Exploring the Performance Spectrum of Bitumen Stabilised Materials' variables: RA Recycled Asphalt, Active Filler and Binder Content

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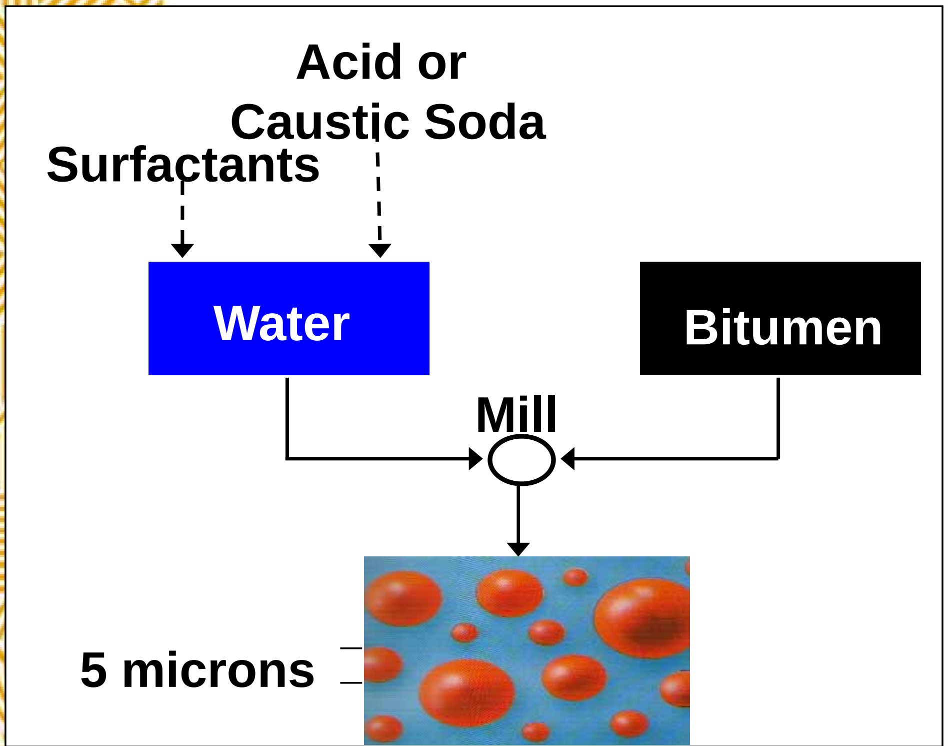
Introduction

1. Environmental Considerations for BSM
2. Pavement Structures and Energy
3. Tests
4. Influence of Active Filler
5. Influence of Bitumen Content
6. Deviations from expected behaviour
7. Conclusions
8. Recommendations
9. Questions

