

# ADOT's Use of RAP in Asphaltic Concrete

Updated & Presented by: Nye McCarty, P.E.

Originally prepared by: Chad Auker &

Scott Weinland

ADOT – Construction-Materials Group



# Overview

---

- ADOT's Existing RAP Specification
  - Implementation
  - Definitions
  - Limits on RAP Usage
  - RAP Sources
  - Testing and Acceptance
  - Measurement and Payment
- Summary of RAP Projects

# Specification Highlights – Implementation

---

- All projects with a bid opening on or after August 21, 2009, included allowance within the specifications for the use of RAP in HMA.
- RAP is allowed in both our 416 and 417 mixtures, **409 Misc, and Aggregate Base.**
- RAP is currently not permitted in ARAC, AR-ACFC, or ACFC mixtures; or mixtures that specify a TR+ binder.
- **Discussion regarding RAP aggregate for Chip Seal Applications.**

# Specification Highlights – Definitions

---

- Reclaimed Asphalt Pavement (RAP) consists of salvaged, milled, pulverized, broken, or crushed asphalt pavement. For purposes of the Specifications, RAP is made up of two main components: RAP aggregate and RAP binder.
  - RAP aggregate consists of the aggregate portion of the reclaimed asphalt pavement.
  - RAP binder consists of the binder, or asphalt cement, portion of the reclaimed asphalt pavement.

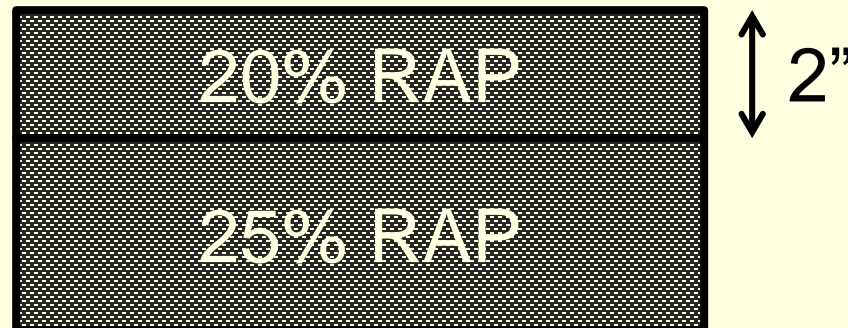
# Specification Highlights – Limits on RAP Usage

---

- The amount of RAP material allowed in a mixture is limited by both a maximum RAP “aggregate” contribution and RAP “binder” contribution to the mixture.
  - Both components can have a significant impact on the mixture properties and performance
  - RAP binder content can vary significantly depending on source

# Specification Highlights – Limits on RAP Aggregate Usage

- A maximum of 20% RAP aggregate, by weight of total aggregate in the mix, may be used in upper 2 inches.
- A maximum of 25% RAP aggregate, by weight of total aggregate in the mix, may be used in lower lifts (minimum 2" below finished surface).



# Specification Highlights – Limits on RAP Aggregate Usage

- Maximum RAP aggregate Size:

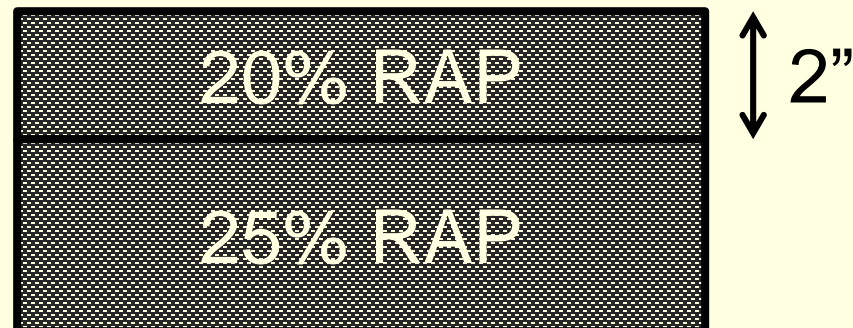


- When more than 15% RAP aggregate is used, by weight of the total aggregate in the mix, the RAP must be fractionated into separate coarse and fine stockpiles.

Stockpile	Sieve Size	Percent Passing
Coarse	1-1/4 inch	100
	3/8 inch	0-25
Fine	3/4 inch	100
	3/8 inch	75-100

# Specification Highlights – Limits on RAP Binder Usage

- A maximum of 20% RAP binder, by weight of total binder in the mix, may be used in the upper 2 inches.
- A maximum of 25% RAP binder, by weight of total binder in the mix, may be used in lower lifts (minimum 2" below finished surface).





# Specification Highlights – Limits on RAP Binder Usage

---

- When more than 15% RAP binder is used, by weight of the total binder in the mix, the RAP binder must be extracted (TCE), recovered, and tested during the mix design process.
- PG of the blend of Virgin and RAP binder must meet the PG specified for the project.
  - AASHTO M 320: Dynamic Shear (Original, RTFO, PAV), Creep Stiffness, Rate of Change in Stiffness (m-value)
  - The grade of virgin binder supplied to the project may need to be different than the grade specified in the bid documents.
    - Virgin binder needs to meet the virgin PG requirements.

# Specification Highlights – RAP

## Sources

---

- There are no restrictions on the source of RAP.
- Contractor is responsible for determining the suitability of any RAP source proposed for use
  - Abrasion:
    - (9% Max @ 100 Rev., 40% @ 500 Rev.)
  - Fractured Faces (composite, virgin and RAP):
    - 70% (at least one fractured face on +No. 4)
    - 85% with two, 92% with one for “special mixes”
  - Carbonates (composite, virgin and RAP):
    - 20% maximum (for final riding surface or subjected to traffic for more than 60 days)

# Specification Highlights –Testing and Acceptance

---

- The testing and acceptance of asphaltic concrete containing RAP is similar to non-RAP mixtures, with some important differences.
- The differences deal primarily with aggregate properties and asphalt cement content.
- For mixtures with RAP, the RAP binder must be tracked separately from the virgin binder. This requires additional sampling, testing, data collection and calculations.

