
0.075 (#200)	3.4	2.0	7.0	
Spec. Voids	4.0	3.0	5.0	
% AC	5.3	4.9		%AC (NEW)

4.5 add (TOTAL)

TM # 6-2009-32 Indicates a Gyratory Density of 148.6 (lbs/ft3) at 90 Design Gyrations
Use of anti-strip required: No

	Pit	Source of Material	Total Sp. G	Minus #4 % Passing	Minus #4 Sp. G
13 %	66110	NELSON 3/4" ROCK	2.712	4 %	2.712
16 %	19123	CASTLE ROCK 1/2" X #4	2.675	3 %	2.675
46 %	19123	CASTLE ROCK MAN SAND	2.627	100 %	2.627
12 %	66110	NELSON NAT. SAND	2.613	90 %	2.613
13 %		BMI MILLINGS	2.645	74 %	2.645
%				%	
%				%	
%				%	
		Mix Aggregate Specific Gravity at the Listed Percentages =	2.646		2.629

FOR LAB INFORMATION ONLY: LAB COMPACTION TEMP. RANGE = 265-275 °F

Remarks: ADDITIONAL QUALITIES TO BE TAKEN AT TIME OF PRODUCTION!

Mix Design Reviewed by:

Ken DeCramer

Mix Design Specialist

cc: Dist Mat'ls Eng. - Tom Meath
Contractor - MATHY/CCA #2