ARC

Asphalt Research Consortium

A: Estimating PG-Grade of Binders in RAP without Extraction: UWM + UNR

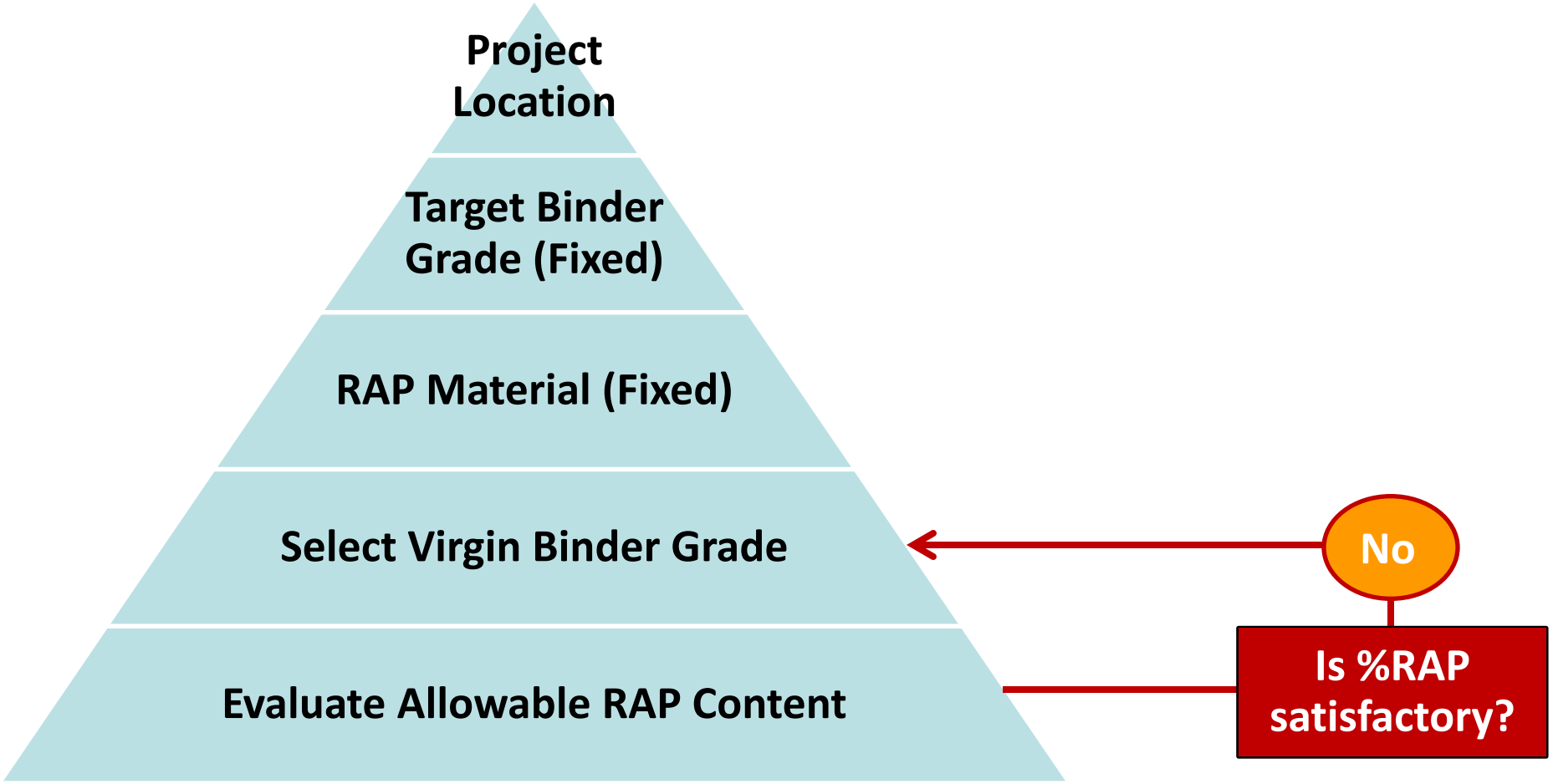
B: Impact of current extraction techniques on properties of extracted RAP aggregates: UNR + NCAT

A: Concept of Testing

- Replace extraction & testing with testing RAP Mortar
  - Mortar: Void-less mix of selected gradation of RAP with binder