# Specification Highlights –Testing and Acceptance

---

- Asphaltic Concrete Testing and Acceptance

- 1) Mixture Properties

- 2) Compaction

- 3) Mineral Aggregate Properties

- 4) Asphalt Cement (Virgin Binder PG)

Including Virgin and Rap Binder Quantities

- 5) RAP Material (RAP mixes only)

RAP Quantity

RAP Binder Content

RAP Gradation (Coarse and Fine if fractionated)

# Specification Highlights –Testing and Acceptance

---

## 1) **Mixture Properties**

Conventional Mixtures - Four samples per day for asphalt content, lab voids, and gradation (Acceptance based on PWL)

RAP Mixtures – Same except RAP material has to be considered during calibration of the ignition furnace.

# Specification Highlights –Testing and Acceptance

---

- Mixture Properties (continued):
  - Total Asphalt Content – Ignition Furnace
    - Ignition Furnace & Tank Stab/Stick Correction Factors
  - RAP Binder Contribution (15%, 20%, or 25% max)
    - % RAP Binder based on quantity of RAP Binder and Total Binder
    - Binder Content of RAP– Ignition Furnace
      - Both coarse and fine if fractionated
      - Correction factor based on TCE solvent extraction
        - Performed on first two days production of RAP
      - RAP Binder Quantity based on RAP Aggregate Quantity
    - Virgin Binder Content – Hot Plant Report

# Specification Highlights –Testing and Acceptance

---

## 2) **Compaction**

Conventional Mixtures - Ten cores to determine in-place voids (Acceptance based on PWL)

RAP Mixtures – Same as Conventional

# Specification Highlights – Testing and Acceptance

---

## 3) Mineral Aggregate Properties

Conventional Mixtures – One cold feed sample every other day for SE, FF, UV. Carbonates and LA Abrasion prior to start up.

RAP Mixtures – Same as Conventional except SE and UV is run only on the virgin aggregate. FF is run on material remaining from the ignition furnace (mix sample). Carbonates and LA Abrasion prior to start up.



# Specification Highlights –Testing and Acceptance

---

## 4) **Asphalt Cement (Binder)**

Conventional Mixtures – Two samples per day

RAP Mixtures – Same as Conventional (only the Virgin Binder is sampled and tested).

# Specification Highlights – Testing and Acceptance

---

## 5) **RAP Material**

Conventional Mixtures – Not Applicable

RAP Mixtures – One sample from each stockpile per day for moisture content, gradation and RAP binder content

# Specification Highlights – Measurement and Payment

---

- Measurement and Payment are made as three separate items:
  - 1) Asphaltic Concrete (Mixture)
  - 2) Admixture
  - 3) Asphalt Cement (Binder)

Item #3 gets a little tricky...

# Specification Highlights – Measurement and Payment

---

## 1) **Asphaltic Concrete (Mixture)**

Conventional Mixtures – Measured and paid for by the ton placed

RAP Mixtures – Same as Conventional mixtures.

Note: Payments for asphaltic concrete are adjusted based on the mix property and compaction test results and corresponding pay factors

# Specification Highlights – Measurement and Payment

---

## 2) **Admixture**

Conventional Mixtures – Measured and paid for by the ton used in the mixture

RAP Mixtures – Same as Conventional mixtures.

# Specification Highlights – Measurement and Payment

---

## 3) **Asphalt Cement (Binder)**

Conventional Mixtures – Measured using the ignition furnace or by invoice. However, payment cannot exceed actual quantity used (invoices).

RAP Mixtures – Measured using the ignition furnace or by adding invoice quantities to the actual RAP binder used in the mixture. However, payment cannot exceed the actual binder used (invoice plus total RAP binder)

# RAP Use on ADOT Projects



# RAP Use on ADOT Projects

---

- Origins of RAP on ADOT Projects
- Summary of Projects that incorporated RAP in HMA on ADOT projects
  - First Year
  - To Date
- Quantity of RAP materials used
- Estimated Cost Savings using RAP in HMA
- Quality of HMA with RAP - Statistical Acceptance (PWL)
- Challenges / Benefits with using RAP



# Origins of RAP on ADOT Projects

---

- Several Experimental projects in 2008 and early 2009
  - Value Engineering / Change Order
- Specifications were created project by project
- Increased knowledge with incorporating RAP
- Provided some resources / experience in creating specifications
- First Production with Complete Testing Regime in 2009:
  - I-40 Holy Moses Wash to Rattlesnake Wash
    - 11,042 tons of 416 with RAP was placed

