Effects of Recycled Materials in Asphalt Field and Lab Operations

By

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Hot Mix Asphalt(HMA) utilizing recycle materials is the predominant form of mix production in the Industry

According to Asphalt Pavement.ORG

- “According to the most recent survey, more than 79 million **tons** of **recycled materials** — primarily reclaimed **asphalt pavement material** (RAP) and **recycled asphalt** roofing shingles (RAS) — were used in new **asphalt pavement** mixtures during the 2016 construction season.”

RECYCLE MATERIALS-RAP

Recycle Materials- Recycled Asphalt Shingles

Waste Manufacturer Shingle Source

<<Post Consumer Waste Shingles

OTHER RECYCLE MATERIALS

- Ground tire rubber(multiple processes used)
- Processed Ground Glass
- Crushed Tiles (and similar composite materials)
- Plastics (in binders)

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - Specifications limits
  - Type of Recycle Material
    - RAP
    - RAS
  - Availability of recycle material
  - Mixture design issues
  - Plant capabilities/issues
  - Laydown operations

Utilization of Recycle Materials

- **Considerations in Using Recycle Materials**
  - Specifications limits
    - EXAMPLE

403.2.6 Reclaimed Asphalt. A maximum of 30 percent virgin effective binder replacement may be used in mixtures without changing the grade of binder. The asphalt binder content of recycled asphalt materials shall be

403.2.6.1 Reclaimed Asphalt Pavement. Reclaimed Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. Mixtures may be used with more than 30 percent virgin effective binder replacement provided testing according to AASHTO M 323 is included with the job mix formula that ensures the combined binder meets the grade specified in the contract. All RAP material, except as noted below, shall be tested in

EX: SP125C w/PG 64-22

-<30 % Effective binder replacement, No additional binder testing

->30 % Effective binder replacement, Will need AASHTO M323, APPENDIX X1,X2 blend data

Utilization of Recycle Materials

- **Considerations in Using Recycle Materials**
  - Specifications limits
    - EXAMPLE

401.2.2 Reclaimed Asphalt.

Binder	Percent Effective Virgin Binder Replacement		
	RAP	RAS	RAP and RAS combination
Contract Grade Virgin Binder shall be used	0 - 20	0 -10	RAP + (2*RAS) ≤ 20
Virgin Binder shall be Softened One Grade[a]	21 - 40	11 - 20	20 < RAP + (2*RAS) ≤ 40
Blend Chart[b]	0 - 100	N/A	N/A
Extraction and Grading of Binder from final Mixture[c]	0 - 100		

[a]The virgin binder shall have a low temperature grade 6 degrees lower than the binder grade specified in the contract. Lowering the high temperature of the virgin binder is not required; however, if lowered, the virgin binder shall have a high temperature grade no lower than 6 degrees below the binder grade specified in the contract. (Ex. Contract grade PG 64-22; virgin binder could be either PG 58-28 or PG 64-28). The Pressure Aging Vessel (PAV) test temperature (AASHTO M320) shall be tested at 19° C, regardless of the high temperature grade of the selected virgin binder

[b]Testing in accordance with AASHTO M323 including raw data shall be included with the mix design which demonstrates that the grade of the combine mixture meets the contract requirements.

[c]Testing in accordance with either AASHTO T319, or AASHTO T164 and R59 along with grading in accordance with AASHTO M320 including raw data shall be included with the mixt design which demonstrates that the grade of the combine mixture and rejuvenator, if applicable, meets the contract requirements.

EX: BP-2 w/PG 64-22

-BP2 w/40 % RAP, RAP %ac=5.0,
% Recycle Binder (in mix)=2.0%
%Effective Binder=4.9 %,
% Effective Binder Replacement=40.8 %
TESTING NEEDED: Binder Blend Chart

Ammann Plant,
Columbus, OH

2019 AVERAGE
RAP%=55 %

60 % RAP in
9.5mm Surface

70 % RAP in
19.0mm Base

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - Type of Recycle Material
    - RAP
    - RAS

Effects of Recycled Materials in Asphalt Field and Lab Operations

Crushing/Screening of RAP is an integral part of making a consistent HMA product

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - RAP:
    - If using lower % RAP (<15 %) may get by with a one grading (ex. 1/2” minus RAP)
    - If using higher % RAP, fractionated RAP will help in maintaining consistency
      - COARSE RAP, FINE RAP

Effects of Recycled Materials in Asphalt Field and Lab Operations

- Testing of recycle products needed to maintain consistent mixture properties:

