PERFORMANCE OF RECYCLED MATERIALS FOR ASPHALT SURFACES: US EXPERIENCE

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ABPV MEETING

FORTALEZA, BRAZIL

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Outline

- **Introduction**
- **Current US Practices**
- **Best Practices**
- **Performance**
- **Cost Savings**
- **Conclusion**

Reclaimed Asphalt Pavement (RAP)

- **In the USA recycling began over 40 years ago because of:**
  - Oil embargo – shortages and high prices
  - Environmental concerns
  - Development of milling machines

MILLING

- Removes old/distressed pavement
- Improves smoothness
- Eliminates costly shoulder work
- Maintains drainage features, curbs, overhead clearance
- Valuable rehabilitation option


WHAT TO DO WITH THE RAP?

Typical Asphalt Mix

- **95% aggregate**
- **5% asphalt binder**

Reusing:

- **Reduces need to quarry more aggregate**
  - Increasingly difficult to open a new pit or quarry
- **Reduces energy/costs to produce, process, transport aggregate**
- **Reduces asphalt demand**

TODAY IN THE USA

- Asphalt pavement is *the* most widely recycled material
- 100 million tons reclaimed annually
- 95% is reused or recycled
- $1.8 billion in savings
- Reduces demand for new aggregates and binder and the energy to produce them
- Strong incentives to use more RAP in more mixes – economic and environmental