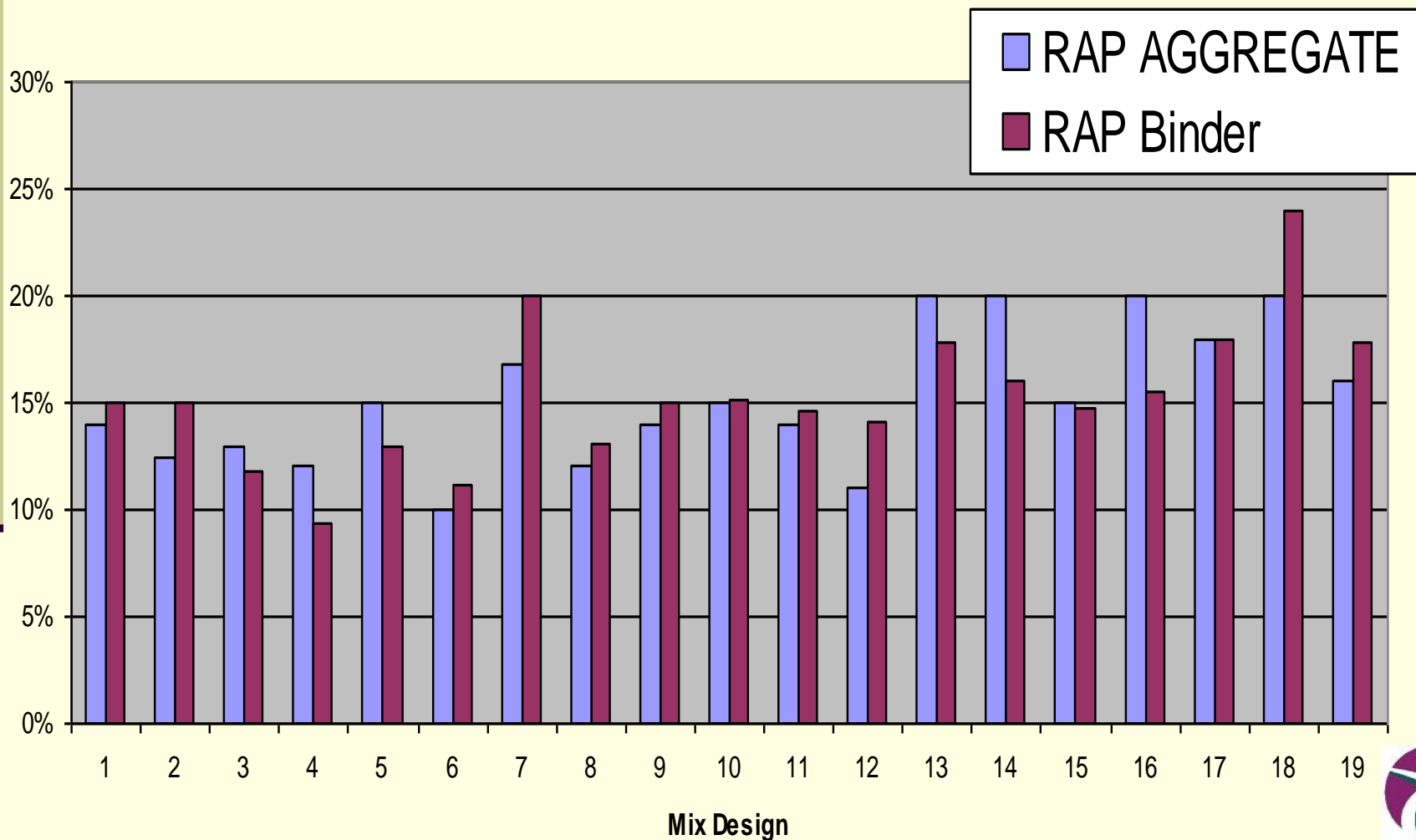
# Origins of RAP on ADOT Projects

---

- Specifications went into projects with Bid Opening on or after August 21, 2009
- 17 Different Projects that incorporated RAP into the HMA in the first year.
- RAP sources varied but most was reclaimed directly from the project site
- Some use of previously stockpiled RAP.
  - Primarily in/near urban areas.

# Summary of Projects using RAP (first 12 months)

Mix Design RAP Percentages



# Quantity of RAP Materials Used (first 12 months)

---

- 650,000 Tons of HMA with RAP in first year
  - 416 and 417 Specifications only
  - Represented approximately two-thirds of HMA placed in the 12-month period following August 2009
  
- 98,000 Tons of RAP Material Used
  - 4,600 Tons of RAP Binder used
  - 93,400 Tons of RAP Aggregate used

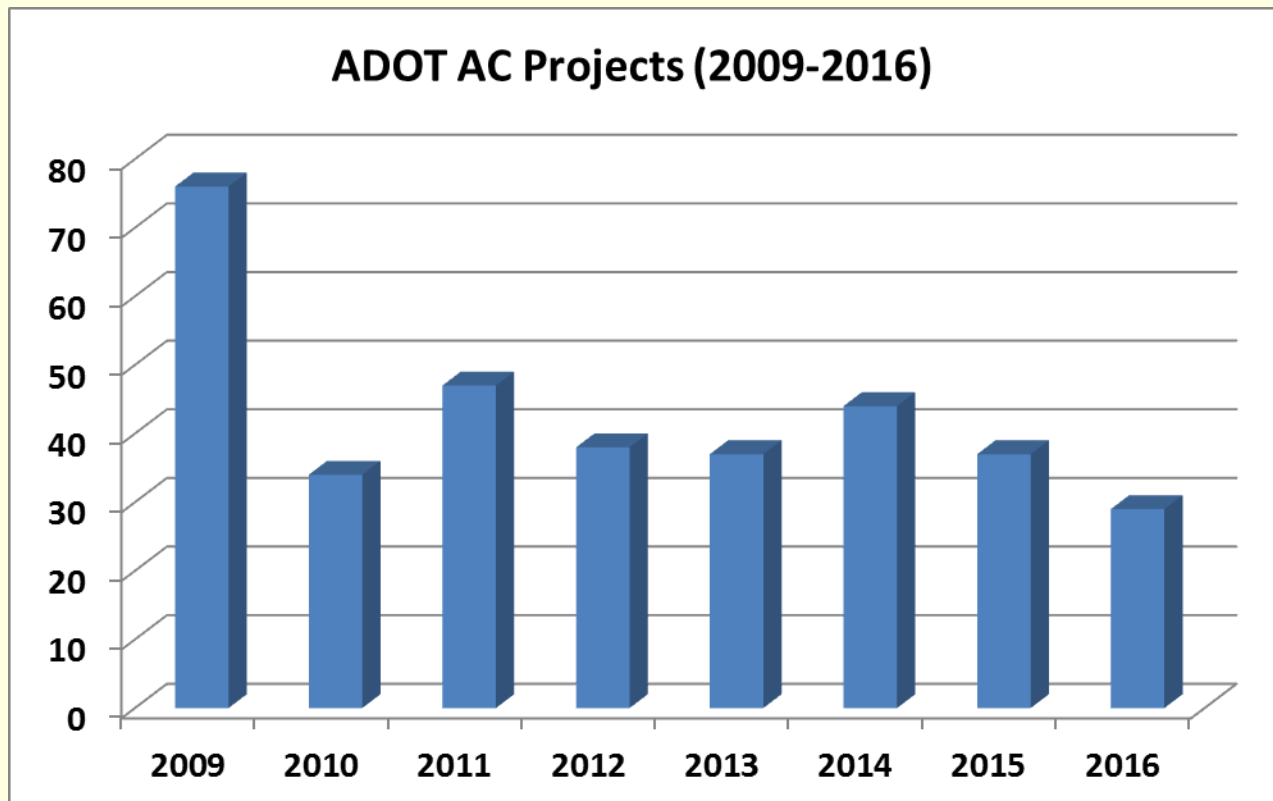
# Quantity of RAP Materials Used (first 12 months)

---

- 98,000 Tons of RAP used in ADOT in 1<sup>st</sup> year
- By Comparison Colorado DOT used 80,000 Tons of RAP in 2008
  - In 2009 CDOT increased the maximum allowed RAP to 25% in base mixes and 20% in surface mixes.
  - In 2009 the new standards resulted in 135,000 tons of RAP on Colorado state highways.