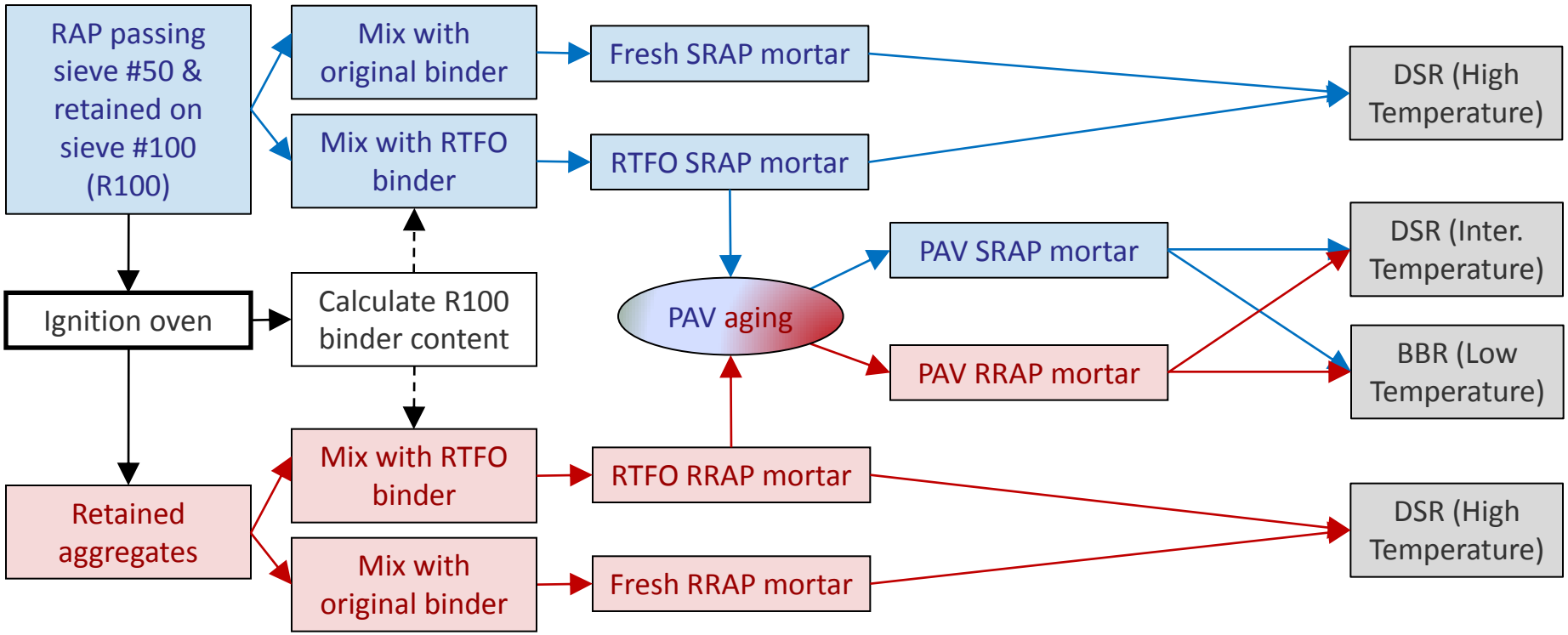
- Estimate *allowable % of RAP* based on RAP properties and final PG grade.