Bitumen Stabilisation Agents

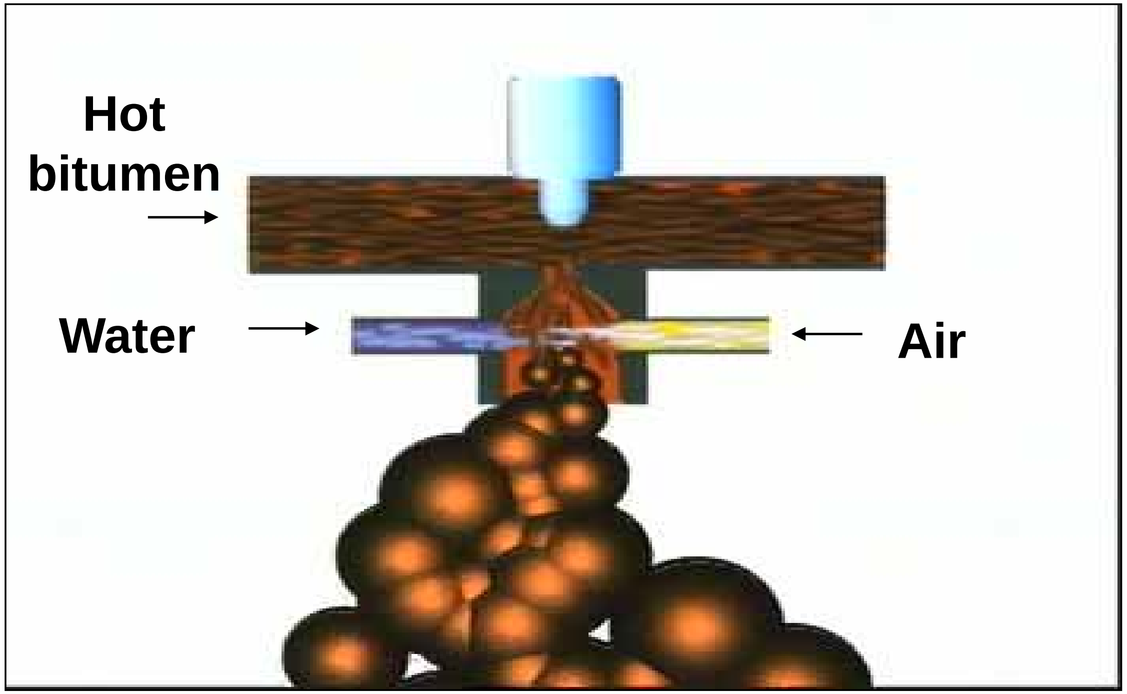
BITUMEN EMULSION

Colloidal Mill

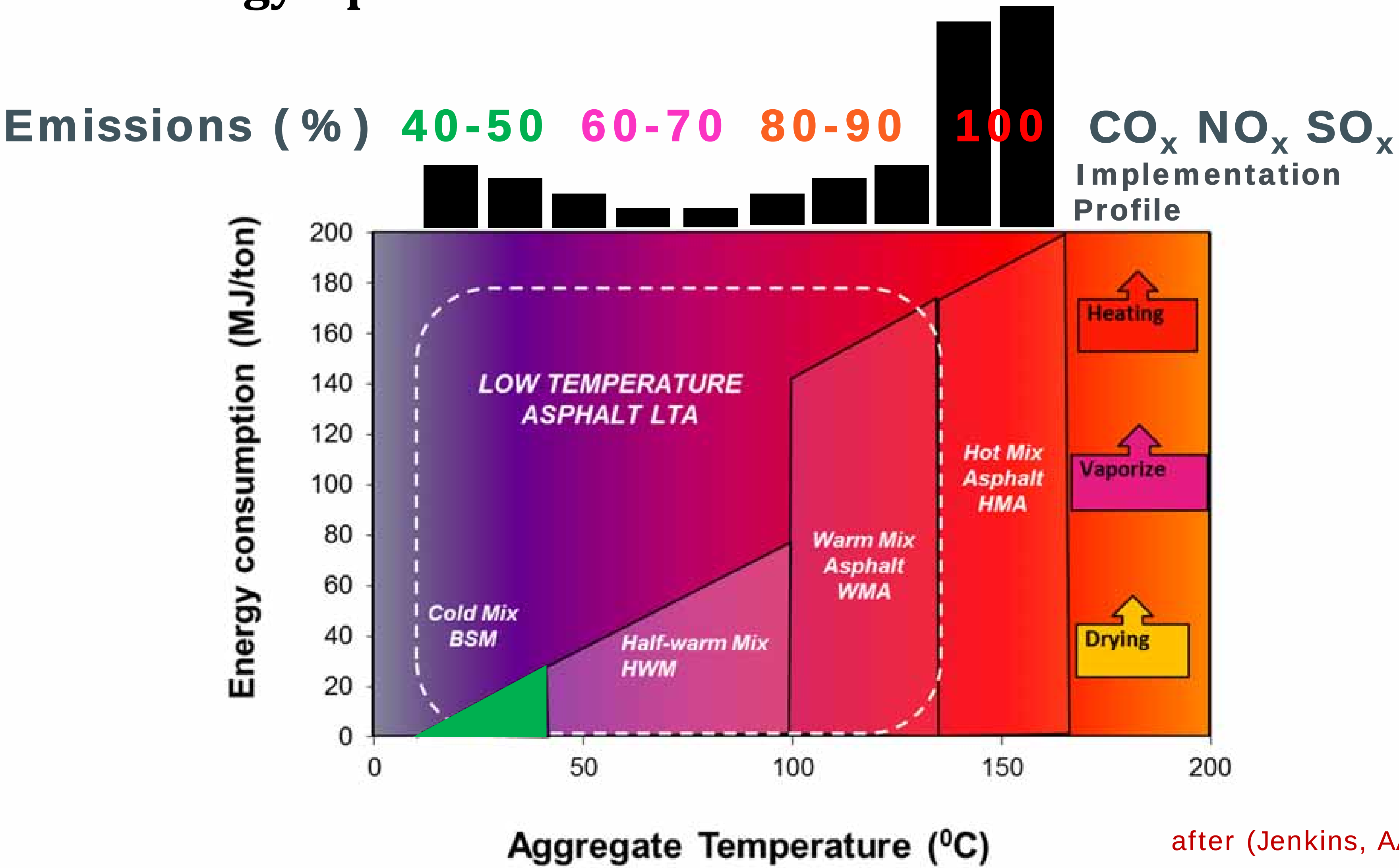


FOAMED BITUMEN

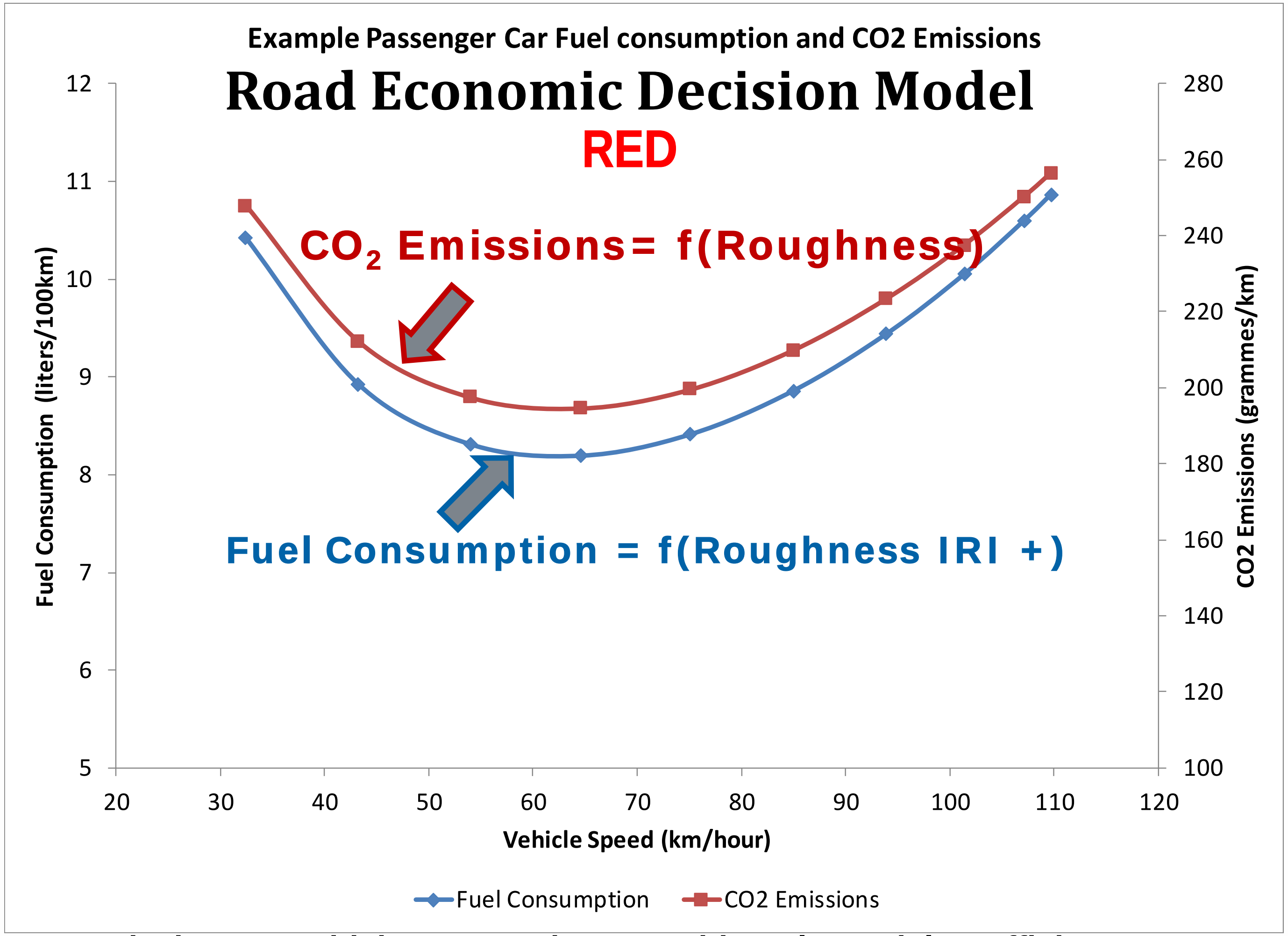
Expansion chamber



Technology Options



after (Jenkins, AAPT, 2001)



Unit CO_2 Emissions Sensitivity to Roughness Cubic Polynomial Coefficients

CO2 Emissions (Grams/vehicle-km) = a0 + a1 * IRI + a2 * IRI^2 + a3 * IRI^3

Coefficient	Motor_ cycle	Small Car	Medium Car	Delivery Vehicle	Four-Wheel Drive	Light Truck	Medium Truck	Heavy Truck	Articulated Truck	Small Bus	Medium Bus	Large Bus	Average Vehicle Fleet
a0	49.73	180.66	211.62	231.06	229.45	419.60	723.46	1344.48	1817.77	272.19	433.73	847.04	337.32
a1	0.7842	-2.4571	-3.4518	-2.4618	-0.8010	0.8989	4.0325	10.5465	8.4855	0.4445	1.9410	0.5878	-0.8268
a2	-0.0655	0.4056	0.5385	0.3792	0.2293	0.1540	-0.1269	-0.8162	-0.0601	0.0920	-0.0143	0.3723	0.2681
a3	0.0020	-0.0106	-0.0141	-0.0093	-0.0053	-0.0038	0.0051	0.0273	0.0041	-0.0017	0.0012	-0.0095	-0.0064

Pavements: Energy per ton of placed material

(Colas)

Technical Recycling Selection

In Place

How to select?