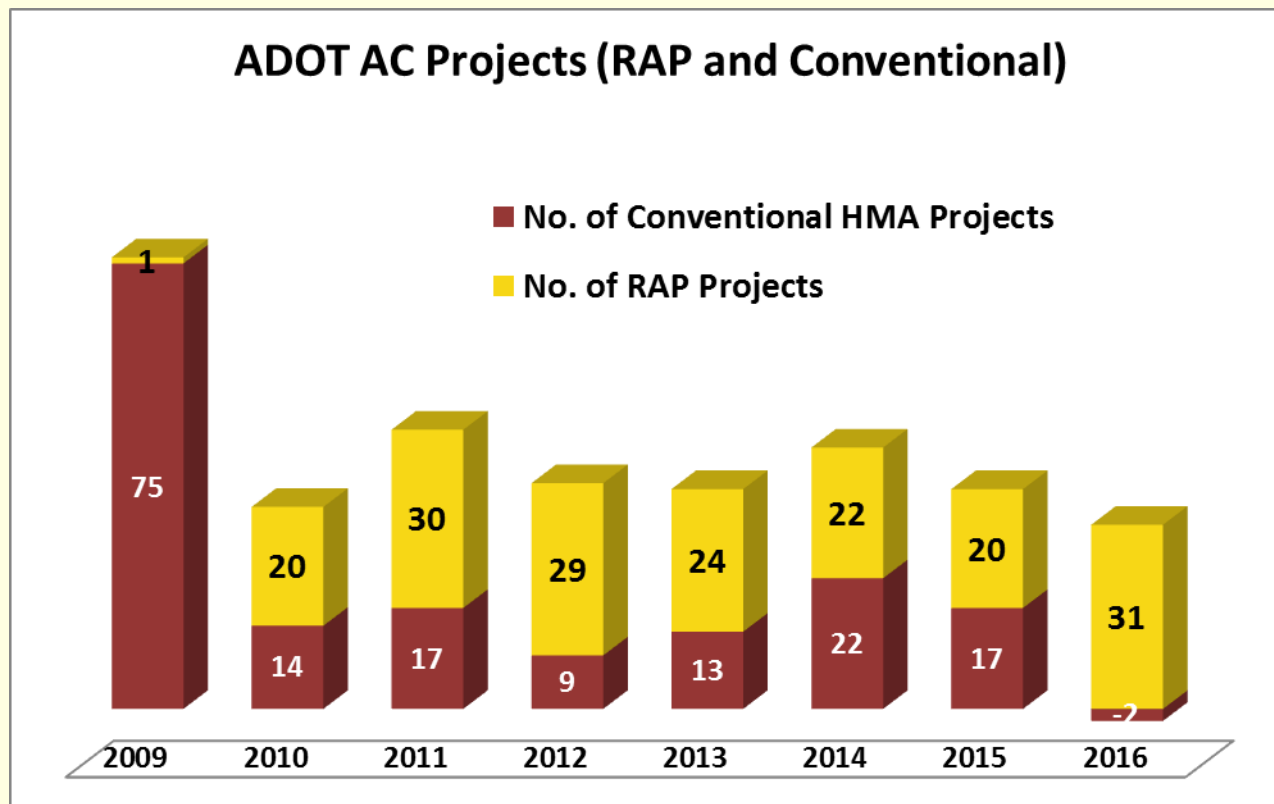
# Overall AC Production for ADOT

- Over 9 Million tons of Asphaltic Concrete From 2009 to 2016
  - Material placed under 416 and 417 specifications



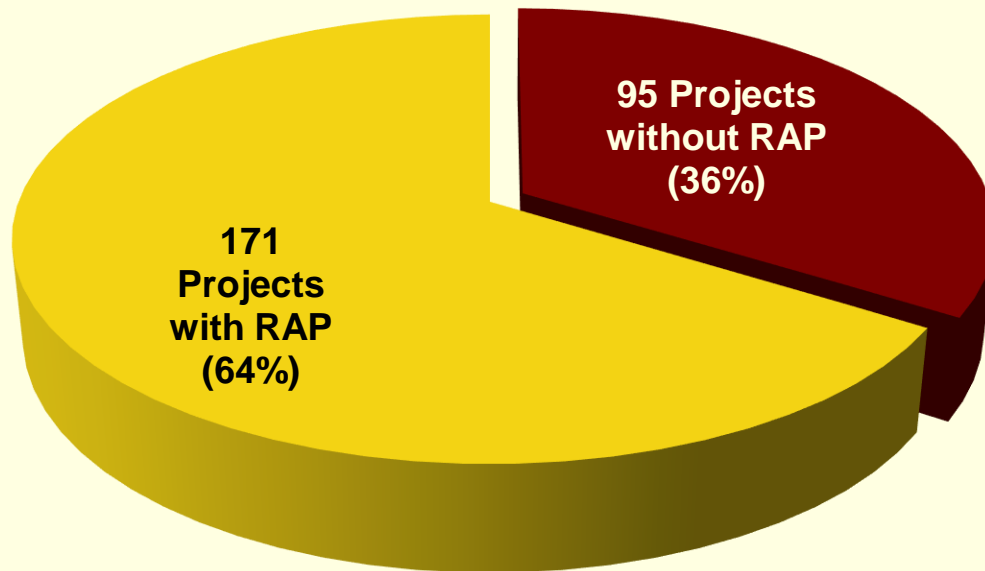
# ADOT Paving Projects with RAP

- Conventional AC and RAP Projects (2009-2016)
  - Material placed under 416 and 417 specifications