A: Concept of Testing

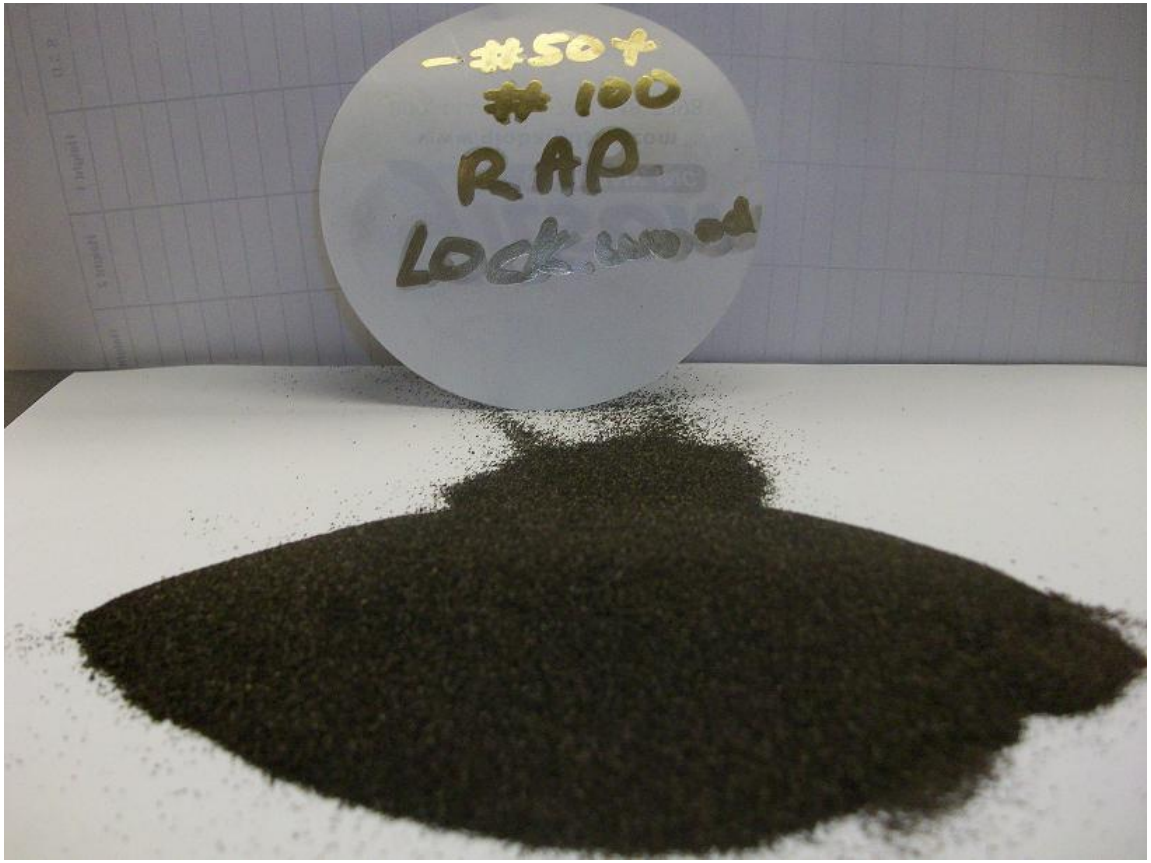


A: Concept of Testing

Flow Chart of Material Preparation and Testing



A: R100 Sample



A: Example

- City of Reno specs:
  - Final PG grade: PG64-22
  - Desired RAP content: 30%

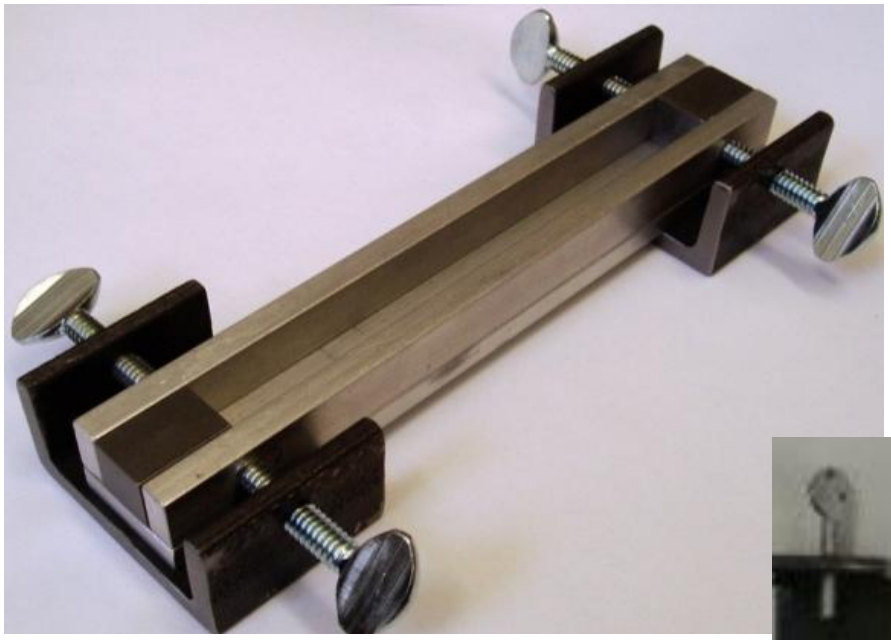
- Define virgin binder grade to meet COR specs.

A: Example

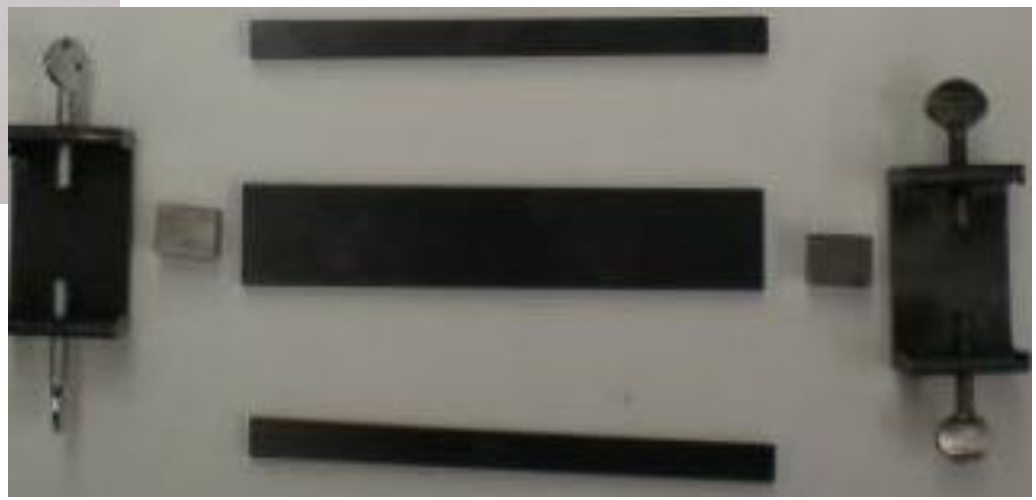
- Virgin binder: PG64-22
- Using the R100 material produce:
  - Fresh SRAP mortar
  - RTFO SRAP mortar
  - PAV SRAP mortar
- Using the R100 burned off material produce:
  - Fresh RRAP mortar
  - RTFO RRAP mortar
  - PAV RRAP mortar

A: Example

3 – Low Temperature



1. Wider Sample: 12.5 x 10.0 mm
2. Teflon coated
3. Stronger end holders



A: Example

3 – Low Temperature

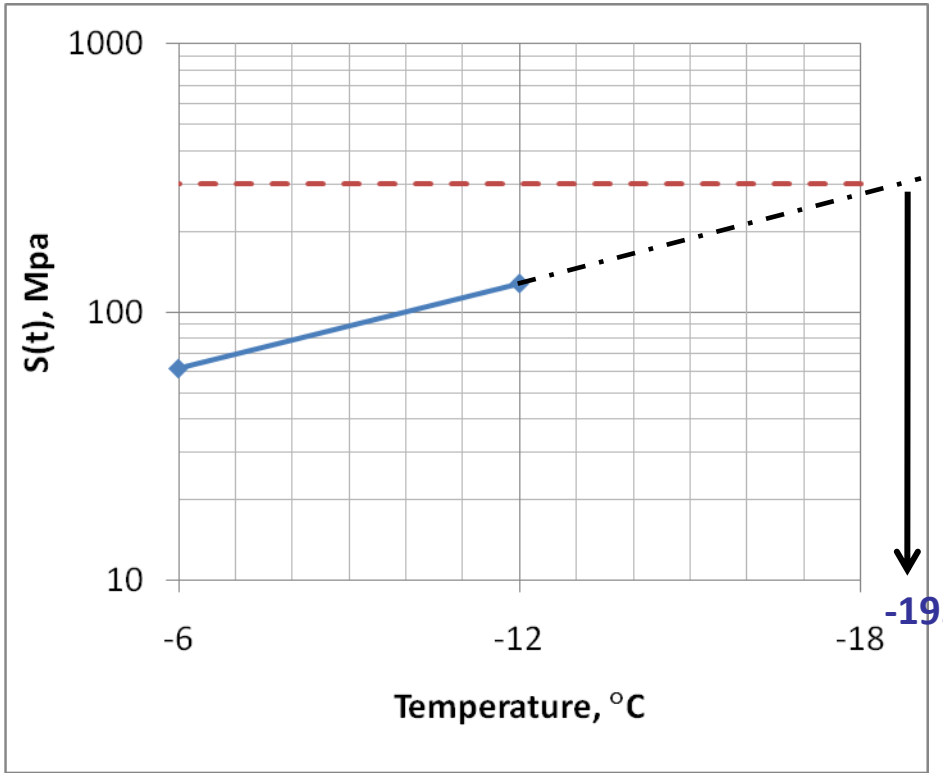
- **Select testing temperatures:**
  - Low PG of the fresh binder = -12°C
  - Low PG of the fresh binder + 6°C = -6°C