Bluegrass Testing Laboratory **Aggregate Testing Results** 2/24/2020

AVOCA CRUSHER FINE RAP

Date	3/20/18	3/21/18	4/4/18	4/18/18	7/5/18	7/5/18	8/13/18	8/1/18	8/13/18	8/15/18	8/21/18	8/28/18	9/10/18	9/25/18	10/9/18	Date
Sampling Notes/ Comments	Avoca Stockpile	Avoca Stockpile	Avoca Stockpile	Avoca Stockpile	Frap from Crusher	Frap from Crusher		Frap from Stockpile?	FRAP from Crusher	FRAP from Crusher	FRAP from Crusher	FRAP from Crusher	FRAP from Crusher	FRAP from Crusher	FRAP from Crusher	Sampling Notes/ Comments
3/4"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	3/4"
1/2"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1/2"
3/8"	99.7	99.7	100.0	99.5	100.0	100.0	98.2	98.0	98.2	99.9	99.7	99.0	99.6	98.9	99.4	3/8"
#4	96.0	95.6	91.6	95.6	98.9	98.4	85.8	87.3	85.8	97.6	94.1	92.5	94.0	92.6	93.8	#4
#8	78.3	77.2	69.7	76.3	80.2	77.6	64.5	63.4	64.5	77.0	72.0	73.9	75.1	74.8	72.7	#8
#16	57.4	56.1	52.2	55.5	56.3	53.8	46.2	44.4	46.2	53.9	53.2	52.6	49.8	51.7	53.0	#16
#30	42.3	41.0	37.5	40.5	40.2	38.5	33.6	31.7	33.6	38.9	37.3	36.4	38.2	37.0	35.9	#30
#50	27.4	26.6	23.7	25.2	24.6	23.6	21.5	19.9	21.5	25.5	23.6	22.3	23.7	21.6	22.2	#50
#100	20.0	19.4	17.3	18.1	17.8	16.8	15.6	14.3	15.6	18.6	17.1	16.5	16.4	17.9	16.9	#100
#200	15.7	15.5	13.8	14.2	13.9	12.4	12.1	11.2	12.1	14.2	12.2	12.8	13.5	13.2	12.1	#200
% AC	7.1	6.4	5.3	5.0	5.4	5.3	5.2	5.8	5.2	5.4	5.3	5.2	5.4	5.3	5.2	% AC

AVERAGE		
Sieve	%Pass	SD
3/4"	100.0	0.00
1/2"	100.0	0.00
3/8"	99.4	0.69
#4	93.6	4.19
#8	73.3	5.22
#16	52.2	3.80
#30	37.5	2.87
#50	23.7	2.07
#100	17.3	1.52
#200	13.3	1.30
% AC	5.5	0.52

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - Recycled Asphalt Shingles
    - Processing the shingles required

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - Recycled Asphalt Shingles
    - If feeding RAS as sole recycle material consider preblending with a sand
      - Erratic feed for low feed rate (2.5-4.0% cold feed)
      - 50/50 blend with sand(mfg. sand/nat.sand) would increase ≥5 % for better feed
    - If feeding both RAP and RAS can preblend RAP/RAS for more consistent feed

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - **Availability of recycle material**
    - **Rural areas may have greater challenge for excess of RAP:**
      - **may choose lower % feed rate to spread RAP over more mix tons**
      - **May choose to blend RAP and RAS to maximize recycle asphalt content**
      - **Less factors to deal with**

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Considerations in Using Recycle Materials**
  - **Availability of recycle material**
    - **Urban areas may have large surplus of recycle (RAP)**
      - **May choose high % RAP**
      - **May have to use softer binder grade or rejuvenator for blending to address:**
        - **Meeting specification requirements**
        - **Minimizing mixture cracking susceptibility**
        - **Workability for laydown crews**

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Mix Design Issues:**
  - **RECYCLE ASPHALT CONTENTS UTILIZED**
    - **Strong thought that RAP may only offer up 80-85 % of the TOTAL RAP % Binder and RAS only 50 %**
    - **If taking 100 % credit for the TOTAL Binder content Mix may be actually be realizing a lower % asphalt content that is truly effective-MIX DRY**
    - **If HMA w/Recycle has the asphalt extracted, recovered and graded is that truly correct?**
    - **Most State agencies require extracted, recovered binder grading for confidence check on blended binder properties**
    - **Performance Testing (CRACK and RUT testing better solution)**

Effects of Recycled Materials in Asphalt Field and Lab Operations

- If recycle % requires a modifier to address binder stiffness:
  - Can use a softer binder grade (ex. PG 58-28 instead of the Contract bid item PG 64-22
  - Can use a rejuvenator with PG 64-22 to address moderate/moderately high RAP %'s (30-40%)
  - If RAP % are very high (45 %+), a softer binder grade and a rejuvenator may be needed
  - RAS: Have seen 176 to 185 C High temperature grades and low temperature grading to +25 C. What do you blend?