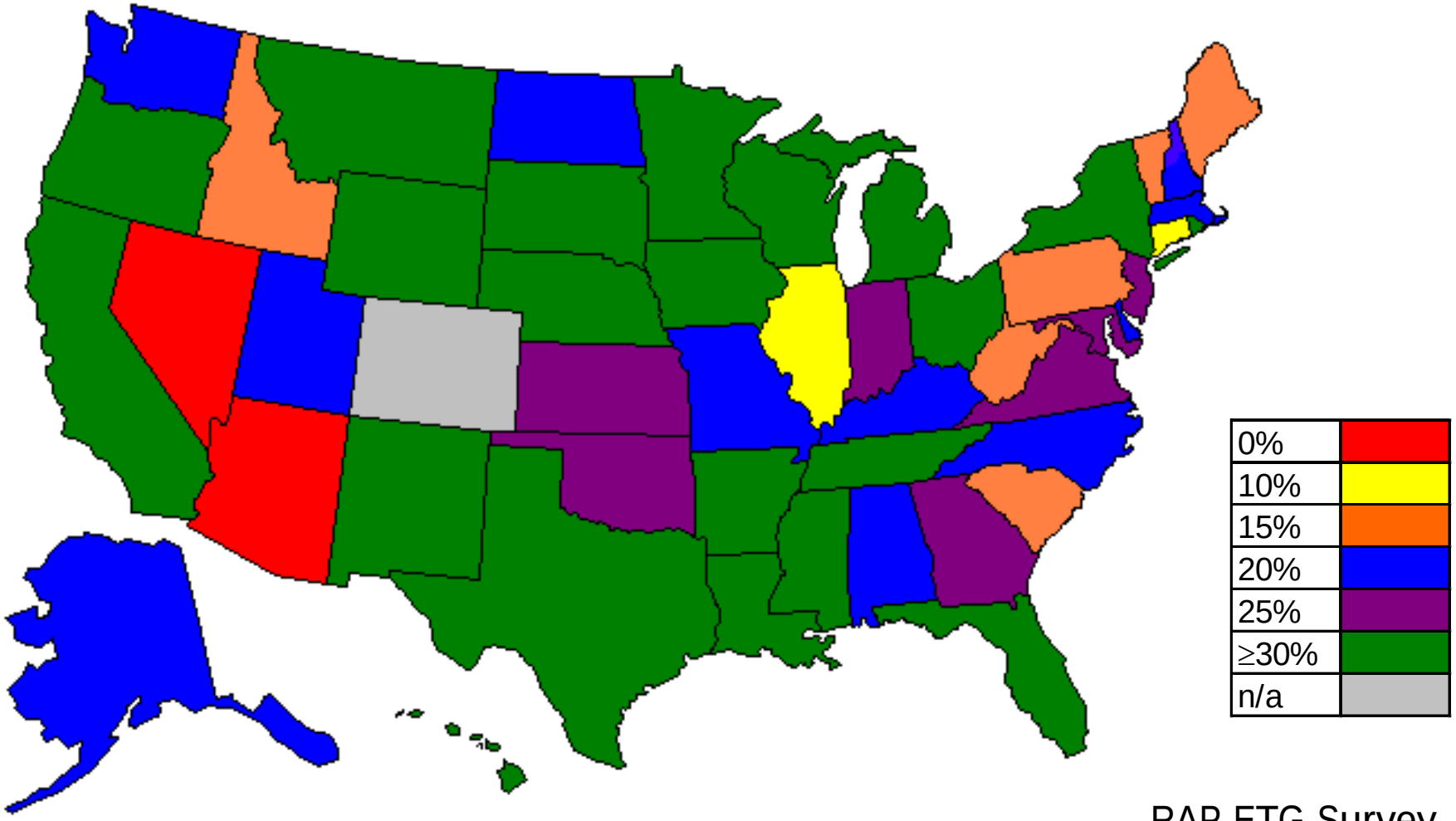
Current US Guidelines

- **Adjust grade of binder added to account for the hard, oxidized binder in the RAP**
  - 0 to 15% RAP, no binder grade change
  - 16-25% RAP, decrease virgin binder grade
  - Over 25% RAP, test RAP binder to determine appropriate virgin grade (or allowable RAP content)
- **Percentage by weight of RAP in the mixture.**
- **Based on non-fractionated mixes with about 5% binder in RAP and new mix.**

50 US States

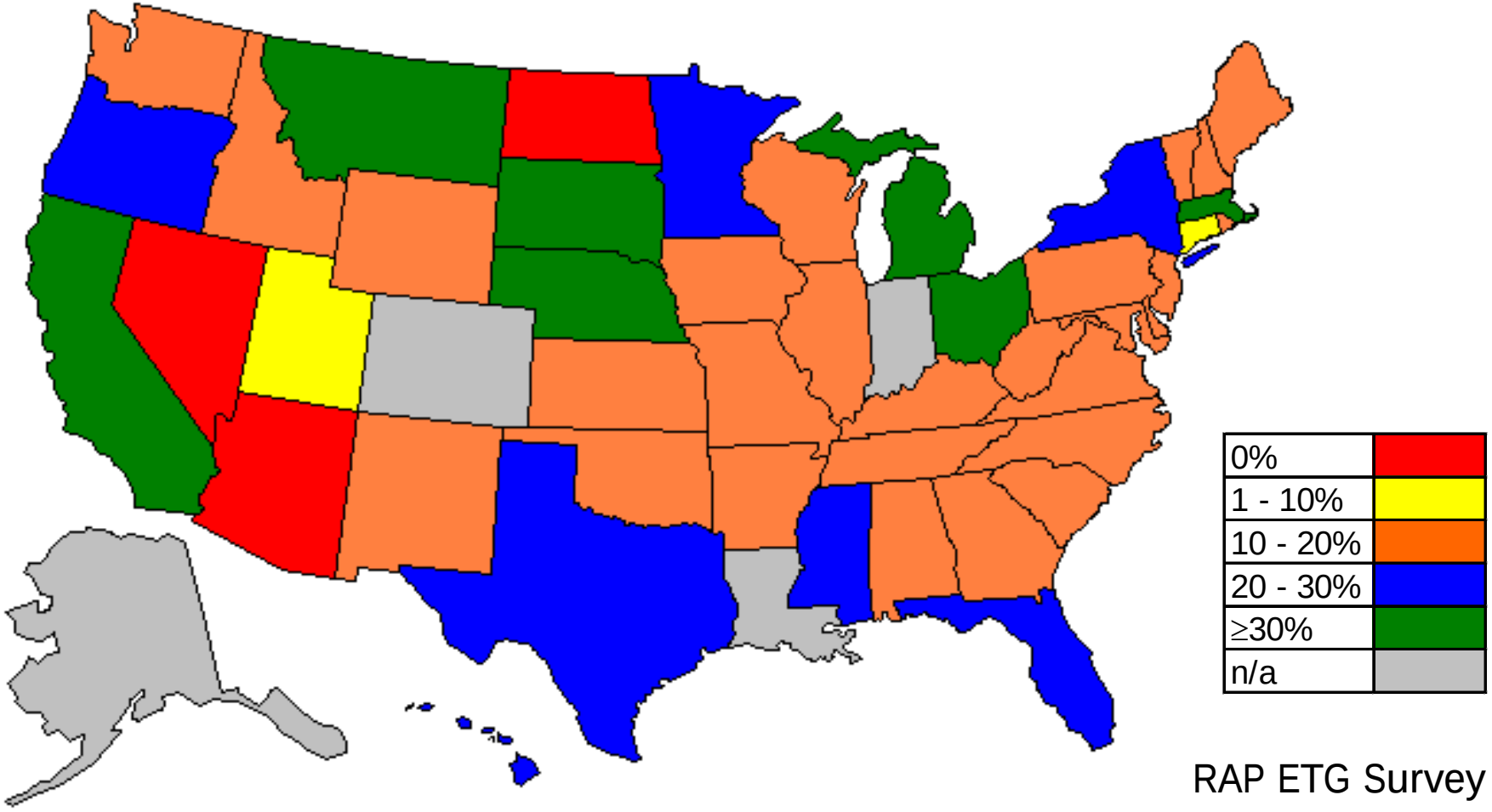
- **Every state is different!**
- **National specifications are guidelines, not requirements**
- **States have adapted the guidelines to suit their methods, perceptions and experience.**