# ADOT Paving Projects with RAP

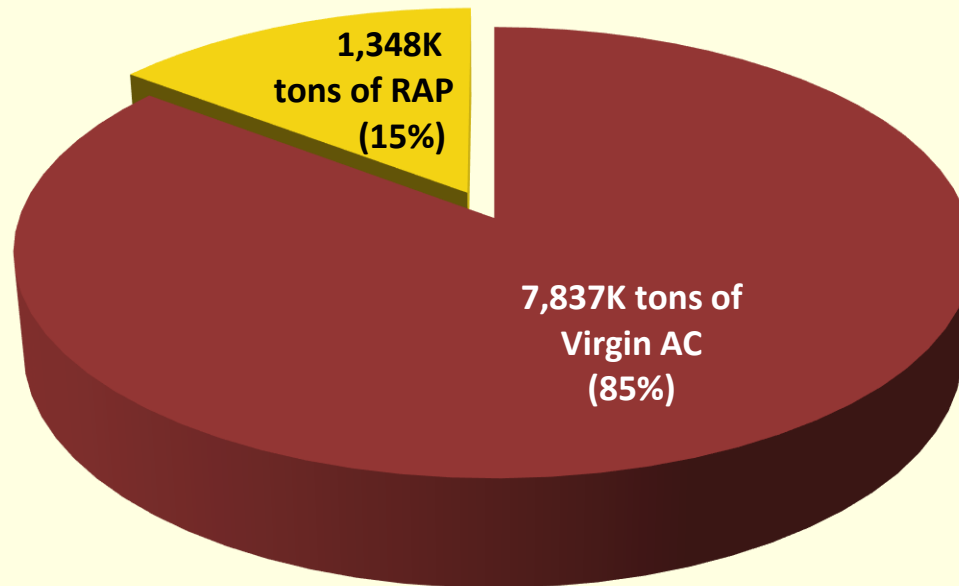
- Paving Projects with and without RAP (2010-2016)
  - Material placed under 416 and 417 specifications





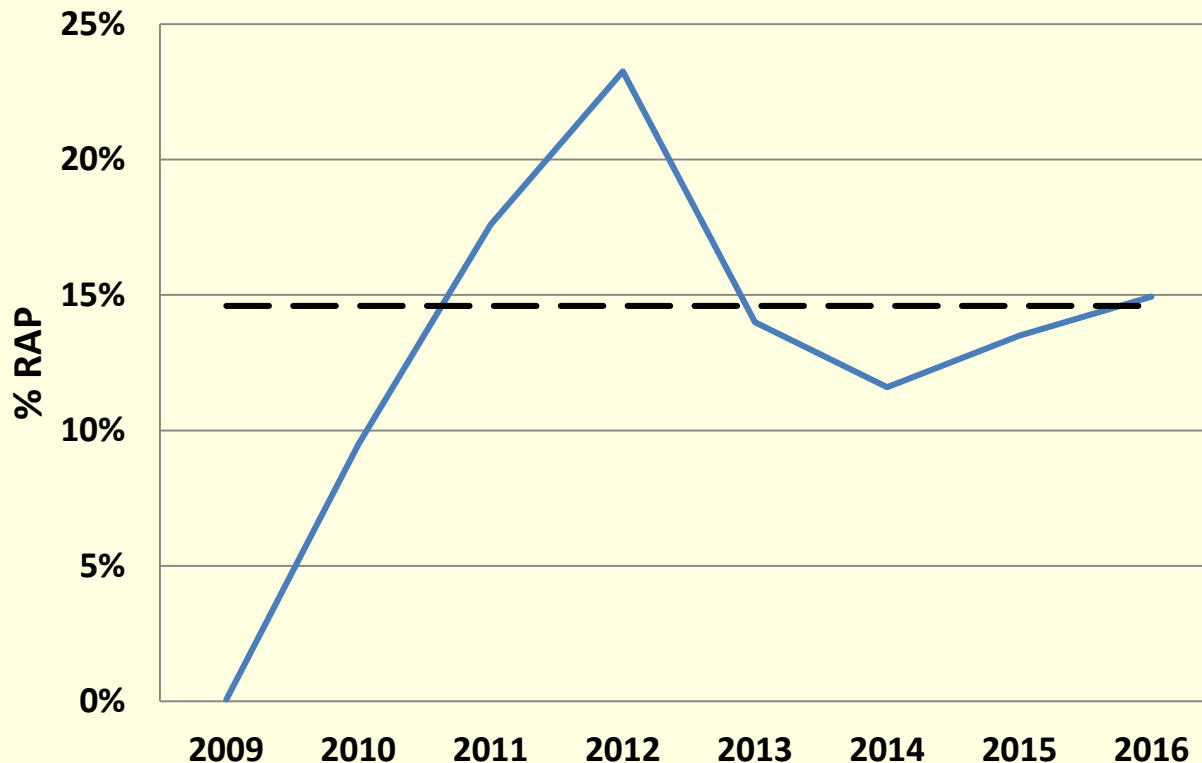
# Overall AC Production for ADOT

- Quantity of RAP used in AC (2010-2016)
  - Material placed under 416 and 417 specifications



