# HIGH RECLAIMED ASPHALT PAVEMENT IN HOT MIX ASPHALT

**THURSDAY DECEMBER 17TH 2009**
**11.00 am**

**RAP Expert Task Group**

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# Outline of Presentation

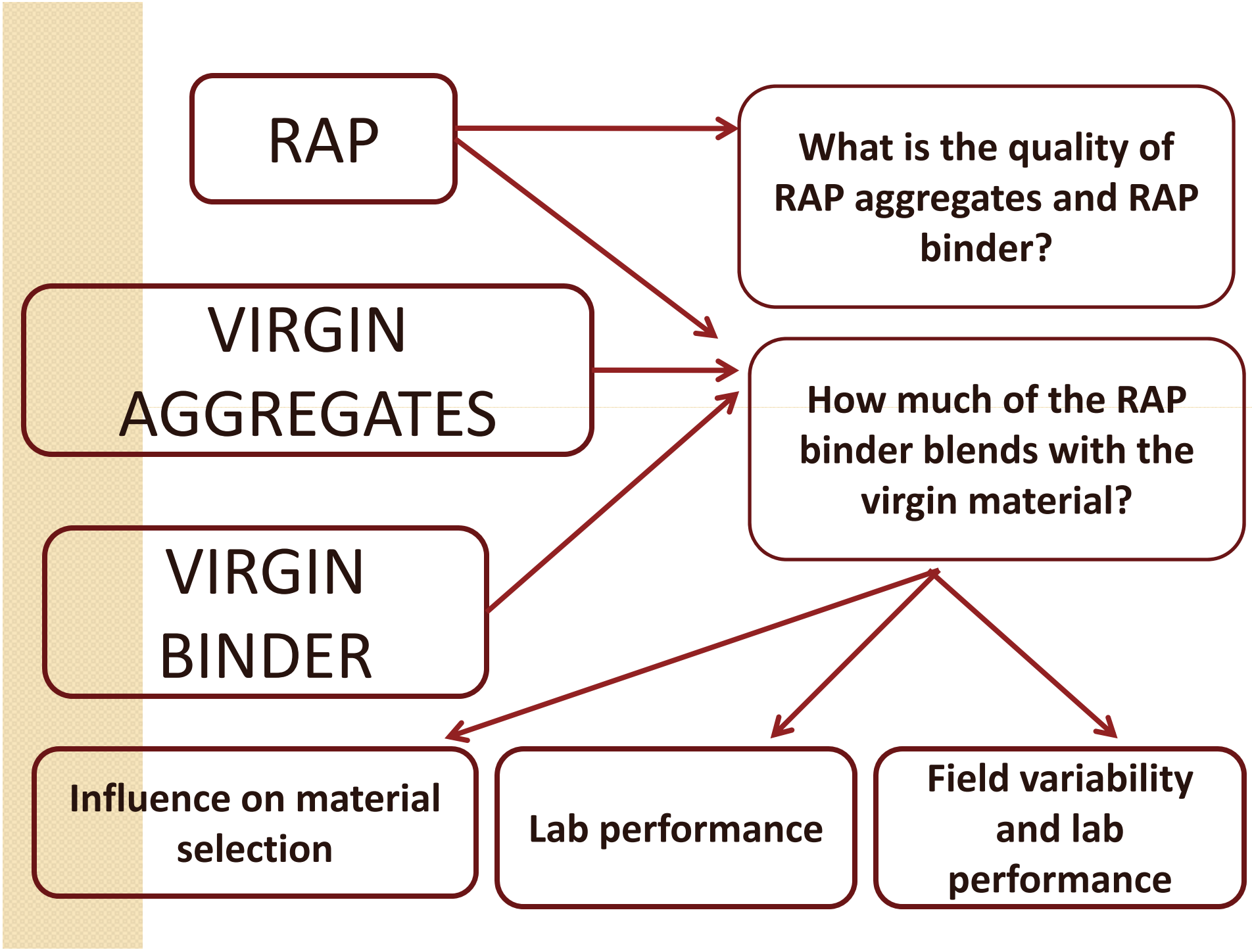
- Background
- Problem Statement
- Degree of partial blending
- Variability Study