In Plant

Cold Recycling

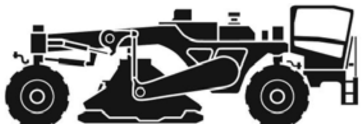
In Place

In Plant

How to select?

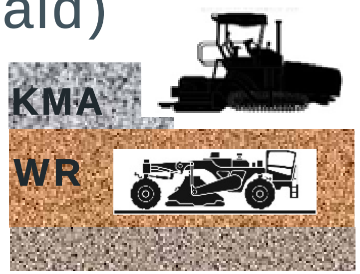
In Place

- Production W380CR >750t/h
- Treat consistent material
- No material transport costs
- Cut-plan necessary
- Joints between wheelpaths

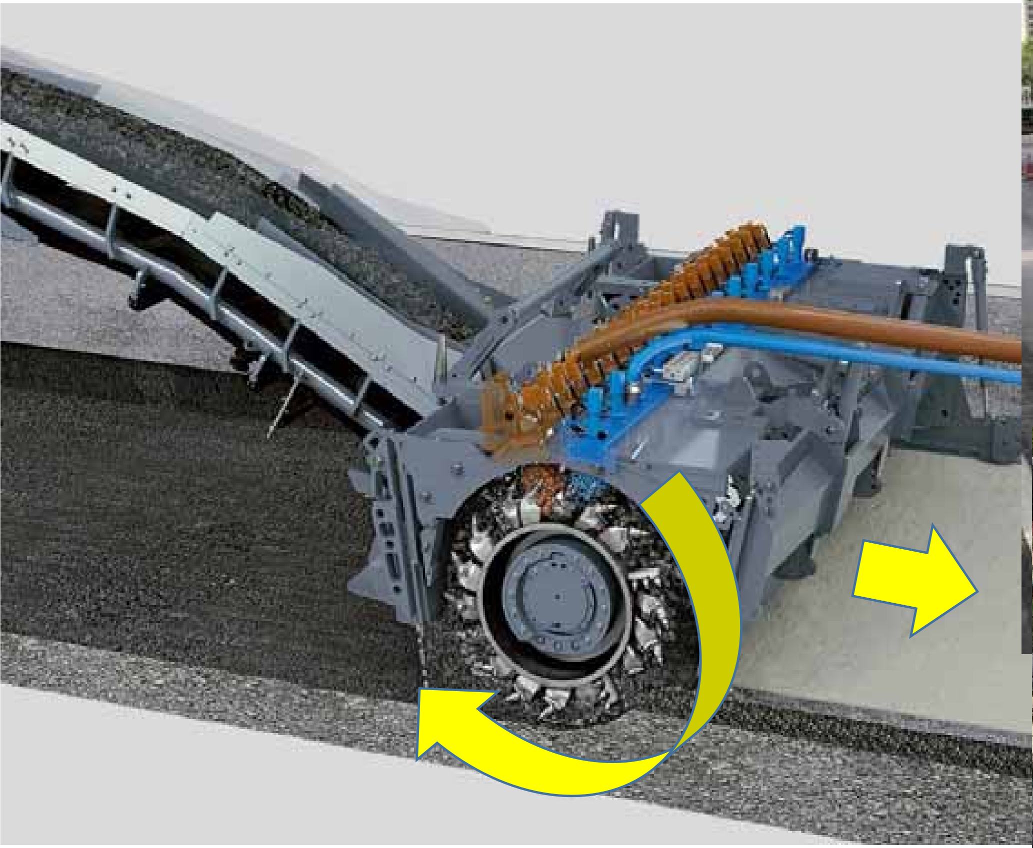


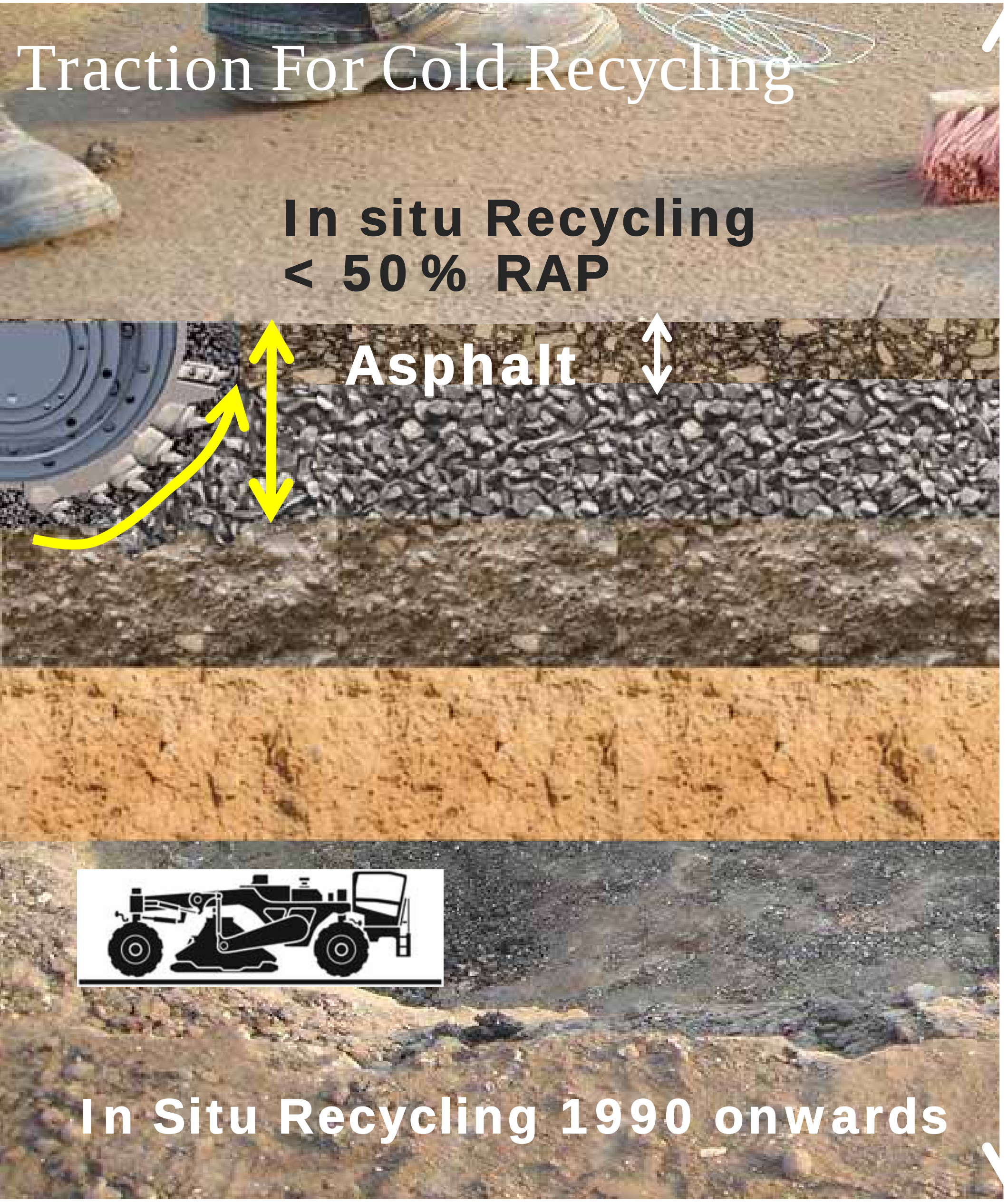
In Plant

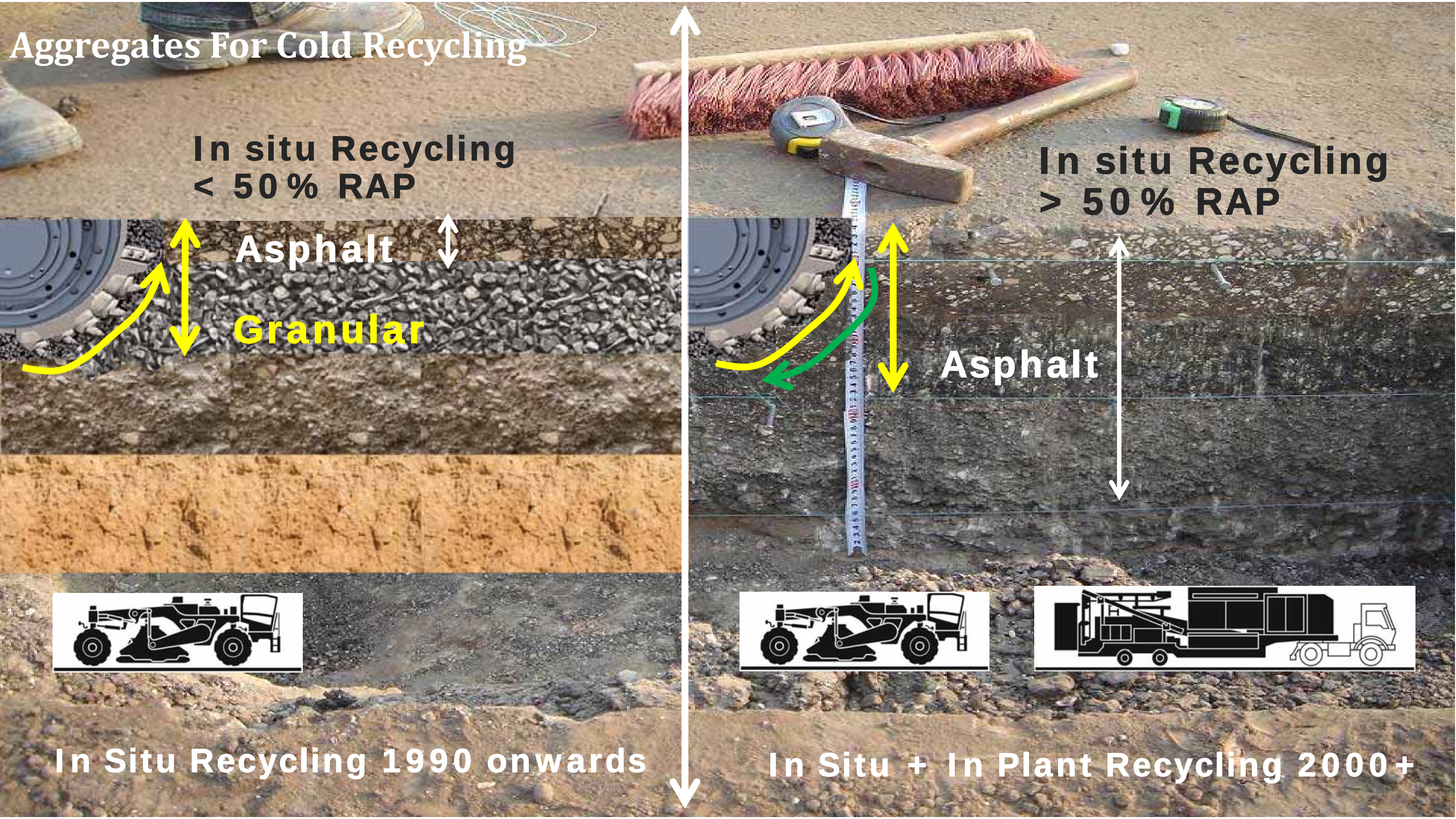
- Production >200t/h
- Blends several materials
- Cross-mixing (3D)
- No grader (paver laid)
- No joints in lanes
- Allows multi-layer treatment