BASE MIXES – SPECIFICATIONS IN 2009



RAP ETG Survey

BASE MIXES -- AVERAGE USE



RAP ETG Survey

Why Aren't Contractors Using All the RAP They Can?

- **Guidelines require use of softer binder for high RAP contents.**
  - May not be readily available
  - May be more expensive
  - May be harder to compact
- **Takes more attention to detail.**

Surface Mixes

- **Typically specifications allow lower RAP contents because of:**
  - Friction of unknown aggregate types
  - Potential for cracking of stiffened mixes
- **Thinner lifts have less overall aggregate demand than intermediate and base mixes**
- **But, they are more frequently replaced**
- **Potential big impact by using more RAP in surfaces**

Changes Occurring in US Practice

- **States are moving to higher RAP contents in more mixtures**
- **More states are changing to expressing RAP content in terms of percent of RAP binder that is replacing new binder**
- **More interest in recycling asphalt shingles**
- **More contractors are splitting the RAP into different size fractions, called fractionating**

FRAP

Fractionated RAP

RECYCLED SHINGLES

RAS = Recycled Asphalt Shingles

- **Asphalt shingles can have very high binder contents, as high as 30%**
  - Greatly reduces demand for new binder
  - Contain hard, angular fine aggregate and fibers
- **But, shingle binder is very stiff (oxidized) so there is concern about cracking**
- **So, allowable shingle content is about 20-25% as high as allowable RAP content**

RAP BINDER REPLACEMENT

$$\frac{(AxB) + (CxD)}{E} \times 100\%$$

where A = binder content in RAP, %
B = RAP content in mixture, %
C = binder content in shingles, %
D = shingle content in mixture, %
E = total binder content in mixture, %

What We Have Learned

- **High RAP contents can work – can *perform well* – if properly designed, produced and constructed.**
- **Start with good mix design that accounts for the RAP.**
- **But, need attention to detail during construction.**

Some Keys to Success

- **Processing the RAP**
- **Stockpiling the RAP**
- **Control during production**

PROPER PROCESSING OF RAP BEGINS WITH REMOVAL

When possible:

Mill layers separately

- So you can reuse high quality aggregates in new surface mixes

Keep different projects and different layers separate

PROCESSING RAP

- **Mixed RAP can be variable**
  - Crushing/Screening to break up clumps
  - Processing can improve uniformity
  - Uniformity is essential to meet specifications

In Composite Pile

After Processing

Crushing and Screening

Before

The reprocessed products are very consistent components

After

FRACTIONATED RAP = CRUSHED AND SCREENED INTO DIFFERENT SIZES

- **Improves uniformity (remixes)**
- **Allows use of different sizes to meet mix design**
- **Better control of gradation (and binder content)**

100% Recycle Plant

Stockpiling Practices

- **Avoid segregation**
- **Avoid contamination**
- **Reduce stockpile moisture**
- **Test the RAP stockpiles regularly – *know what is in your stockpiles!***

SEGREGATION

- **Follow normal stockpiling techniques to minimize segregation**
  - Building
  - Managing
  - Pulling material

Causes of Contamination

- Stockpiles too close together can intermix – keep separated
- Putting wrong material in stockpile – label clearly
- “Dirty” stockpile – pave stockpile area
- Tracking mud into pile – install drainage to help keep area dry, keep mud off loader tires