# Background

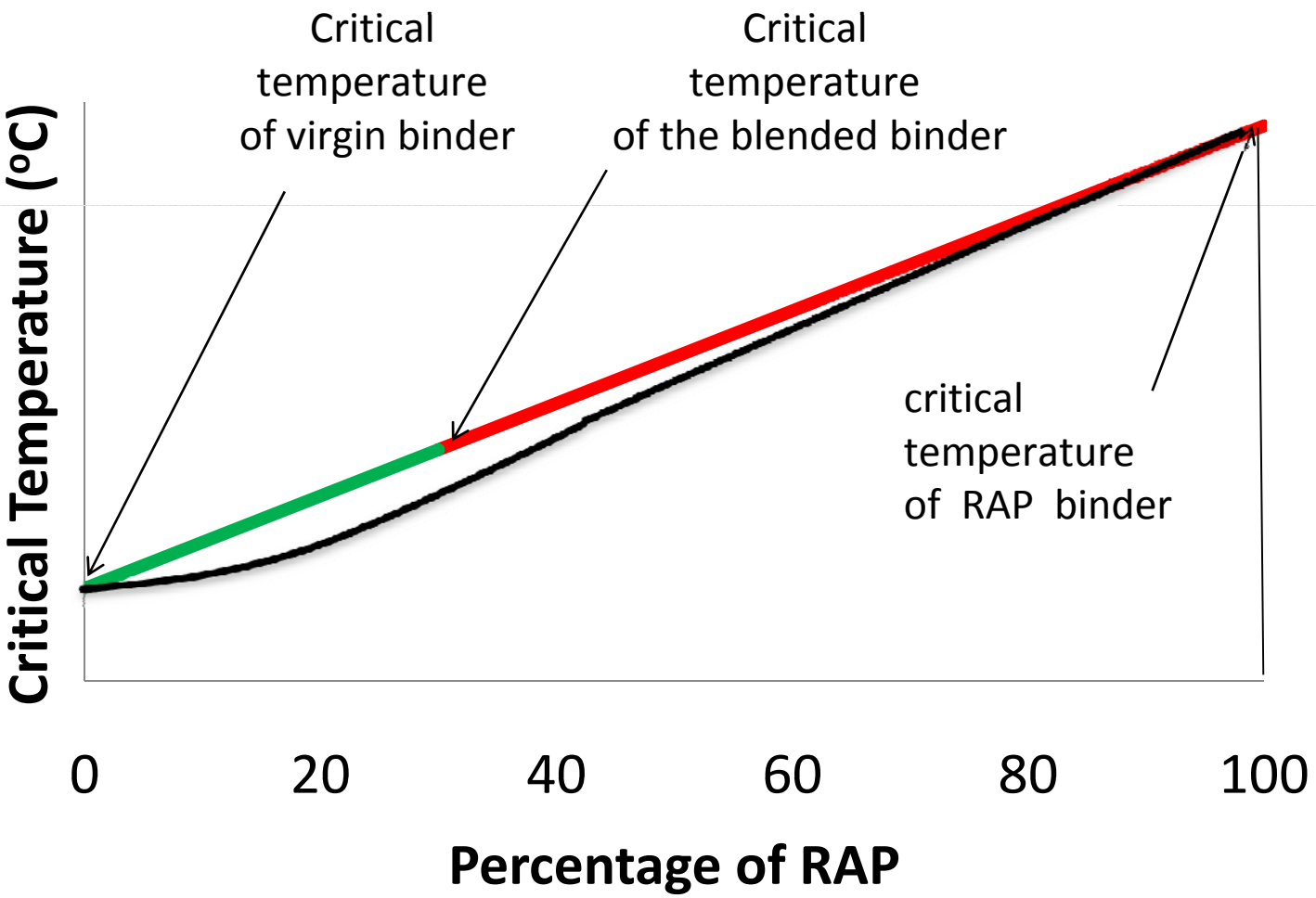
- Large quantity of unused RAP

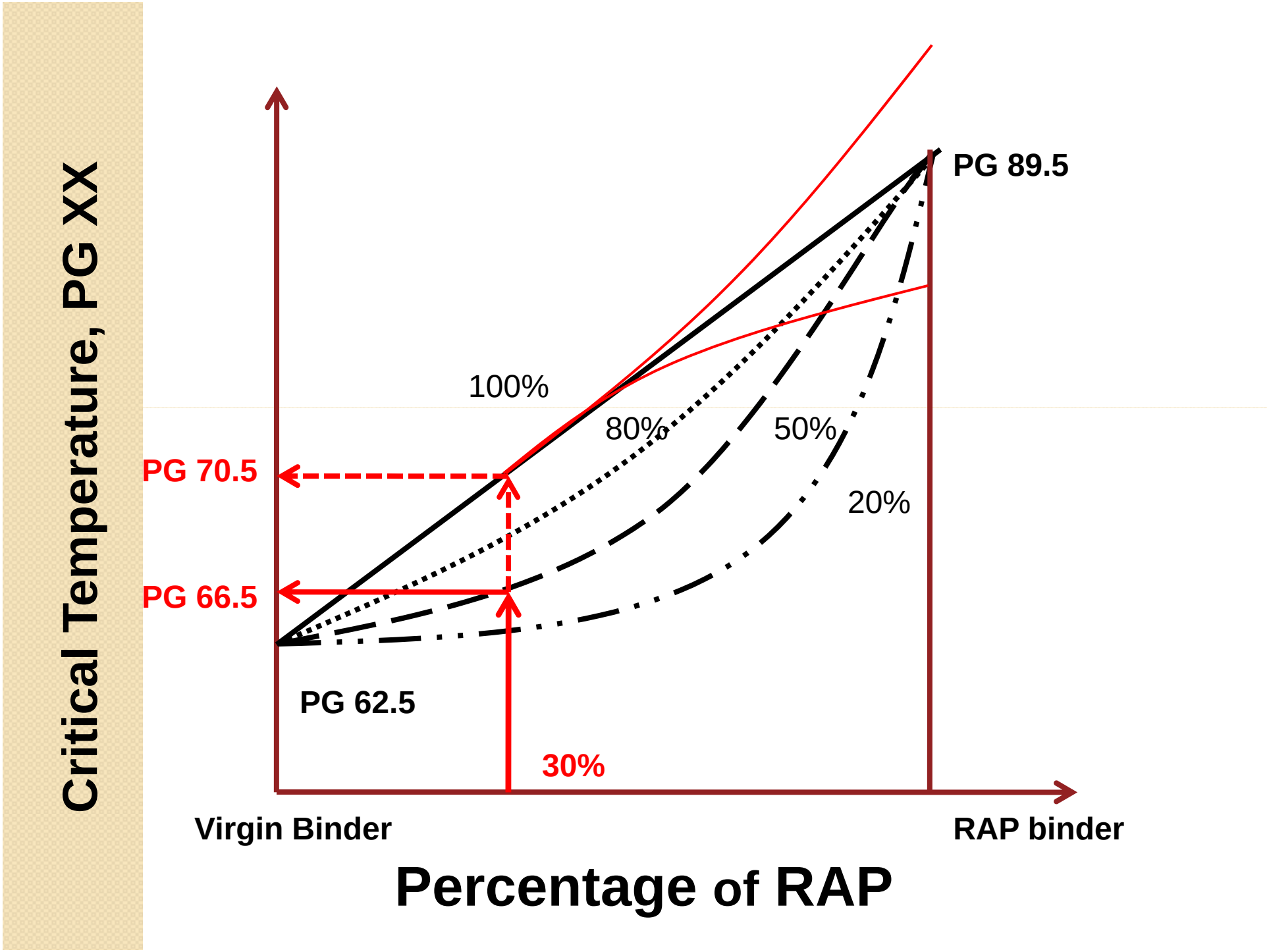
- Use of RAP
  - Cost Effective
  - Environmental Friendly