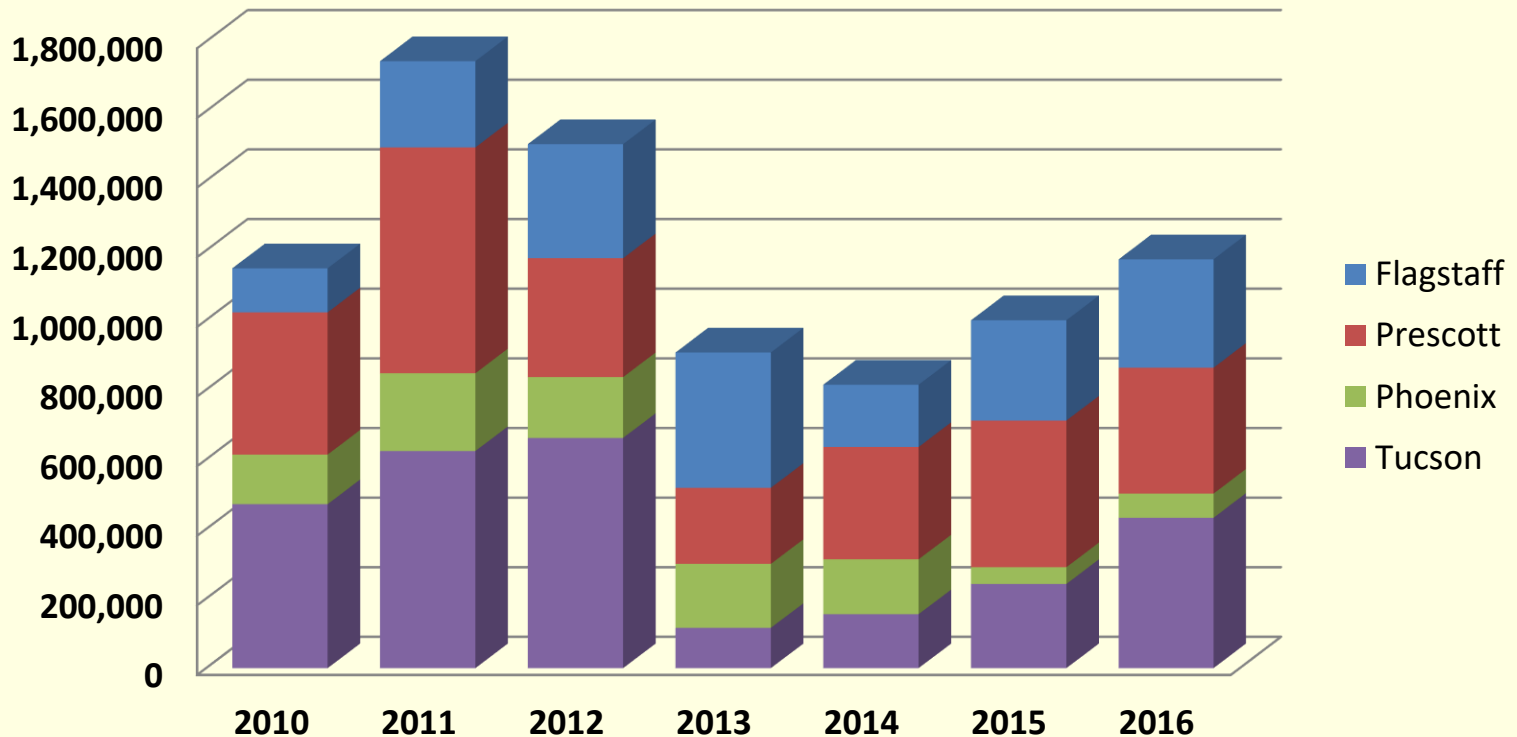
# Overall AC Production for ADOT

- RAP Content in AC Production (2009-2016)
  - Material placed under 416 and 417 specifications



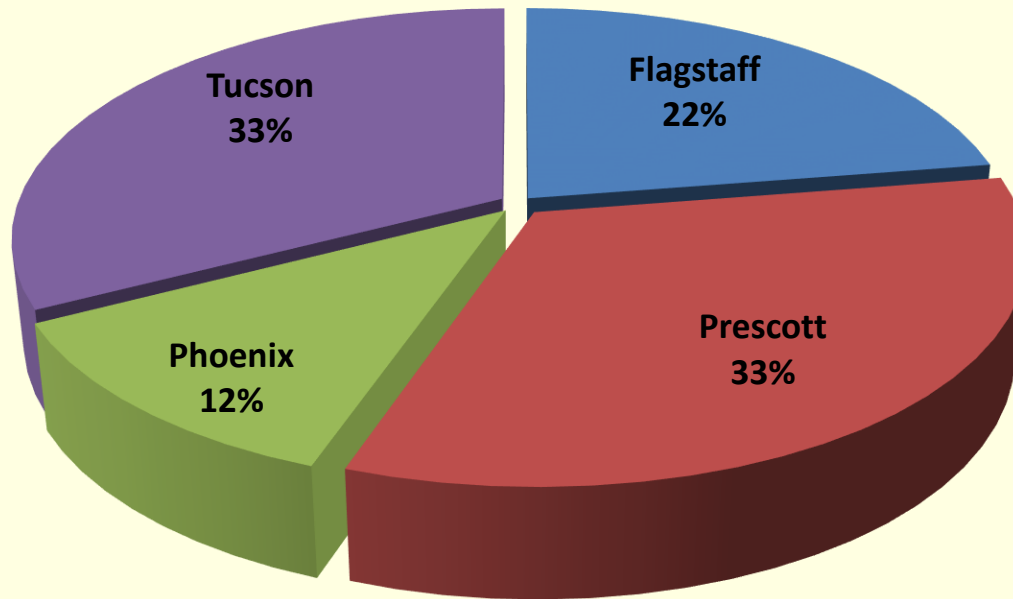
# Overall AC Production for ADOT

- Tons of AC w/ RAP by ADOT Region (2010-2016)
  - Material placed under 416 and 417 specifications