Cold Recycling in 100% RAP
Down Cutting

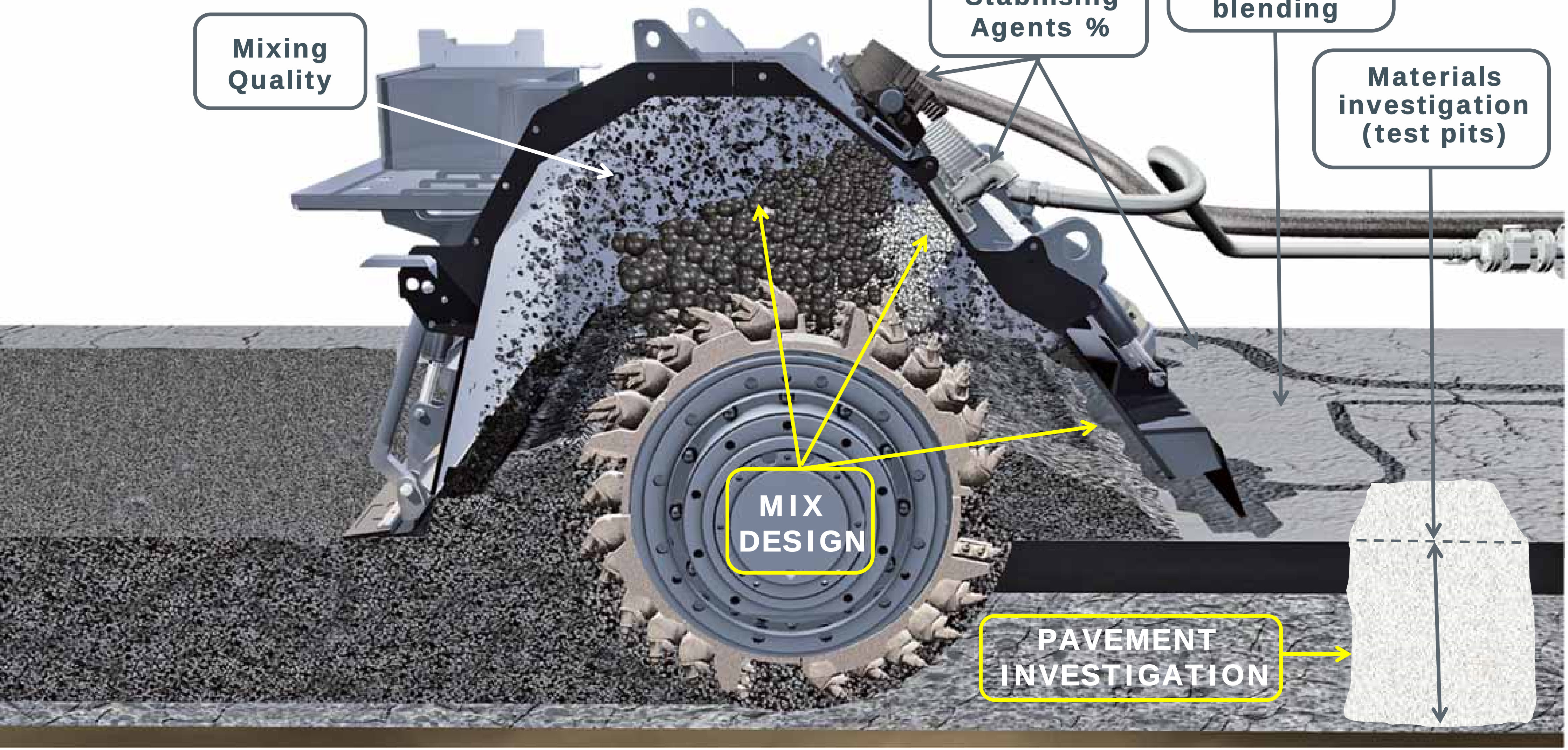



Traction For Cold Recycling
In situ Recycling
< 50% RAP
Asphalt
In Situ Recycling 1990 onwards



Aggregates For Cold Recycling
In situ Recycling
< 50% RAP
Asphalt
Granular
In Situ Recycling 1990 onwards
In situ Recycling
> 50% RAP
Asphalt
In Situ + In Plant Recycling 2000+

Materials For Mix Design

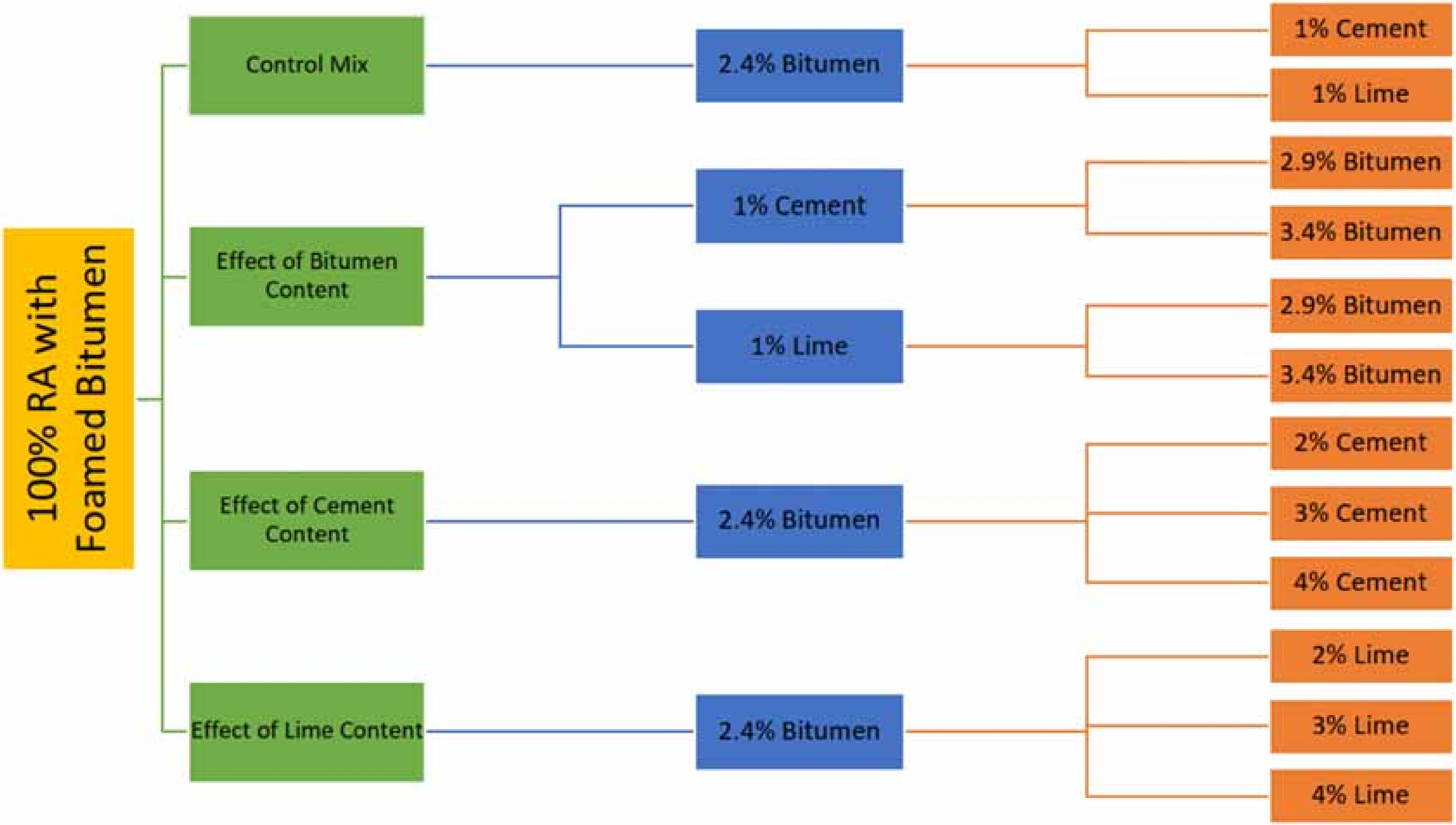


Advanced Mix Design – Triaxial Test

Test at 25^0C

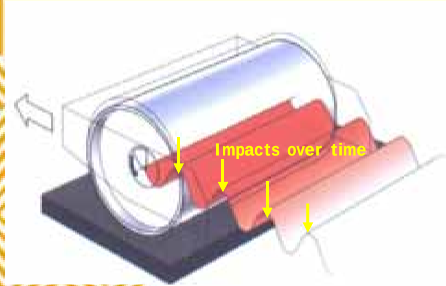
Confining Pressure
0 kPa 50 kPa
100 kPa 200kPa