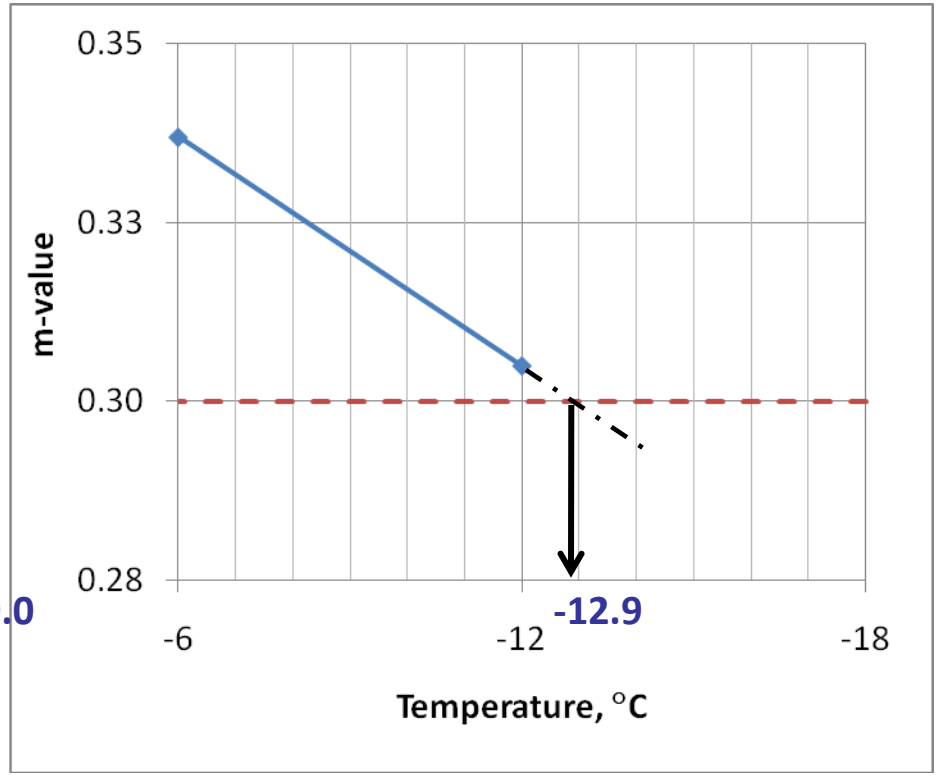
- **Test**
  - *PAV binder*
  - *PAV RRAP Mortar*
  - *PAV SRAP Mortar*

A: Example

3 – Low Temperature

- **Critical low temp for *PAV binder***





A: Example
3 – Low Temperature

- **BBR test results on *RRAP mortar* (i.e. % RAP binder = 0)**

Test Temperature 1:					-6	Test Temperature 2:					-12
Time [sec]	Trial 1	Trial 2	Trial 3	Average	COV	Time [sec]	Trial 1	Trial 2	Trial 3	Average	COV
	RRAP Mortar, S-value (MPa)						RRAP Mortar, S-value (MPa)				
60	239.0	231.0	242.0	237.3	2.4	60	459.0	447.0	485.0	463.7	4.2
	RRAP Mortar, m-value						RRAP Mortar, m-value				
60	0.335	0.331	0.340	0.335	1.3	60	0.279	0.286	0.283	0.283	1.2

A: Example
3 – Low Temperature

- **BBR test results on *SRAP mortar* (i.e. % RAP binder = 27.4%)**

Test Temperature 1:					-6	Test Temperature 2:					-12
Time [sec]	Trial 1	Trial 2	Trial 3	Average	COV	Time [sec]	Trial 1	Trial 2	Trial 3	Average	COV
	SRAP Mortar, S-value (MPa)						SRAP Mortar, S-value (MPa)				
60	294.0	307.0	299.0	300.0	2.2	60	601.0	599.0	606.0	602.0	0.6
	SRAP Mortar, m-value						SRAP Mortar, m-value				
60	0.327	0.321	0.331	0.326	1.5	60	0.274	0.273	0.272	0.273	0.4