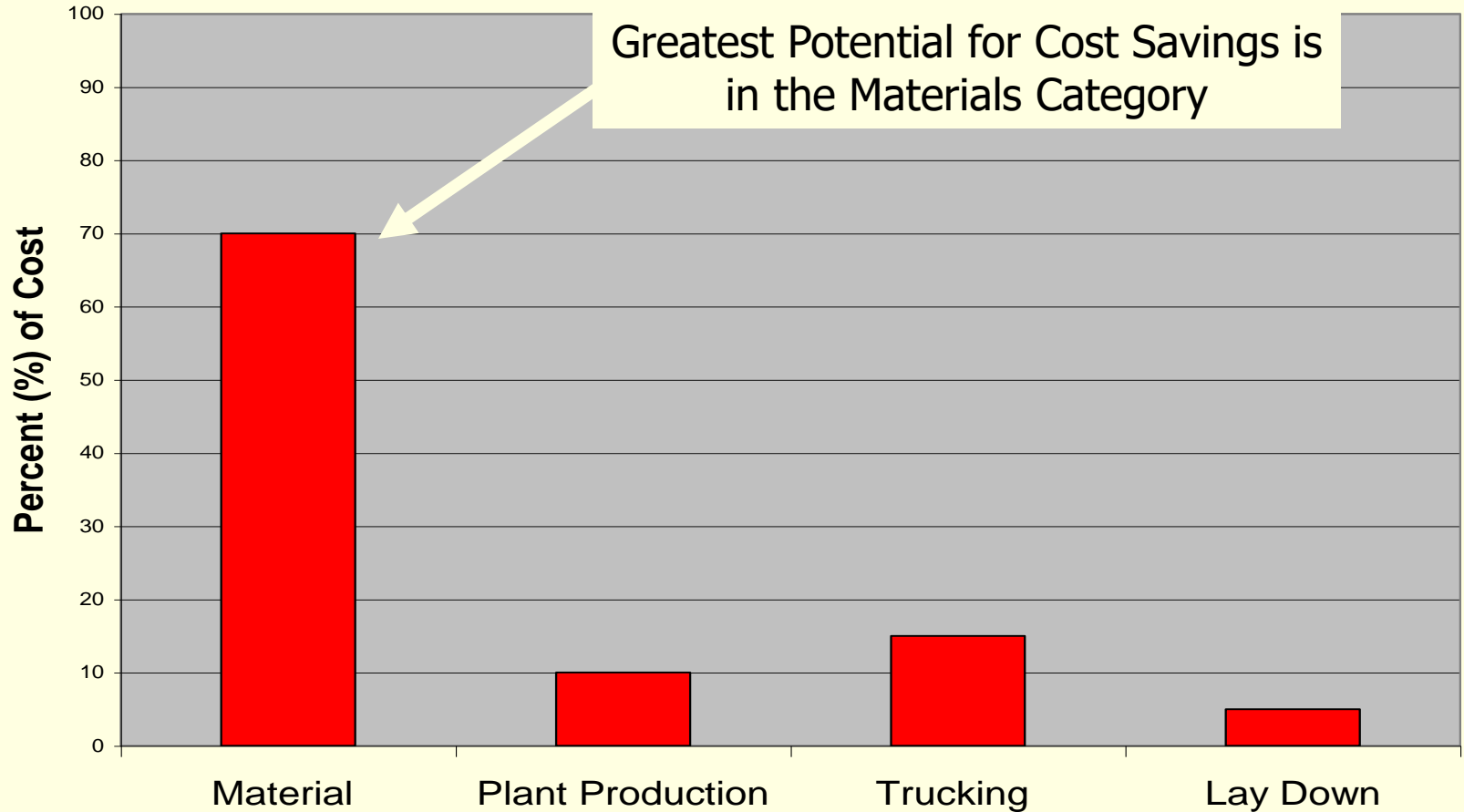


# Overall AC Production for ADOT

- Tons of AC w/ RAP by ADOT Region (2010-2016)
  - Material placed under 416 and 417 specifications



# Asphalt Production Cost Categories



# Estimated Cost Saving with RAP

---

- RAP Binder savings are approximately \$3 to \$5 / ton of HMA
  - Dependent on the amount of RAP used
- RAP Aggregate saving are approximately \$1 - \$3 / ton of HMA
  - Dependent on the amount of RAP used
  - Dependent on the location of virgin aggregate source to the project

# Estimated Cost Savings with RAP

- **Combined Estimated cost saving is \$6/ton of HMA** (\$4 / ton for RAP binder and \$2 / ton for RAP aggregate)
  - Equates to about 10% saving for HMA
- Estimates approximately \$3.9 million dollars savings in ADOT's first year of allowing RAP
  - 650,000 tons x \$6 / ton = \$3.9 million
- Estimated savings of over **\$55 Million** since 2009
  - 9,185,000 tons x \$6 / ton = \$55,110,000