Contamination-
Not Good

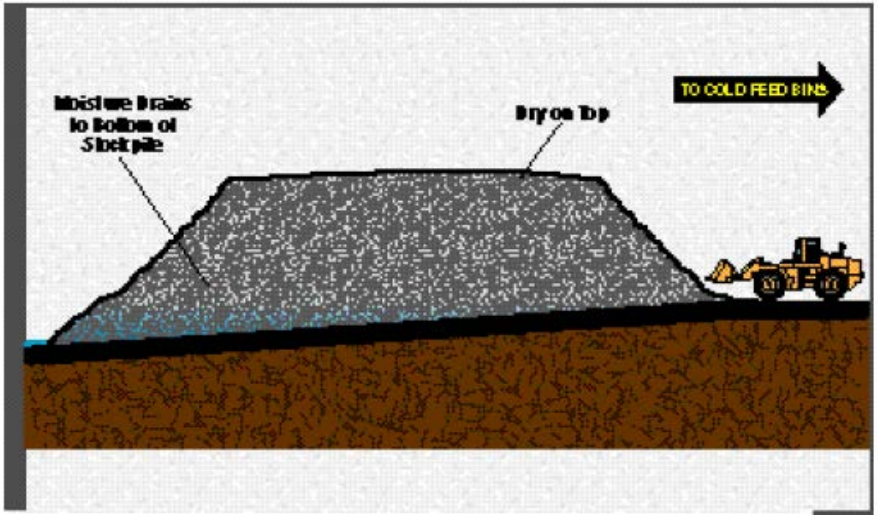
Reduce Stockpile Moisture

- Expect to lose 12% production capacity for every percent stockpile moisture above 2%
- Reduce fuel consumption and drying costs by keeping your materials dry
- Lower moisture leads to increased production capacity
- Lower maintenance and fuel costs for loaders
- Lower paving costs

How to Reduce Moisture

- Paved stockpile area
- Sloped stockpile area
- Covered stockpiles

Benefits of Sloped Stockpile



- Moisture drains to bottom of pile
- On slope, moisture drains away
- Slope grade 3 to 4°
- Pick off high side of pile
- Face slope towards sun to more drying
- Can reduce moisture 2% overall

COVERED STOCKPILES

Still rare but useful, especially in high moisture areas

Mix Plant Operations

Plant Control for RAP Mixes

- Control plant inputs (cold feeds)
- Control material variability
- Follow-up Quality Control test results
- Watch drum flighting – maintain protective RAP veil
- Avoid overheating mix
- Normal production care and attention

Summary of RAP Best Practices

- Mill layers separately when you can
- Process RAP and stockpile properly
- Fractionate RAP
- Avoid contamination
- Keep the RAP dry –paved and sloped area, covered stockpile
- Test the RAP stockpiles regularly
- Watch plant production

PERFORMANCE: RAP VS. VIRGIN

- Randy West, NCAT
- Using data from Long Term Pavement Performance (LTPP) 20-year study
  - Rutting, mm
  - Roughness (IRI), m/km
  - Fatigue cracking, m^2
  - Transverse cracking, # per section
  - Longitudinal cracking, m
- 340 comparisons

PERFORMANCE OF RAP MIXES

- Pavements using ≥ 30% RAP perform equal to or better than virgin pavements in *most* cases
- Somewhat more transverse and fatigue cracking in some pavements with RAP compared to pavements with all virgin materials
- Differences in cracking for several locations may have been due to lower asphalt contents and/or higher dust contents (poor mix design)

COST/BENEFITS OF RAP

- **Milling or Pavement Salvage Costs**
  - Mill, haul & stockpile: ≈$6.50/ ton
  - Excavate, haul & stockpile: ≈ $7.00/ton
  - Reprocessing: ≈ $5.00/ton
- **Virgin Material Costs**
  - Coarse Aggregate ≈ $12.00/t
  - Fine Aggregate ≈ $8.00
  - PG Binder ≈ $450.00 (when this analysis was done)
  - Ton of Virgin Mix = $50 for Intermediate, $60 for surface course

Don Brock, ASTEC

Cost Savings using RAP for a typical 19.0 mm Intermediate

% RAP	Per ton Savings $ (materials only)	Notes
0	0	
15	$3.40	
25	$5.50	Does not include premium PG58-28
40	$6.80	Includes premium PG58-28

25% RAP in an intermediate 19.0mm HMA will save approximately 11% per ton.

Cost Savings using RAP for a typical 9.5 mm Surface

% RAP	Per ton Savings $ (materials only)	Notes
0	$0	
15	$3.40	
25	$5.50	Does not include premium PG58-28
40	$6.80	Includes premium PG58-28

25% RAP in a Surface 9.5 mm HMA will save approximately 9% per ton.

Another Way to Look at Savings

- **One medium sized US paving contractor uses 900,000 tons RAP per year**
- **That is equivalent to 1,460,000 gallons of gas**
- **Which is enough to fuel 1,650 big Ford Expeditions**

CONCLUSIONS

RAP has long history of successful use.

Asphalt recycling is sustainable.

Asphalt recycling is economical.

Asphalt recycling works!

OBRIGADA!

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