A: Example

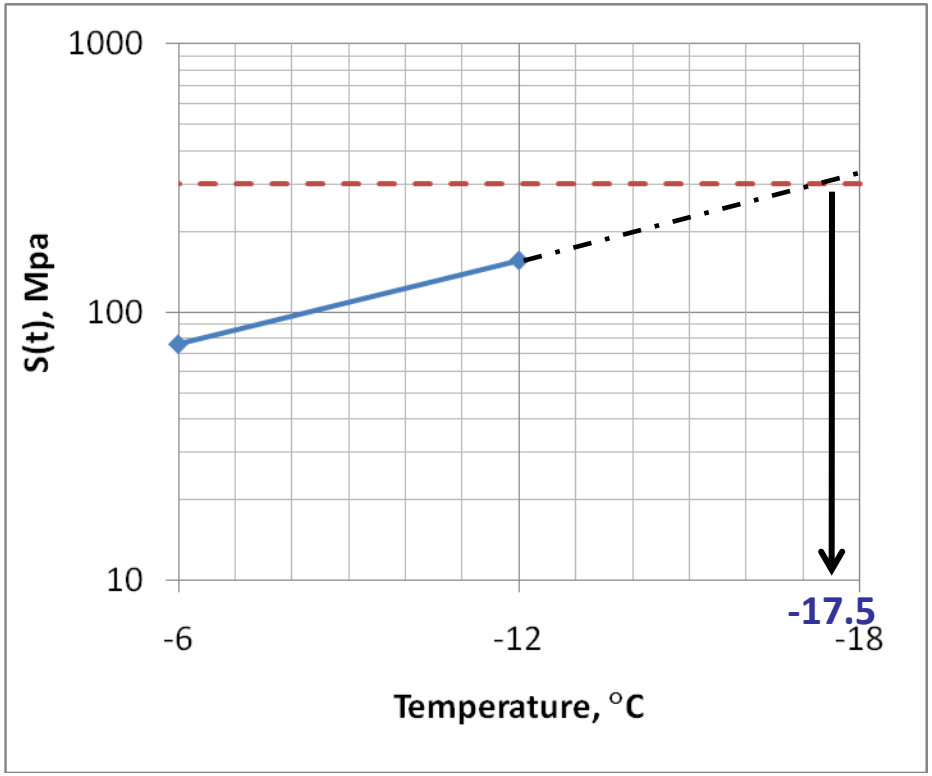
3 – Low Temperature

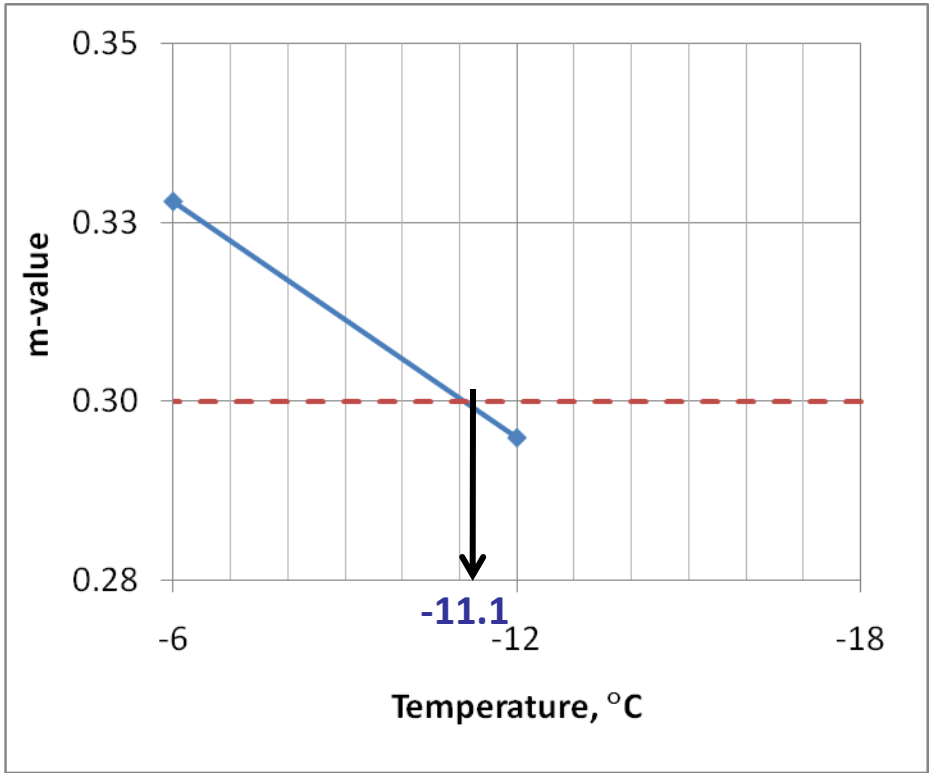
- The comparison of the S and m of the **SRAP** to the S and m of the **RRAP** allow for the backcalculation of the S and m of the **blend binder** (virgin + RAP)