- Limitation on RAP use
  - Agency specification
  - Variability of RAP

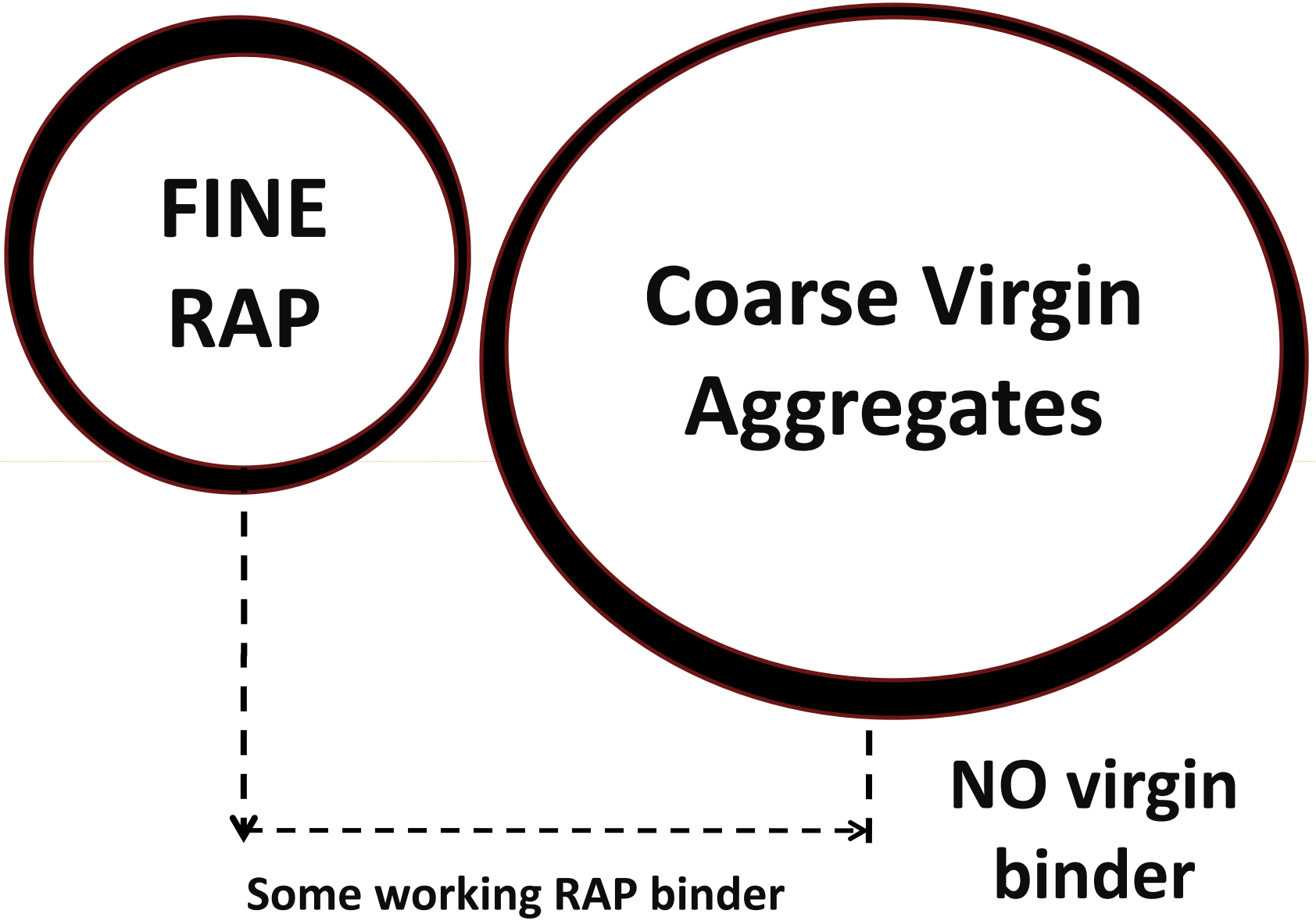

RAP
VIRGIN AGGREGATES
VIRGIN BINDER
What is the quality of RAP aggregates and RAP binder?
How much of the RAP binder blends with the virgin material?
Influence on material selection
Lab performance
Field variability and lab performance

# Blending Chart




Critical Temperature, PG XX
PG 89.5
100%
80%
50%
20%
PG 70.5
PG 66.5
PG 62.5
30%
Virgin Binder
RAP binder
Percentage of RAP

# COATING STUDY TO ESTIMATE RAP WORKING BINDER


FINE
RAP
Coarse Virgin
Aggregates
NO virgin
binder
Some working RAP binder

# Summary of Coating Study

| | % of RAP binder Transferred for different mixing times | | |
|---|---|---|---|
| % RAP | 1 Min | 2 Min | 3 Min |
| 10 | 14 | 31 | 29 |
| 25 | 11 | 35 | 35 |
| 40 | 3.5 | 26 | 25 |

# Blending Study Result

## RAP below #4

| % of RAP | Working Binder (%) |
|---|---|
| 30 | 48 |

## RAP below #8

| % of RAP | Working Binder (%) |
|---|---|
| 25 | 30 |
| 35 | 20 |

# Findings

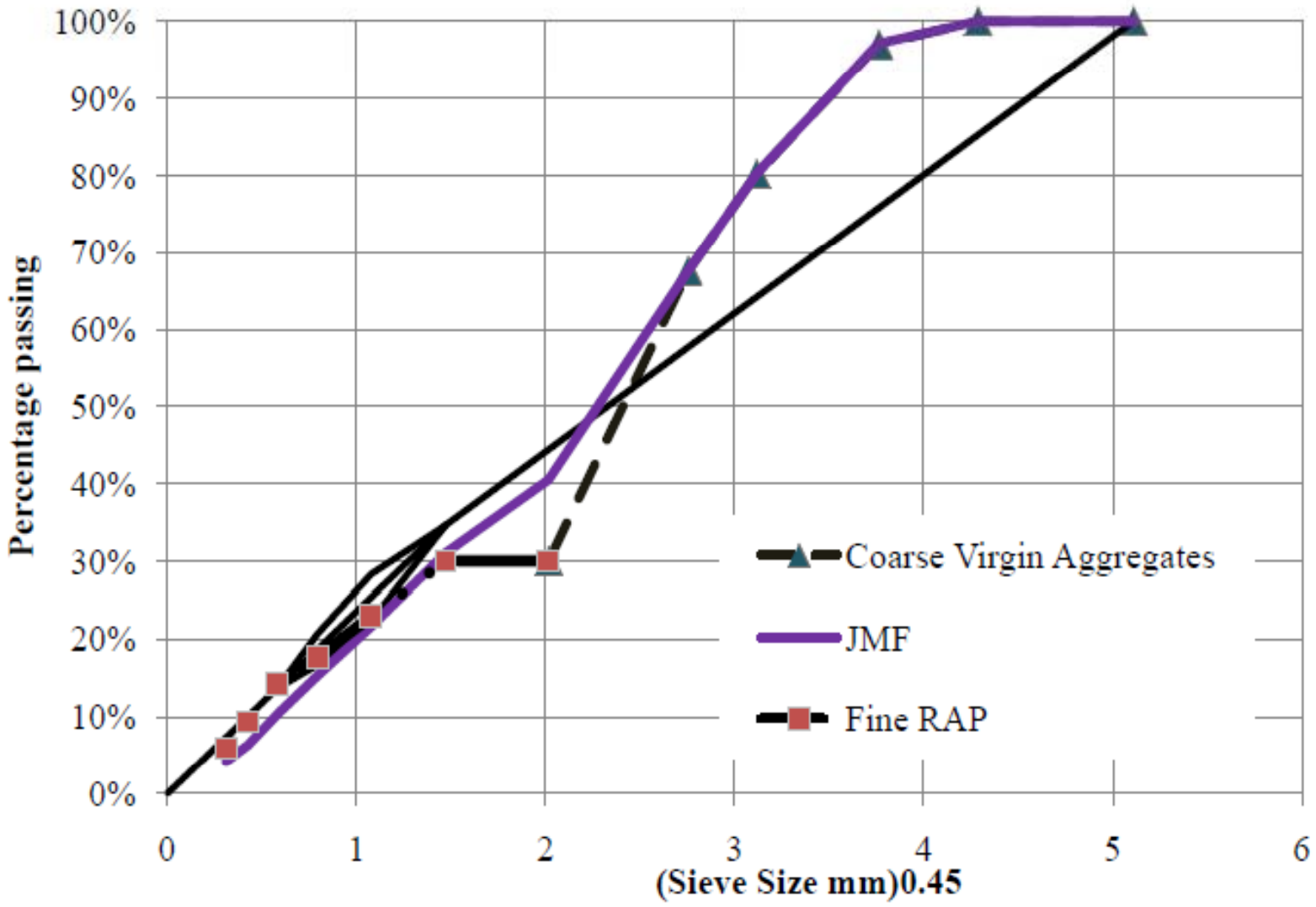
- Binder transfer after 2 min was almost constant
- Gradation of RAP affect degree of blending
- Increase in aggregate weight and decrease in RAP weight doesn't match
  - RAP not dried
  - RAP binder adhere to bucket
  - **RAP binder coated other RAP particles**