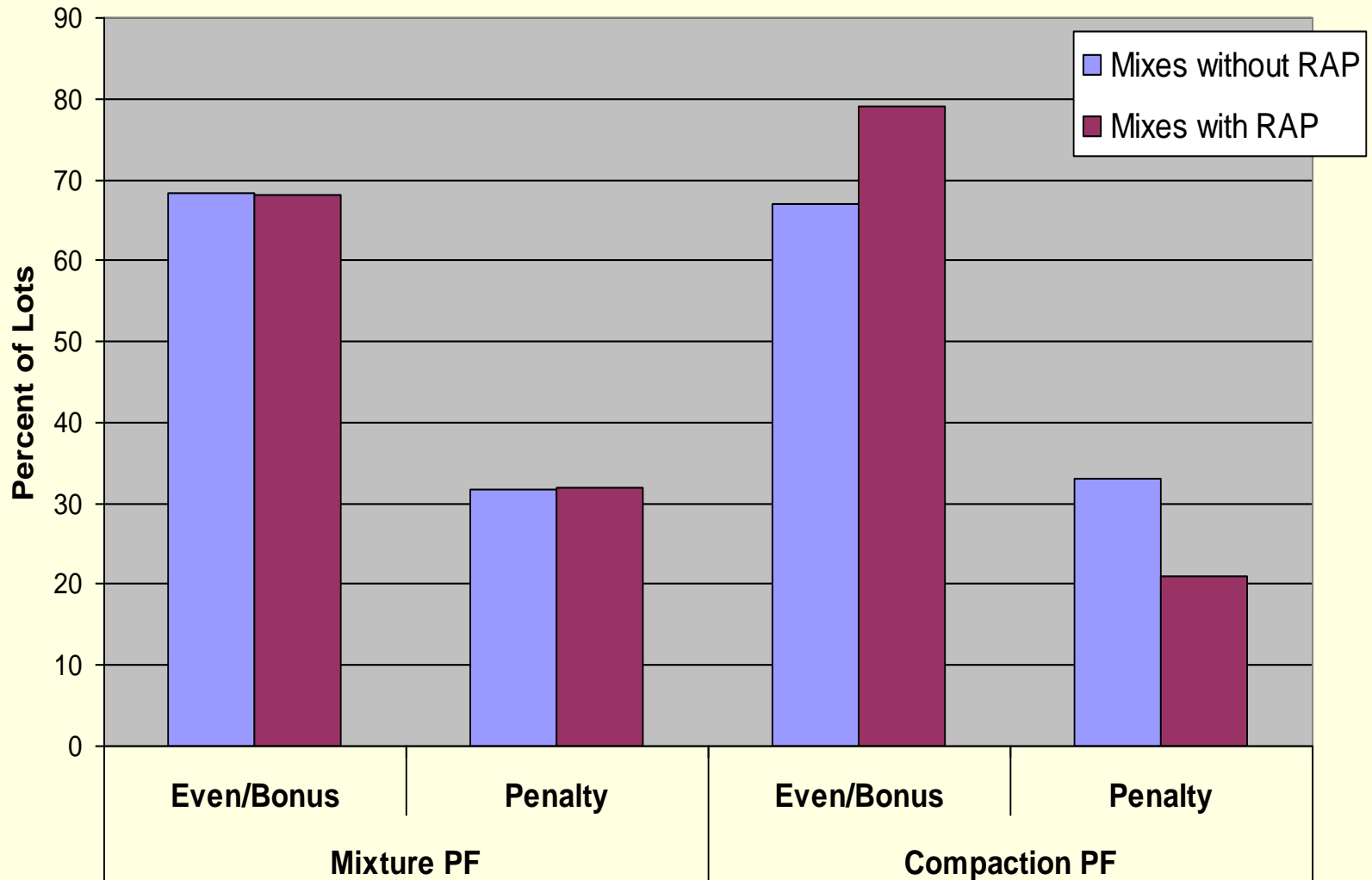
# Statistical Acceptance

---

- 416 & 417 ADOT End-Product Specifications
- Statistical Acceptance - Percent Within Limits
  - $PWL \geq 95$  = Bonus
  - $PWL 90 - 94$  = Even
  - $PWL \leq 89$  = Penalty
- Incentive or Disincentive for Mixture Lot and Compaction Lot
  - Mixture – Lab voids, asphalt content, gradation
  - Compaction – In-place voids



# Statistical Acceptance



# Challenges with implementing RAP

---

- New Specification
  - Education with RAP specifications
  - Additional Sampling and Testing requirements
  - Test procedure changes and new mix design process
  - Practice and Procedure Directive (PPD No.20) was created to help the knowledge transfer

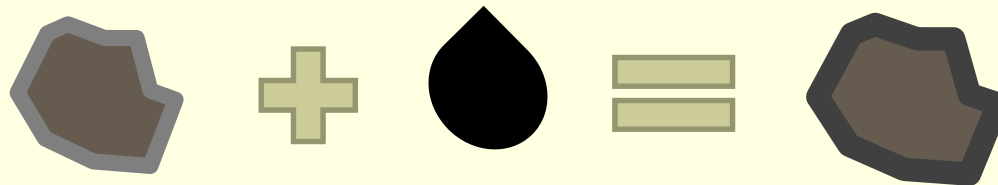
# Challenges with implementing RAP

---

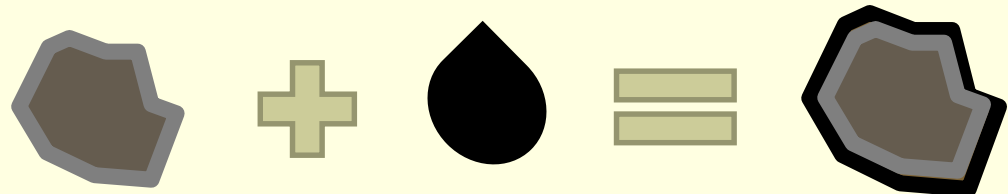
- Binder Payment – RAP binder vs Virgin Binder
- Mandatory Binder correction factor (tank stab) if greater than 0.1% from ignition furnace results (First 5 lots)
- Adjustments to ADOT Computer Software (FAST)

# Concerns with RAP

- Can production be controlled (RAP variability)?
- Is Asphaltic Concrete with RAP too stiff/brittle?
- Is the RAP binder behaving like binder?
  - Is the blended binder PG representative?



or

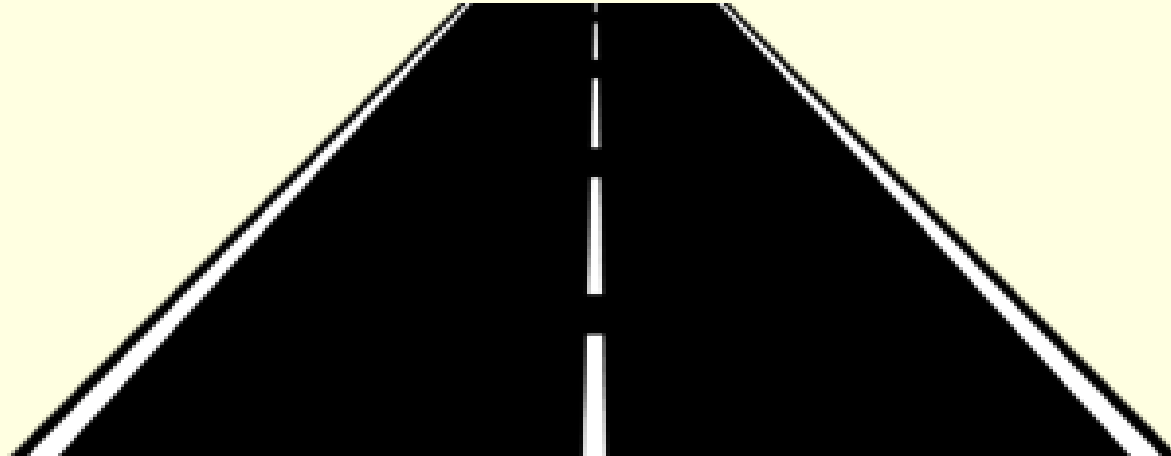


- Will the pavement have a shorter performance life / will it require increased maintenance?

# Benefits of RAP

---

- Cost Savings
- Reduced Environmental Impact
- Re-use of and Existing Material
- Increased Production Control



# Future use of RAP within ADOT

---

- SPS-10 Test Sections
  - 20% and 30% RAP (with/without WMA)
    - I-40, Sun Valley Road to Washboard Road
    - I-10, US60 to MP42
- Additional reclamation strategies using RAP
  - Cold Recycling (in-place & cold central plant)
  - Full Depth Recycling
  - Hot in-Place Recycling
  - Base Material (50% RAP, 50% virgin aggregate)
  - RAP aggregate for Chip Seals

# Additional Information

---

Policy and Procedure Directive No. 20 *Guidance on the Use of Reclaimed Asphalt Pavement (RAP) in Asphaltic Concrete*

[http://www.azdot.gov/Highways/Materials/QA/QA\\_Manuals/index.asp](http://www.azdot.gov/Highways/Materials/QA/QA_Manuals/index.asp)

## Contacts:

Nye McCarty  
928 779 7522

[nmccarty@azdot.gov](mailto:nmccarty@azdot.gov)

Chad Auker  
928-779-7551

[cauker@azdot.gov](mailto:cauker@azdot.gov)

Dharminder Sharma  
602-712-8041

[dsharma@azdot.gov](mailto:dsharma@azdot.gov)

***Thank You! Questions??***