A: Example

3 – Low Temperature

- **Calculate the critical low PG for the blend binder**

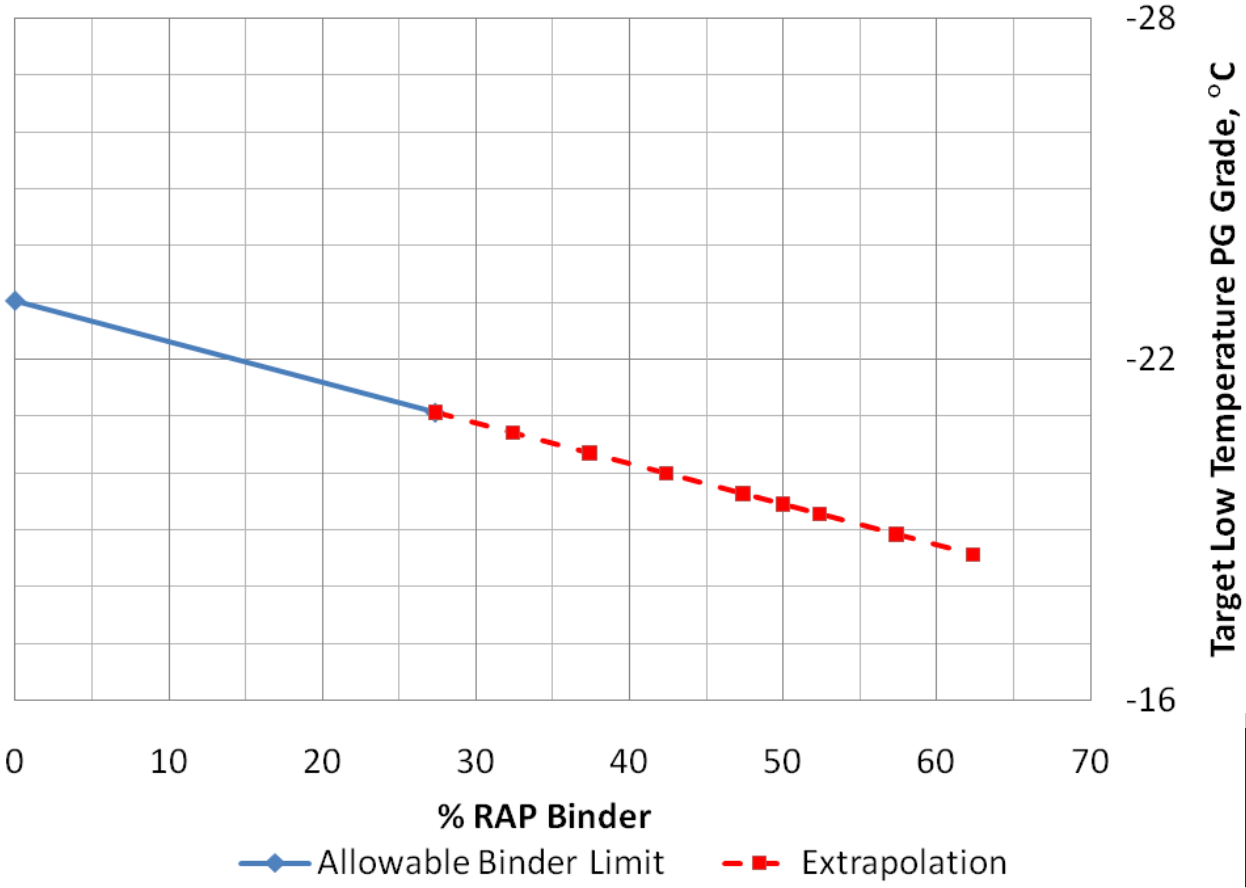




A: Example

3 – Low Temperature

- For 0% RAP binder: Low PG true grade = -12.9 -10 = -22.9°C
- For 27.4% RAP binder: Low PG true grade = -11.1-10 = -21.1°C



A: Example

- Convert %RAP Binder to %RAP

- You will find that the City of Reno specs of 30% RAP were not met with the virgin binder of PG64-22.

Specific Gravity of RAP Aggregates

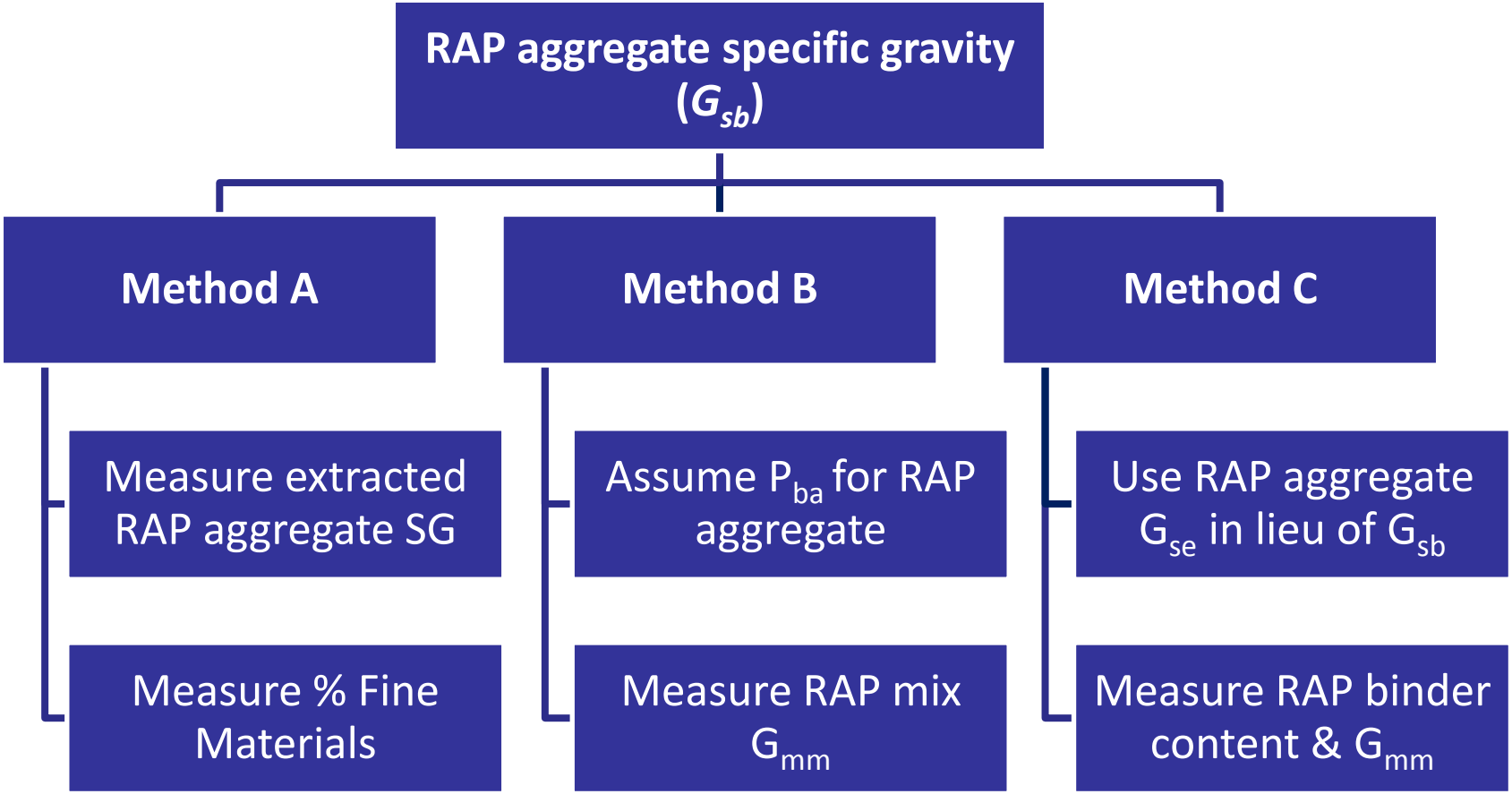
- Evaluate impact of current extraction techniques on Specific gravity of extracted RAP aggregates.