Experimental Design

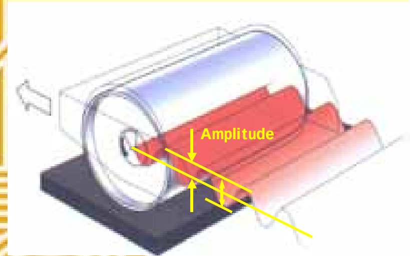


Mix Design: Cold Recycling Improvements

Frequency – vpm (hz)



Amplitude - mm



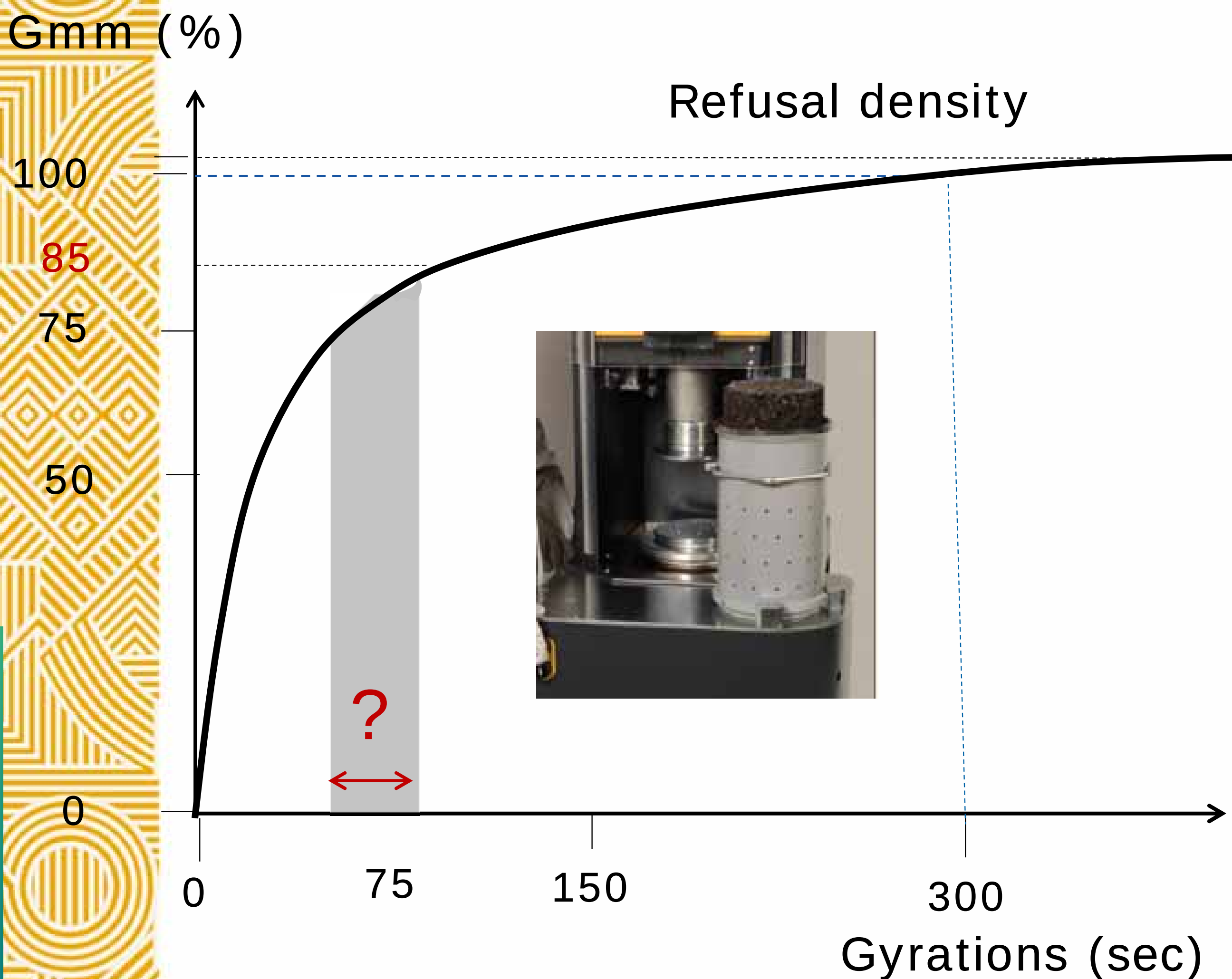
Padfoot
Dynamic Roller

Drop Weight
Hammer

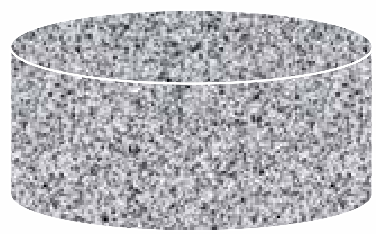
	Field (Vibro)	Lab (Mod.Proc)
Frequency (Hz)	50 – 65	1
Amplitude (mm)	0.4 – 1	457.2

COMPACTION OPTIONS FOR HIGH % RA

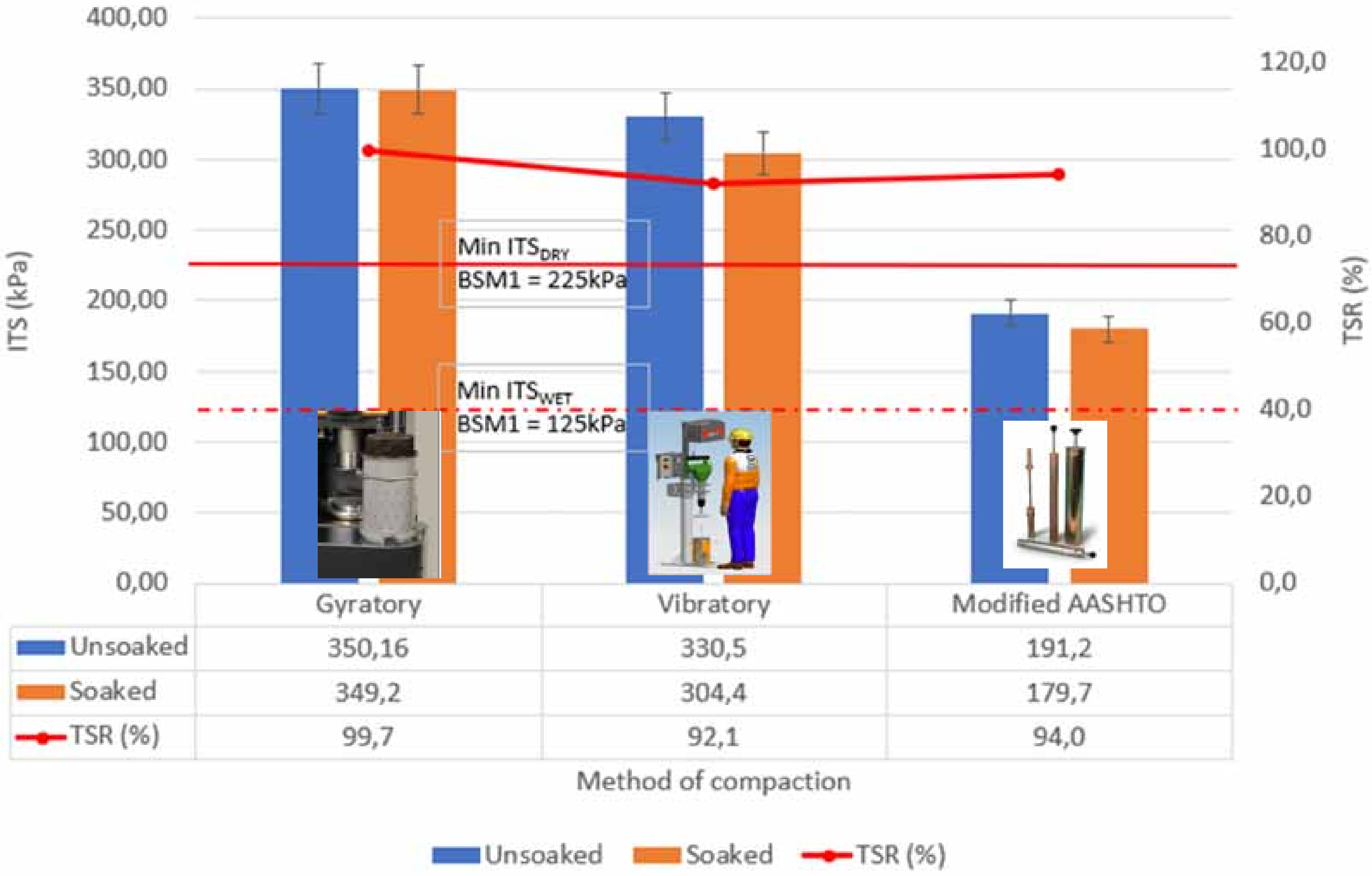
USA & EU EXPERIENCE?