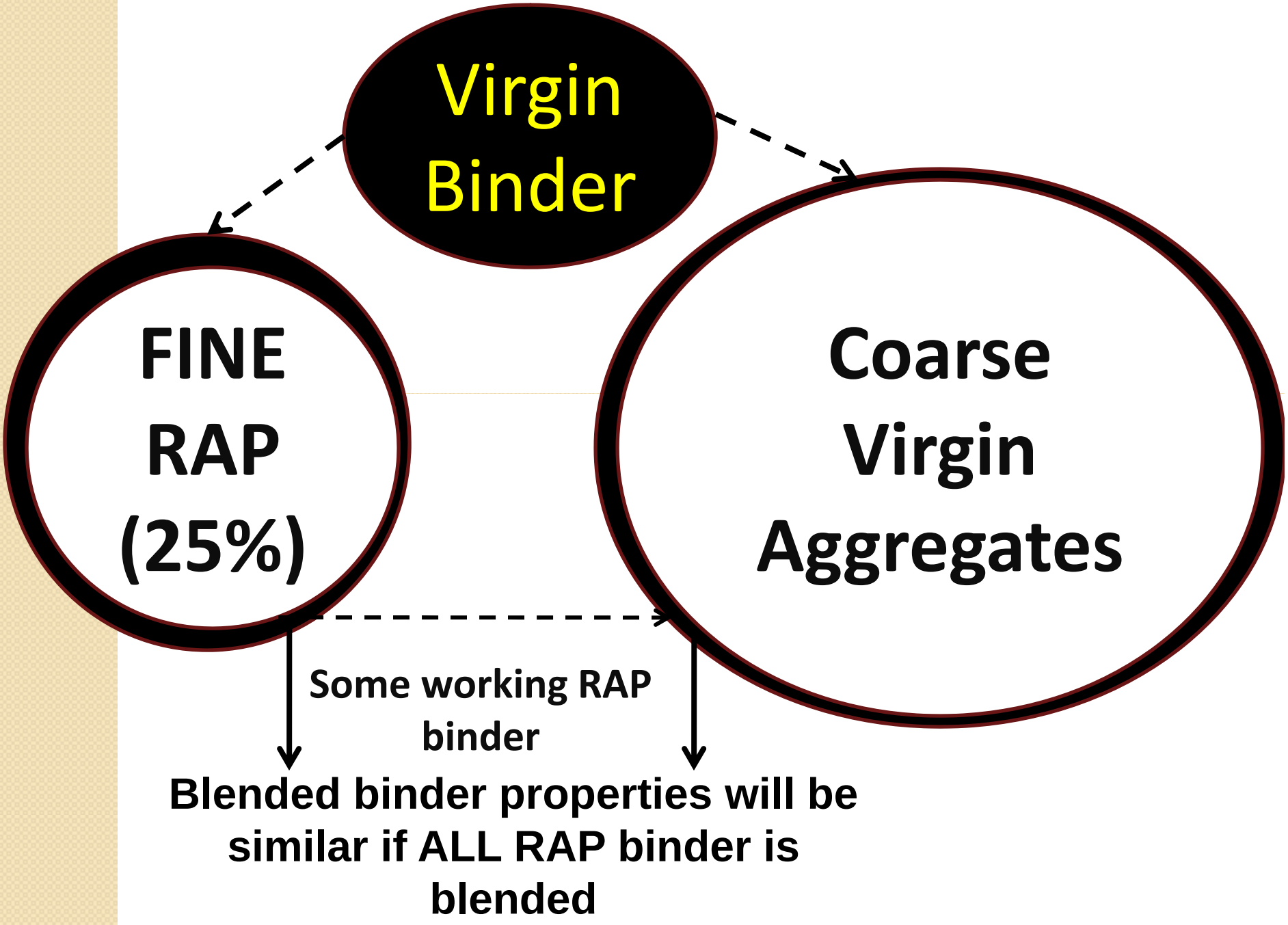
# DEGREE OF PARTIAL BLENDING

# Materials from plant

- Approved Job Mix Formula
- RAP – 25%
- Virgin aggregates
- Binder – PG 70-28

# Gradation

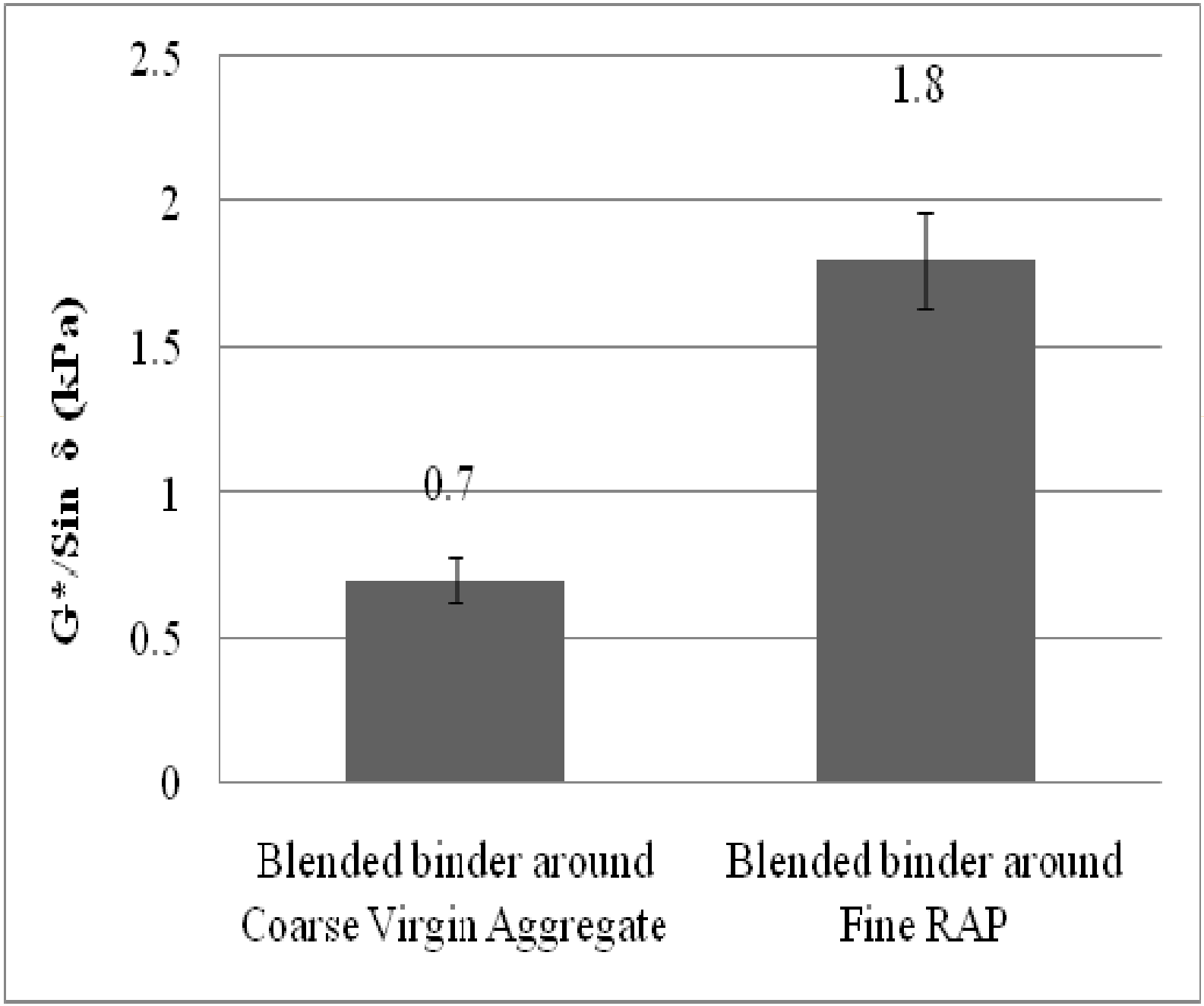

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage passing
0
1
2
3
4
5
6
(Sieve Size mm)0.45
Coarse Virgin Aggregates
JMF
Fine RAP


Virgin Binder
FINE RAP (25%)
Coarse Virgin Aggregates
Some working RAP binder
Blended binder properties will be similar if ALL RAP binder is blended

Determine degree of partial blending
= 100 x |1−Blending Ratio|

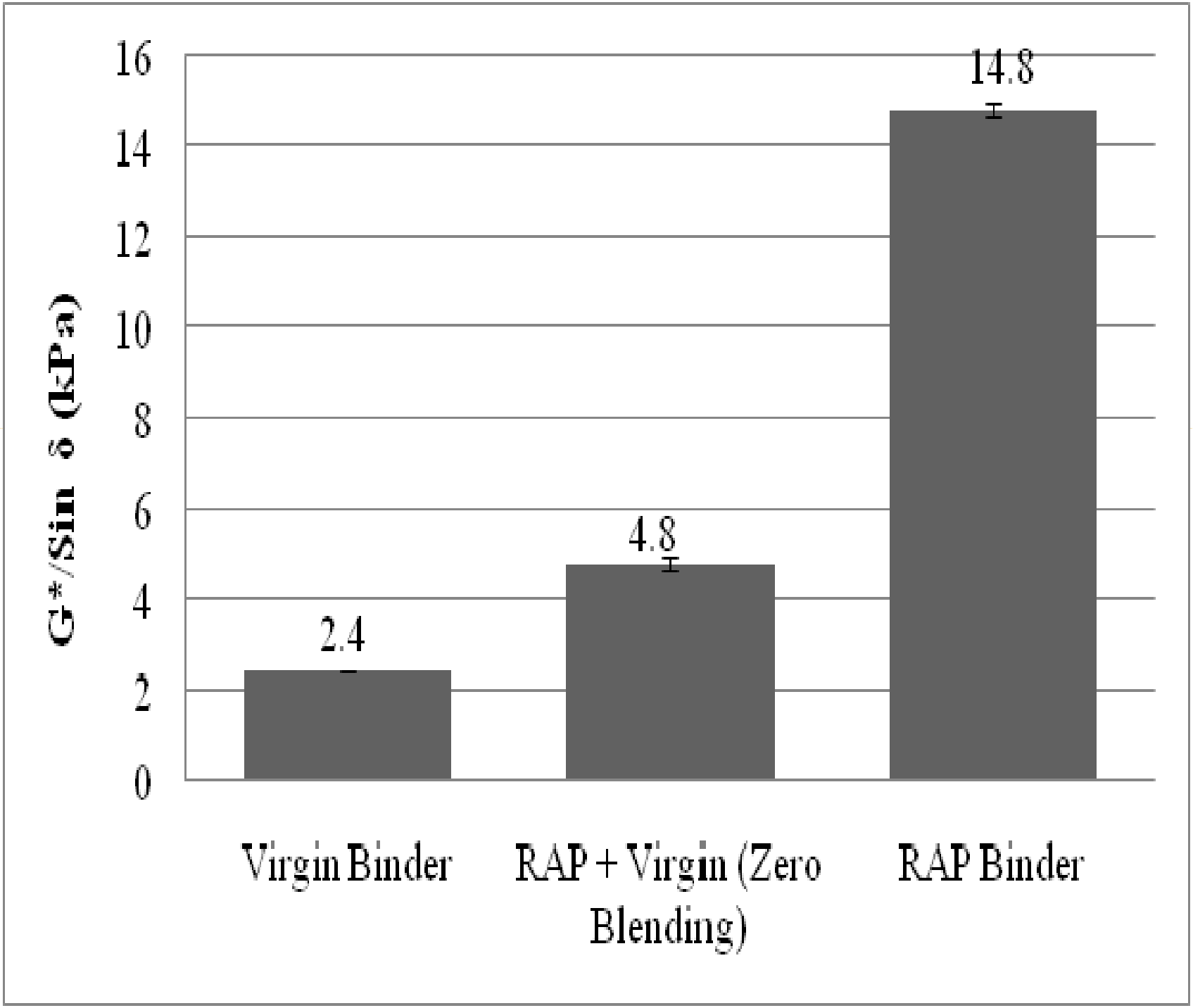
$$Blending\_Ratio = \left( \frac{\left| (G^*/\sin(\delta)_{blend\_binder\_virgin\_agg} - (G^*/\sin(\delta)_{blend\_binder\_RAP\_agg} \right|}{\left| (G^*/\sin(\delta)_{virgin\_binder} - G^*/\sin(\delta)_{RAP\_virgin\_binder\_0\_blend} \right|} \right)$$

Estimate virgin binder coating all aggregates based on the surface area of all aggregates


2.5
2
1.5
1
0.5
0
G*/Sin δ (kPa)
1.8
0.7
Blended binder around Coarse Virgin Aggregate
Blended binder around Fine RAP

# Bailey's Method

| | |
|---|---|
| Assuming, specific gravity of asphalt binder = | 1.02 |
| Average thickness of binder around RAP = | 22.8 microns |
| Weight of effective asphalt binder around the RAP = | 0.14 kg/kg of aggregate |
| Total amount of aggregates below #8 = | 275.3 gms |
| Total amount binder coating the RAP = | 37.42 gms |
| Amount of RAP binder around aggregate = | 16.42 gms |
| Amount of binder content around RAP from extraction recovery = | 5.63% |
| Amount of RAP binder coating the RAP= | 37.42 gms |
| The ratio of the RAP binder and the virgin binder coating the RAP = | 44:56 |