- Extract aggregates from Lab-produce RAP mixes using:
  - Centrifuge (Trichloroethylene)
  - Reflux (Trichloroethylene)
  - Ignition oven

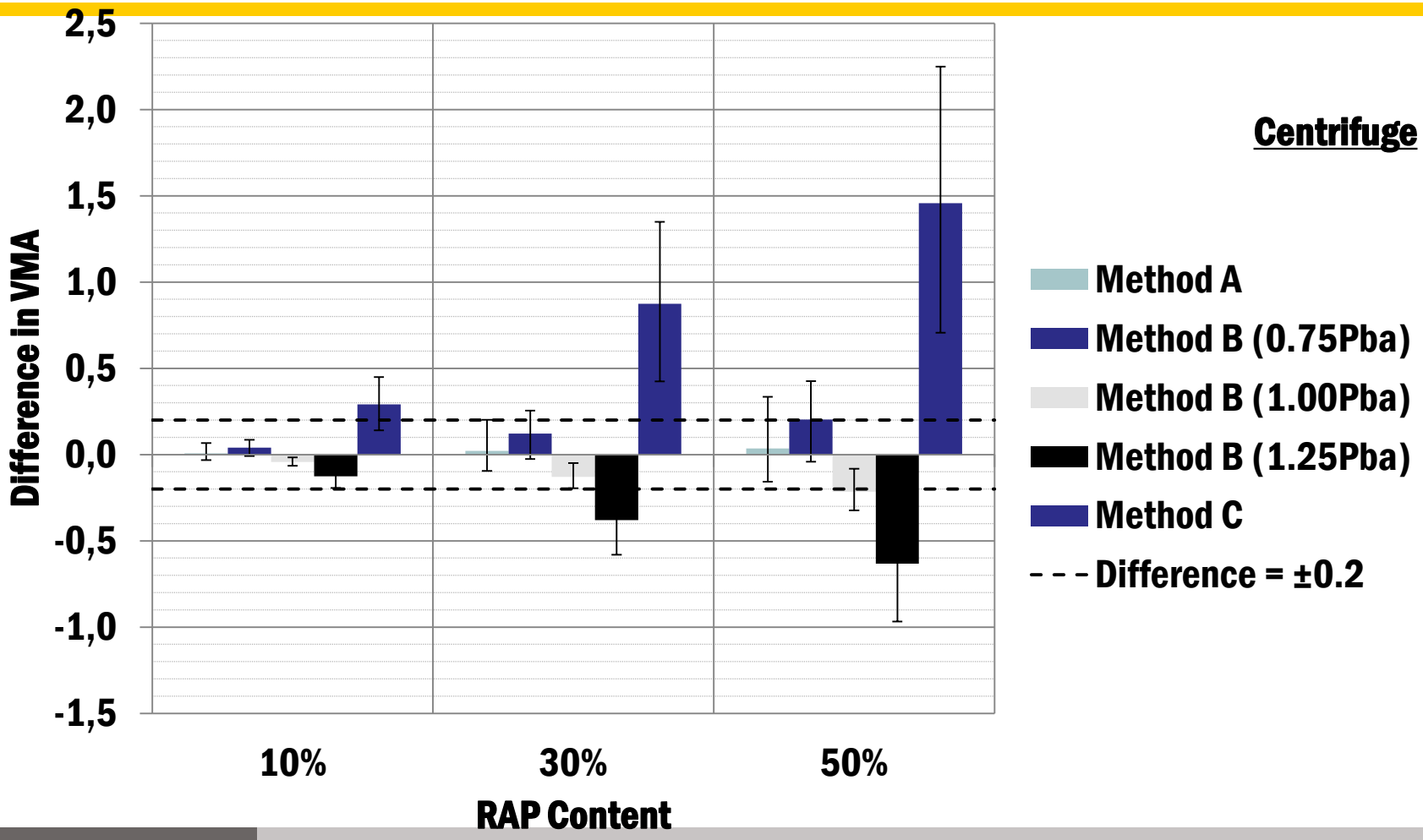
Specific Gravity of RAP Aggregates

- Aggregate Sources:
  - Nevada: Rhyolite (UNR)
  - California: Granodiorite (UNR)
  - Alabama: Hard Limestone (NCAT)
  - Florida: Soft Limestone (NCAT)