- 100% RA processed with impact crusher
- Mix Design
  - 1% cement
  - 2 to 2.2% foamed bit
- Lab specimen for ITS is 150 mm ϕ x 125 mm h
- Gyratory Compaction: Range of # Gyrations = Field Comp?
- Guidelines for Moisture Impact



ITS versus Compaction Method: 100% RA in BSM-foam **correct**

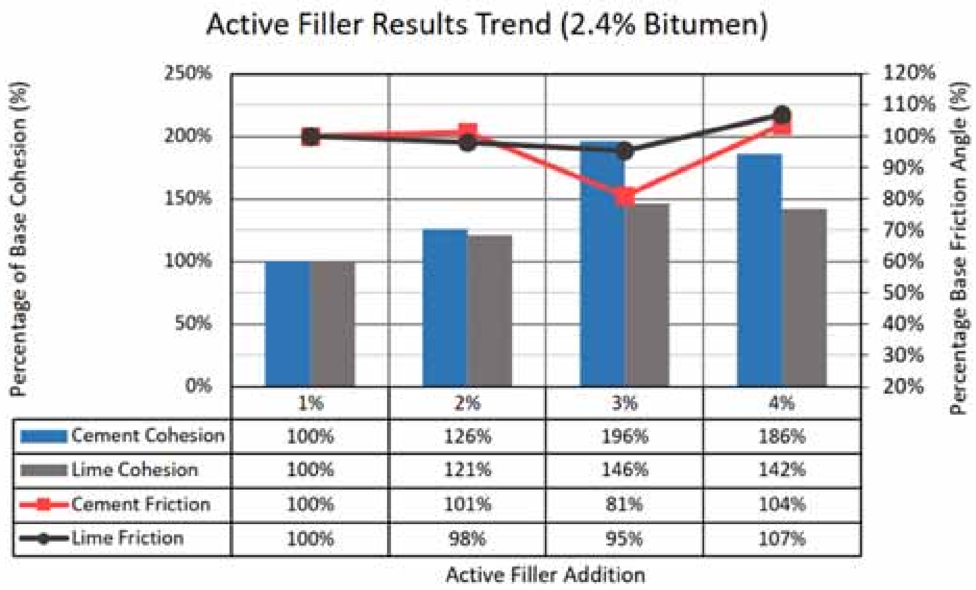


	Gyratory	Vibratory	Modified AASHTO
Unsoaked	350,16	330,5	191,2
Soaked	349,2	304,4	179,7
TSR (%)	99,7	92,1	94,0

(N.Malapane, 2022)

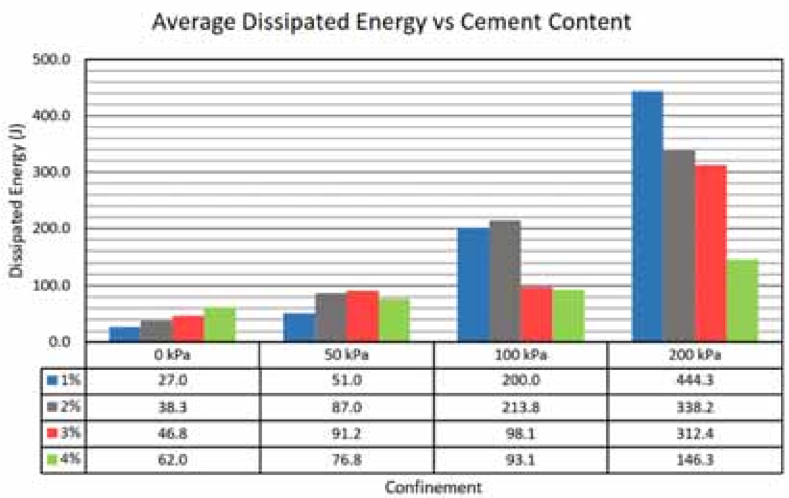
Influence of Active Filler: Evaluations

- Similar overall trends:
  - Shear properties
  - Resilient Modulus
  - ITS
- Those trends were more pronounced with cement than lime.
- Cement generally produced stronger and stiffer mixes, increasing the Resilient Modulus



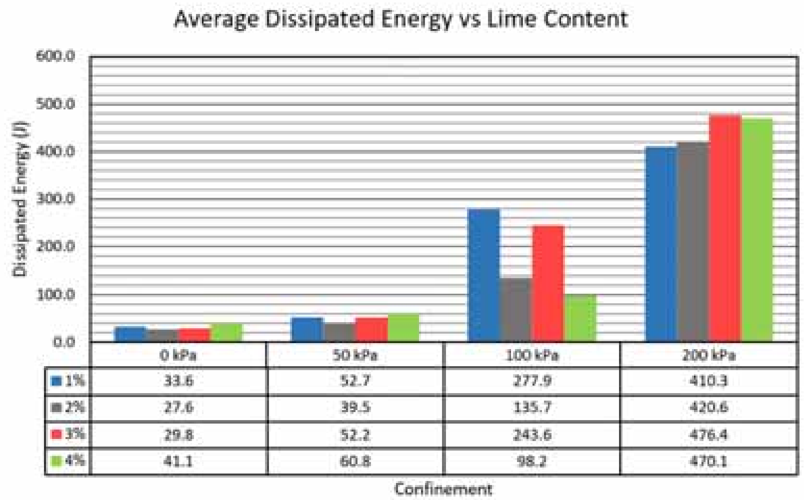
Influence of Active Filler: Dissipated Energy (DE)