16
14
12
10
8
6
4
2
0
G*/Sin δ (kPa)
2.4
4.8
14.8
Virgin Binder
RAP + Virgin (Zero Blending)
RAP Binder

Determine degree of partial blending
= 100 x |1−Blending Ratio|

$$Blending\_Ratio = \left( \frac{\left| (G^*/\sin(\delta)_{blend\_binder\_virgin\_agg} - (G^*/\sin(\delta)_{blend\_binder\_RAP\_agg} \right|}{\left| (G^*/\sin(\delta)_{virgin\_binder} - G^*/\sin(\delta)_{RAP\_virgin\_binder\_0\_blend} \right|} \right)$$

Estimate virgin binder coating all aggregates based on the surface area of all aggregates

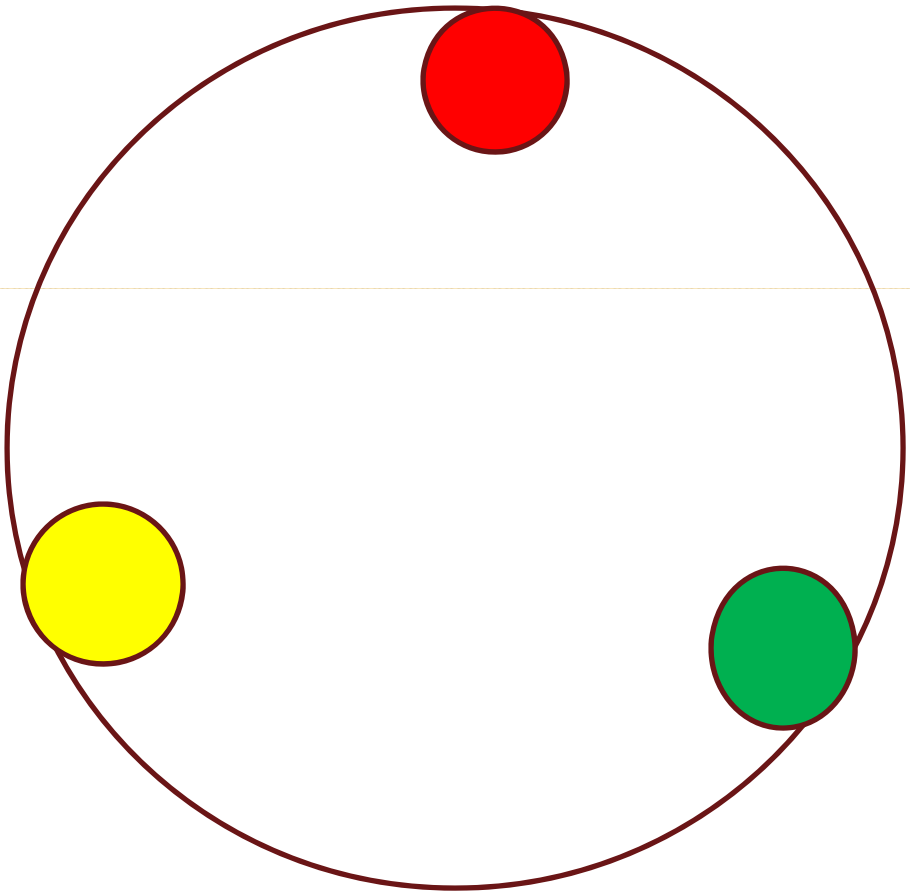
**Degree of partial blending is 53%**

# VARIABILITY STUDY

# Objectives

- Determine the variability and the amount of RAP that can be added to the mixture for four plants in the state of New Jersey