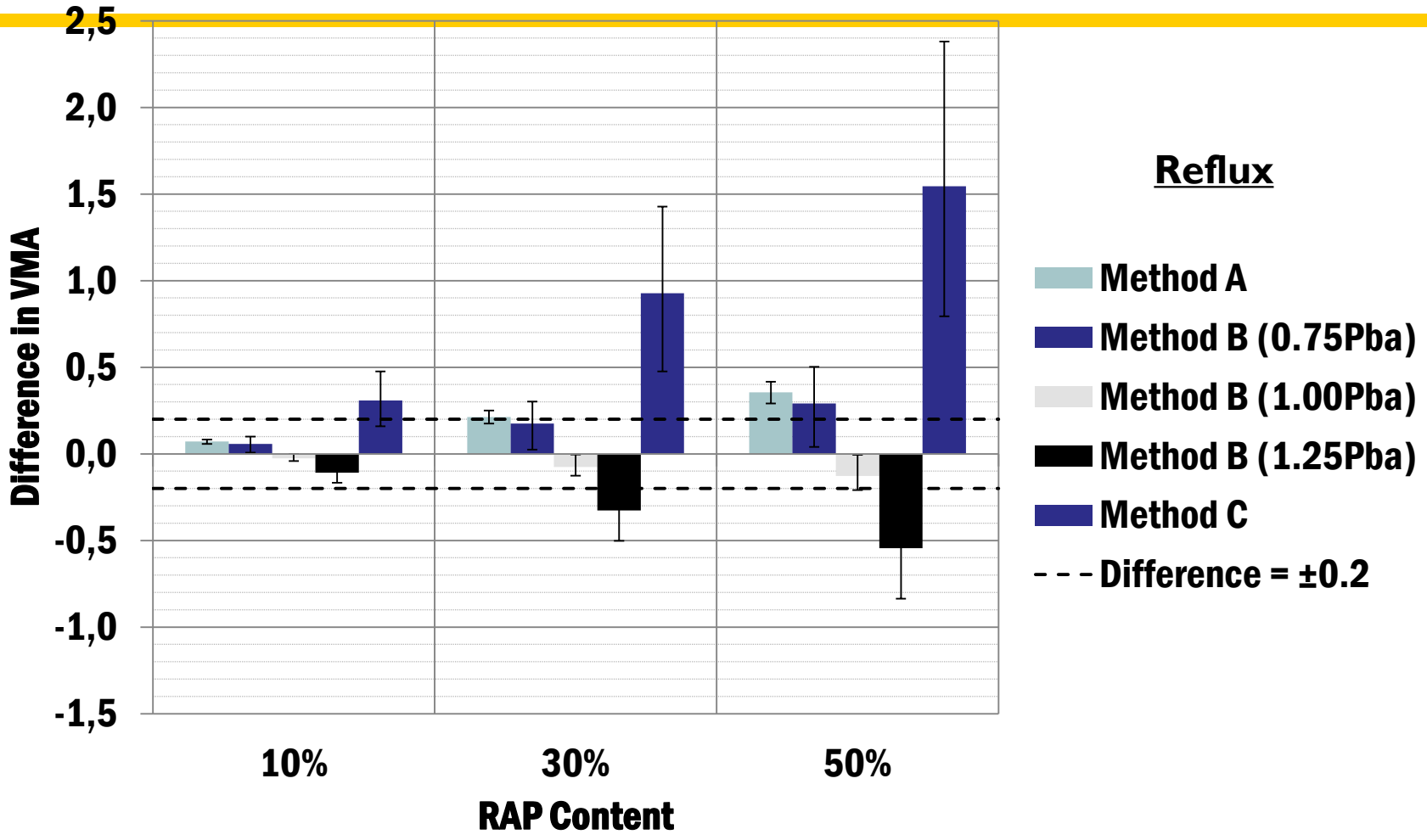
Specific Gravity of RAP Aggregates



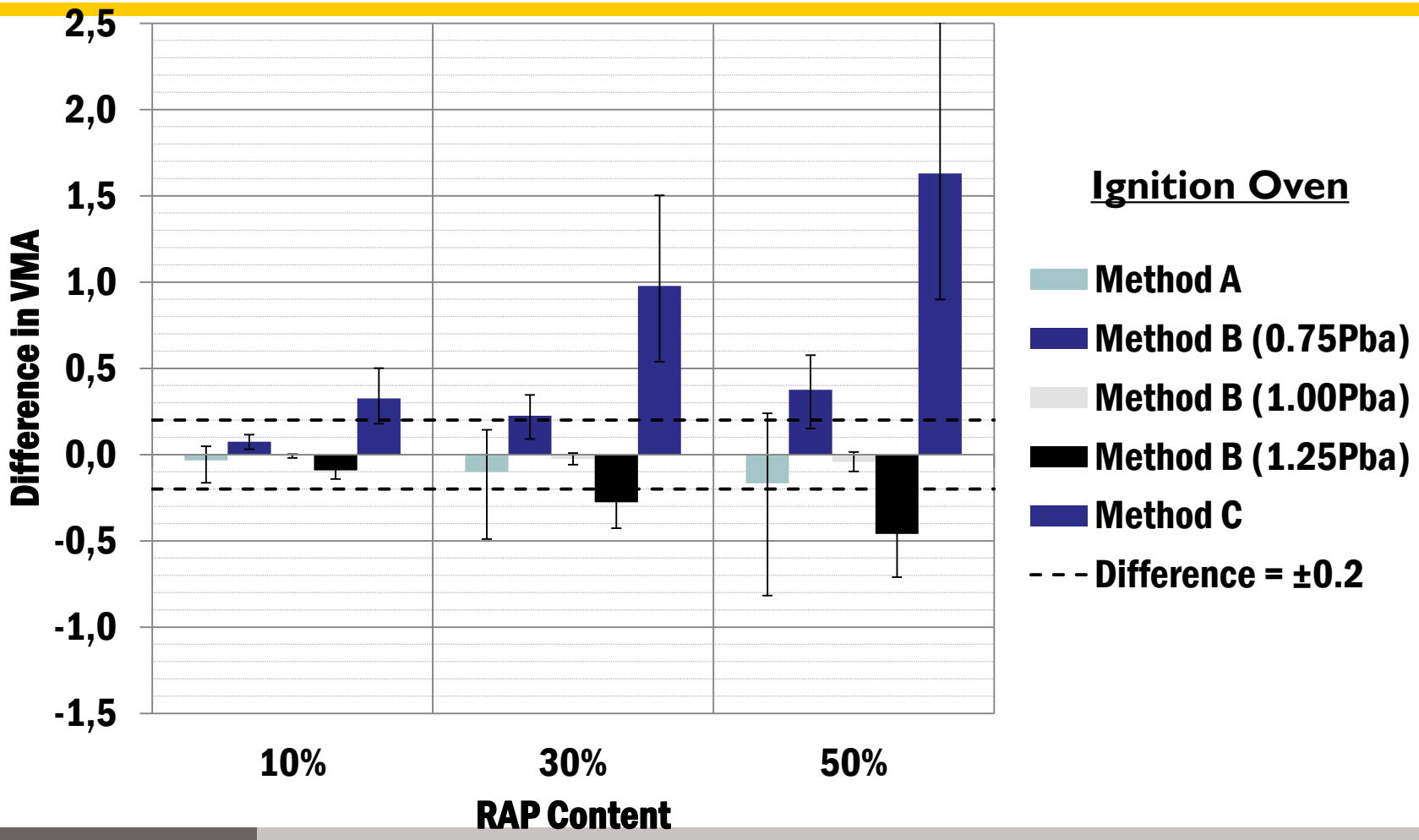
Impact on VMA Calculations



Impact on VMA Calculations



Impact on VMA Calculations



Impact on VMA Calculations

Methods for estimating RAP aggregate specific gravity	RAP Percentage Extraction Methods			Expected Error in VMA
	Centrifuge	Reflux	Ignition Oven	
Method A[e]	≤ 25%	≤ 25%	≤ 10%	± 0.2%
	25% - 50%	25% - 50%	10% - 25%	± 0.4%
Method B [f, g]	≤ 10%	≤ 10%	≤ 15%	± 0.2%
	10% - 20%	10% - 20%	15% - 25%	± 0.4%