Cement



- Low σ_3: Increase cement % = increase in DE (dissipated energy)
- High σ_3: Increase cement % = decrease in DE
- DE results show more brittleness (vulnerable to cracking)

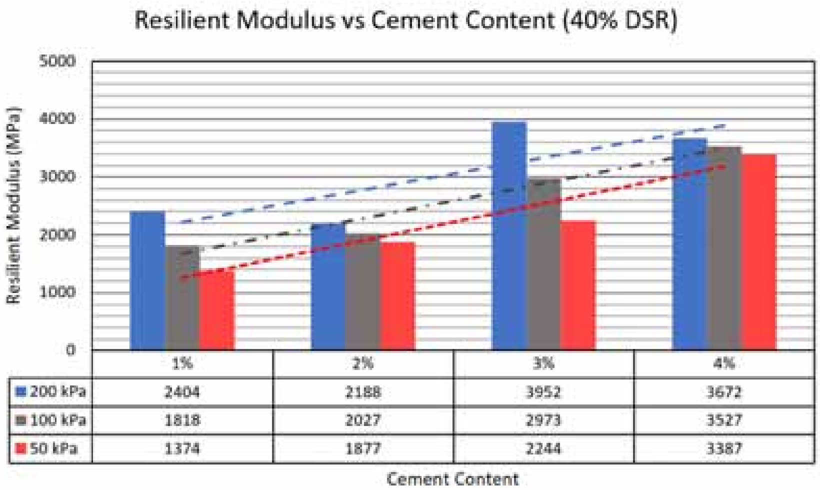
Lime



- Low σ_3: Increase lime % = small increase in DE (dissipated energy)
- High σ_3: Increase lime % = increase in DE
- DE results show more flexibility (less brittleness)

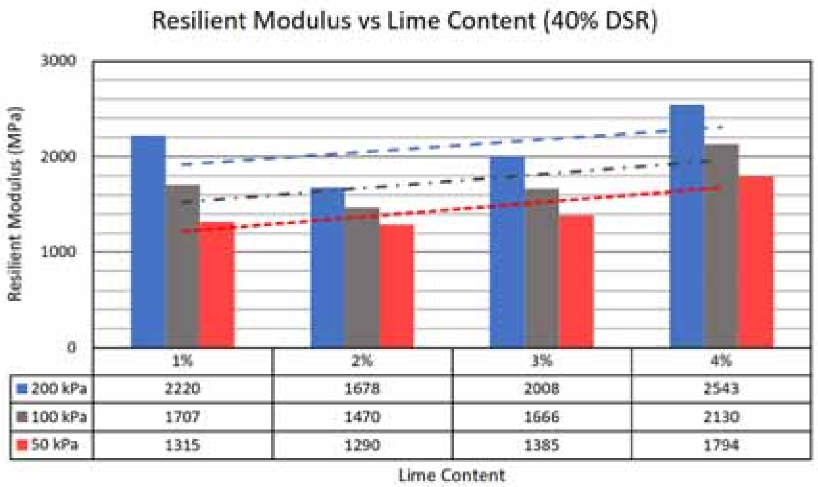
Influence of Active Filler: Resilient Modulus and ITS

Cement



- Increase in cement % = increase in Resilient Modulus.
- Increase in cement % = increase in ITS (Wet and Dry).

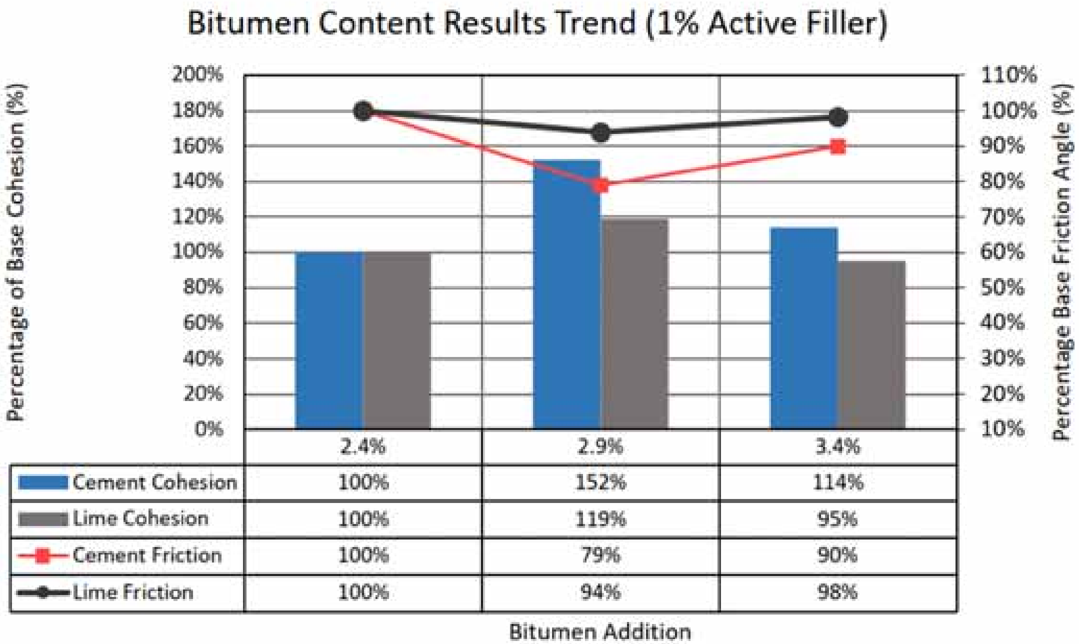
Lime



- Increase in lime %= increase in Resilient Modulus.
- Increase in lime % = increase in ITS (Wet and Dry).

Influence of Bitumen: Conclusions

- Similar overall trends in:
  - Shear properties
  - Resilient modulus
  - ITS
- Those trends were more pronounced with cement than lime, except for resilient modulus.
- Dissipated energy results showed similar trends



Conclusions

- Increasing cement content in BSM:
  - Increase in strength and stiffness.
  - Varied influence on shear properties.
  - Increase in brittleness.
- Increasing lime content in BSM:
  - Increase in strength and stiffness (less significant than cement).
  - Varied influence on shear properties.
  - No increase in brittleness.
- Increasing bitumen content:
  - Similar regardless of type of active filler.
  - Strength and stiffness peak at bitumen = 2.9%
  - Cohesion peak and friction angle trough at bitumen = 2.9%.
  - Dissipated energy decreases with increasing bitumen content (at high σ_3), but no sign of brittle behaviour.
  - The primary purpose of **bitumen** in BSM mix is for **durability** i.e. moisture resistance, and not strength and stiffness.

Questions?