# Study Sampling Protocol



Bucket 1

Bucket 2

Bucket 3

Bucket 4

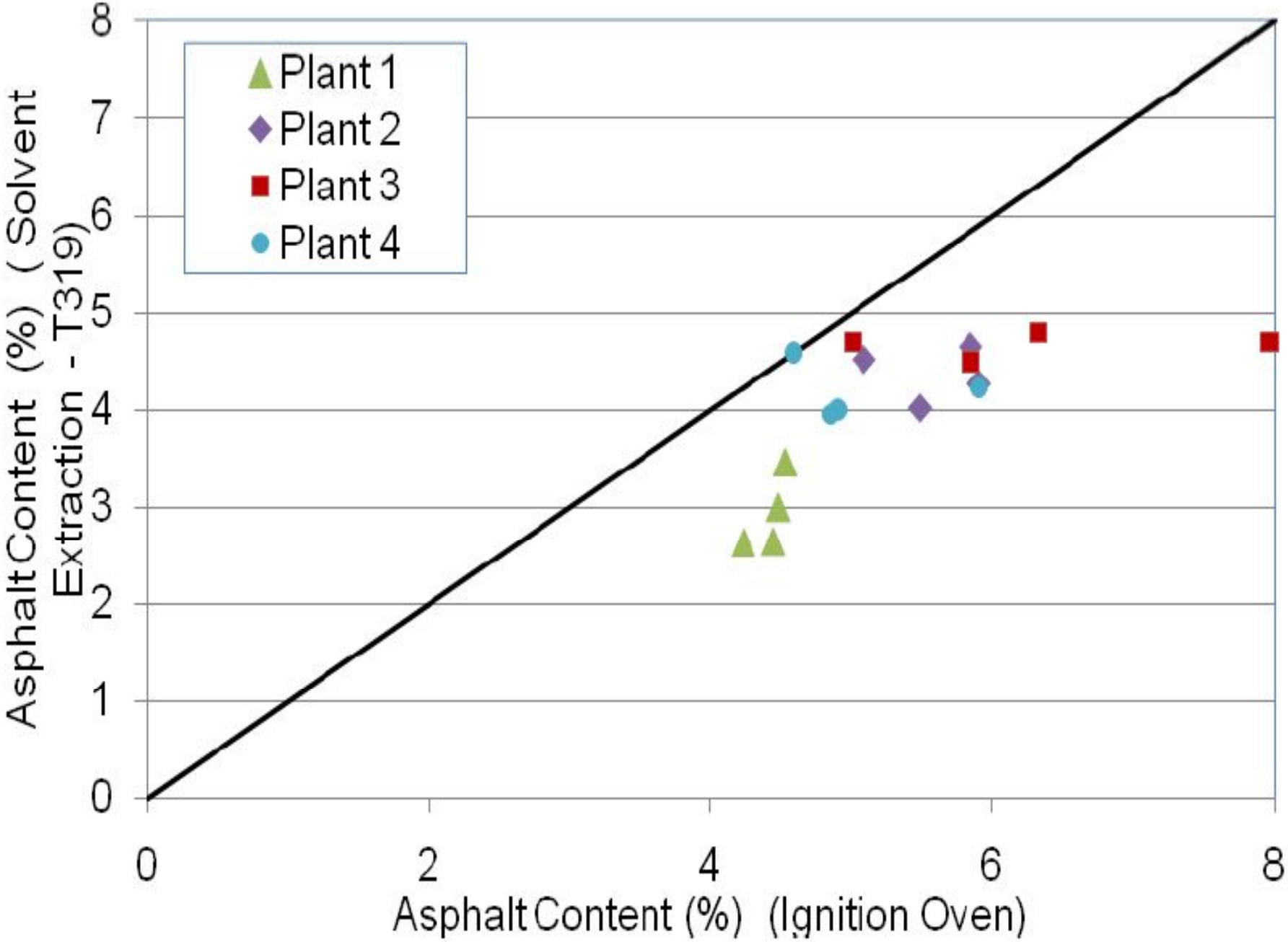
# Experimental Design

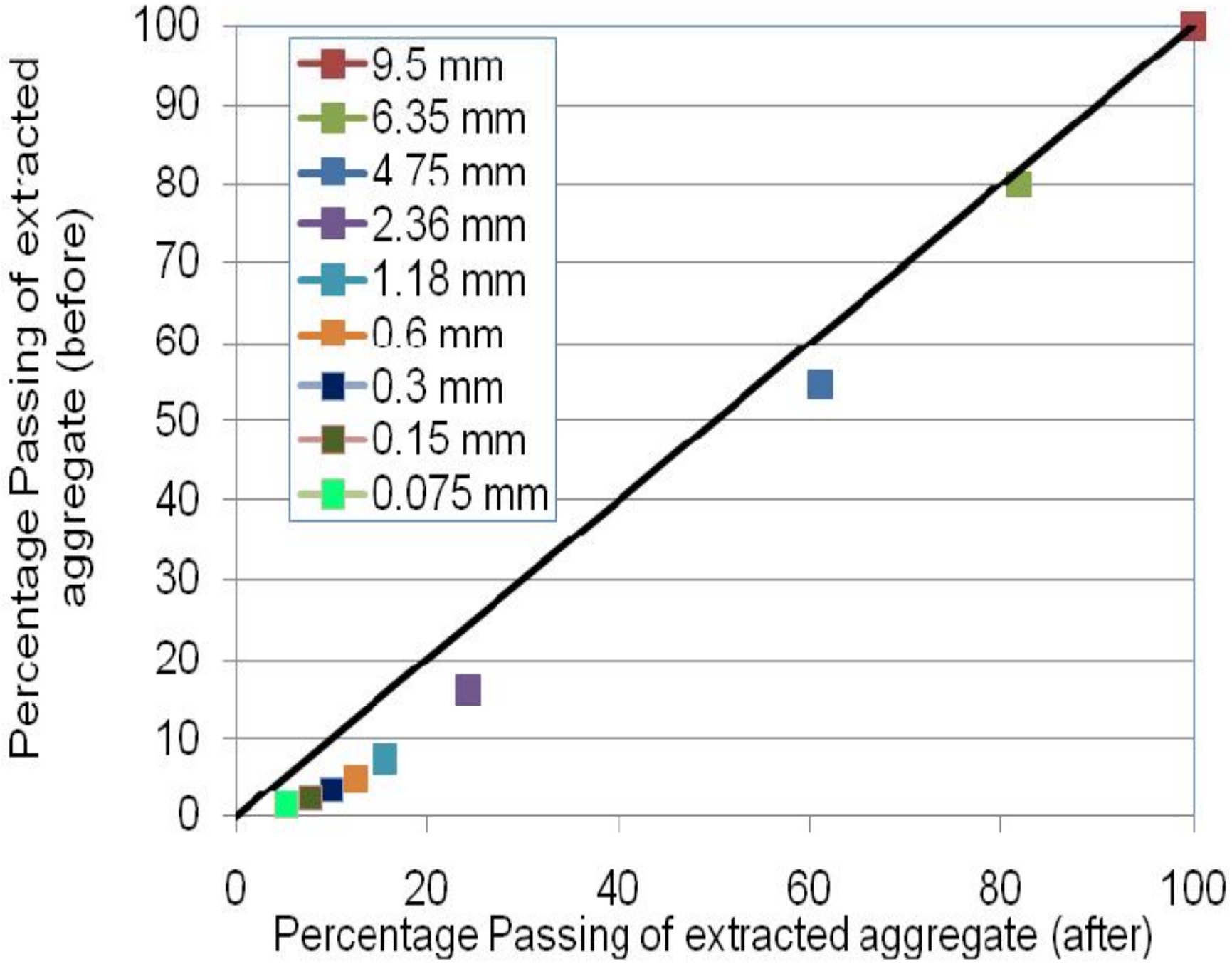
## Asphalt Content and Gradation

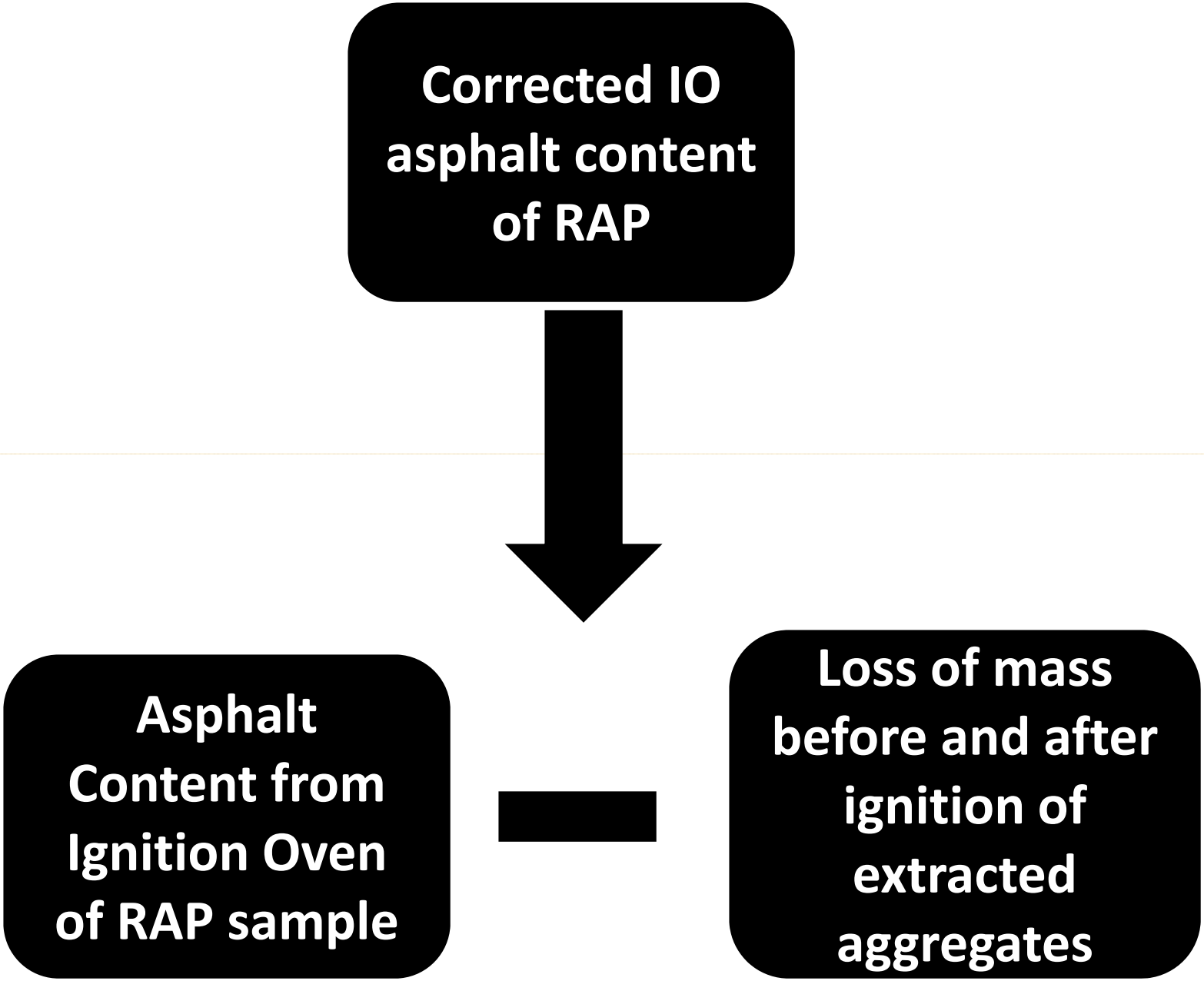
| | Plant 1 | | Plant 2 | | Plant 3 | | Plant 4 | |
|---|---|---|---|---|---|---|---|---|
| Bucket | (T319) | (T309) | (T319) | (T309) | (T319) | (T309) | (T319) | (T309) |
| **1** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **2** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **3** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **4** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

# Steps for Determining Correct Asphalt Content from IO

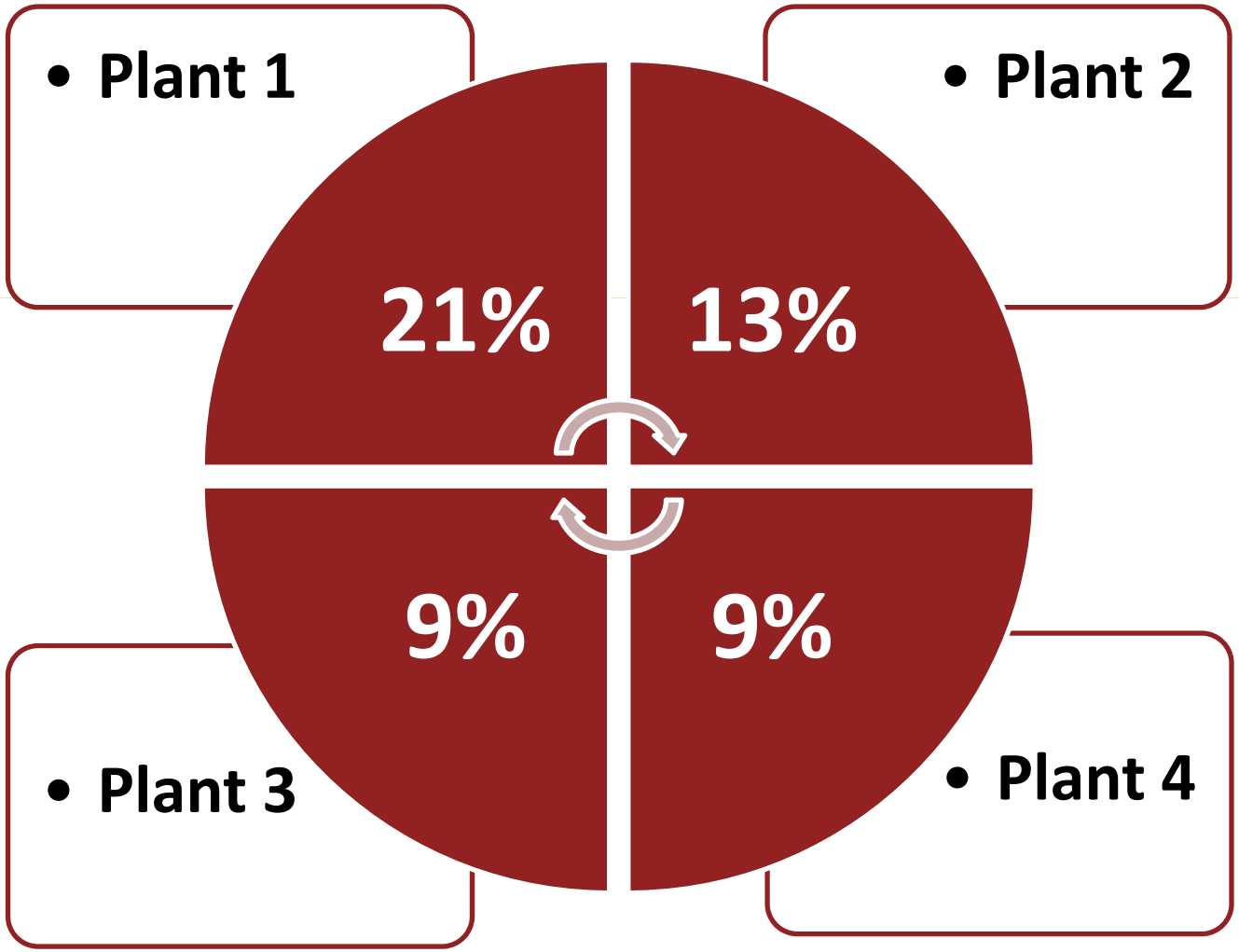
1. • Calculate asphalt content with both methods
2. • Burn extracted aggregate from T319 in Ignition oven
3. • Note the change in mass


Plant 1
Plant 2
Plant 3
Plant 4
Asphalt Content (%) ( Solvent Extraction - T319)
Asphalt Content (%) (Ignition Oven)
0
1
2
3
4
5
6
7
8
0
2
4
6
8


Percentage Passing of extracted aggregate (before)
100
90
80
70
60
50
40
30
20
10
0
9.5 mm
6.35 mm
4.75 mm
2.36 mm
1.18 mm
0.6 mm
0.3 mm
0.15 mm
0.075 mm
0
20
40
60
80
100
Percentage Passing of extracted aggregate (after)


Corrected IO asphalt content of RAP
Asphalt Content from Ignition Oven of RAP sample
Loss of mass before and after ignition of extracted aggregates

# Allowable percentage of RAP



# THANK YOU