ADDITIVE (REJUVENATOR) SUPPLY SYSTEM

INDIVIDUAL TOTES(for smaller production targets)

BULK STORAGE TANKS (for larger production targets)

Ammann Plant,
Columbus, OH

2019 AVERAGE
RAP%=55 %

60 % RAP in
9.5mm Surface

70 % RAP in
19.0mm Base

EXAMPLE HIGH % RAP SURFACE AND PERFORMANCE TESTING

DATE: 5/28/2019

PROJECT NAME: 60 % RAP w/REJUVENATOR and PG 58-28 vs 25 % RAP w/PG 64-22

MIX TYPE: 9.5mm Surface

	Mix A (50 % Binder Replacement)	Mix B (21 % Binder Replaceent)
MIXTURE COMBINATION	60 % RAP w/0.10 % (wt. of mix) REJUVENATOR and PG 58-28	25 % RAP w/ PG 64-22
TEST PROPERTY		
IDEAL CT-INDEX	126.3	108.2
Disk-Shaped Compact Tension (DCT), Fracture Energy (J/m²)	**389.7** (@ -12 C)	**362.3** (@ -12 C)
Hamburg Loaded Wheel Rut Depth (mm):	3.4 mm @ 10,000 cycles	4.1mm @ 10,000 cycles

Effects of Recycled Materials in Asphalt Field and Lab Operations

- **Plant capabilities/issues**
  - **To keep sufficient RAP for higher daily mix production:**
    - **crushing/screening operation critical to maintain supply**
    - **Two RAP fractions**
      - **Coarse RAP(1/2”x3/8”)**
      - **FINE RAP(3/8” minus)**
      - **Typical 60-65% FRAP**
      - **35-40% Coarse RAP**

QC CONCERN: ASPHALT CONTENT CONCERN DUE TO HIGH RAP USE

Powerscreen: RAP % AC Higher

RAP Crushing/Screening:% AC Lower

Effects of Recycled Materials in Asphalt Field and Lab Operations

- PLANT PRODUCTION CONCERNS:
  - **PLANT LIMITATIONS ON RAP %**
    - **RAP FEED SYSTEM**
    - **HEATING/DRYING RAP (HEAT TRANSFER FROM VIRGIN AGGREGATES)**
    - **RAP w/HIGH % MOISTURE and MAINTAINING BAGHOUSE TEMPERATURES**
    - **HIGH RAP % AND MAINTAINING ADEQUATE VEIL OF VIRGIN AGGREGATE IN DRUM**

PLANT STORAGE TIME AND MIX TEST PROPERTIES

- **DOES EXTENDED PLANT STORAGE HAVE AN EFFECT ON MIXTURE PROPERTIES?????**
  - **CRACK TESTING**
    - **IDEAL CT-INDEX**
    - **FLEXIBILITY INDEX**

Hurstbourne Lane Laboratory Design Phase

- IDEAL CT Index = 95.3
- More absorptive dolomite coarse aggregate

HURSTBOURNE LANE CT INDEX VALUES FOR ALL SUBLOTS

SUBLOT#	CT-INDEX	DATE	Time to Placement	NOTES:
1.1.5	125.52	10/29/18	50 min.	
1.2.0	117.65	10/29/18	50 min.	
1.2.5	76.03	10/30/18	5 hrs.	
1.3.0	102.35	11/2/18	50 min.	
1.3.5	103.90	11/2/18	50 min.	
1.4.0	78.20	11/2/18	50 min.	%AC low 0.4 %
1.4.5	96.90	11/6/18	1.5 hrs.	
2.1.0	113.70	11/6/18	1.5 hrs.	
2.1.5	92.50	11/6/18	3.0 hrs.	
2.2.0	102.90	11/6/18	3.0 hrs.	
2.2.5	103.90	11/7/18	3.0 hrs.	
2.3.0	109.80	11/7/18	3.0 hrs.	
2.3.5	112.40	11/7/18	1.5 hrs.	
2.4.0	80.90	11/8/18	1.5 hrs.	%AC low 0.4 %

OBSERVATIONS:

(1)	AVERAGE CT INDEX FOR ALL SUBLOTS=	101.19
(2)	LOW CT-INDEX VALUE=	76.03
(3)	HIGH CT-INDEX VALUE=	125.52
(4)	FACTORS AFFECTING CT-INDEX VALUES:	
	- STORAGE TIME	
	-% AGGREGATE ABSORPTION CHARACTERISTICS	

MoDOT Performance JSP

2.0 Flexibility Index (FI) Testing. The FI testing will be completed in accordance with Illinois Test Procedure 405 dated 01/01/16 available at http://www.modot.org/business/contractor_resources/forms.htm

FLEXIBILITY INDEX	Ideal CT	
NMAS <190	NMAS <190	Percent of Contract Price
< 2.0	< 32	98%
2.0 – 3.9	32 – 60	100%
4.0 – 7.9	60 - 97	102%
>8.0	> 97	103%

MnDOT Superpave Performance Testing and Increased Density - JSP

Effects of Recycled Materials in Asphalt Field and Lab Operations

- LAYDOWN CONCERNS (ISSUES):
  - If lower % Recycle, placement of mix is less affected
  - If high % recycle, WITHOUT ADDRESSING STIFFNESS OF MIX, the asphalt mixture will be more difficult to place/compact
    - Softer binder grade or 64-22 with rejuvenator to help

CONCLUSIONS

- Asphalt mixes utilizing recycle can be designed to accommodate even the very high RAP %'s
- Fractionating the RAP into multiple gradings gives much better control of final mixture volumetrics
- If using high recycle content the need to address hardness of the recycle binder by either softer binder grade and/or rejuvenator is there

THANKS