

**LISBOA 2010**  
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**16th World Meeting**



# LABORATORY ASSESSMENT OF WARM MIXES BY THE MEANS OF TWO MIX DESIGN METHODS

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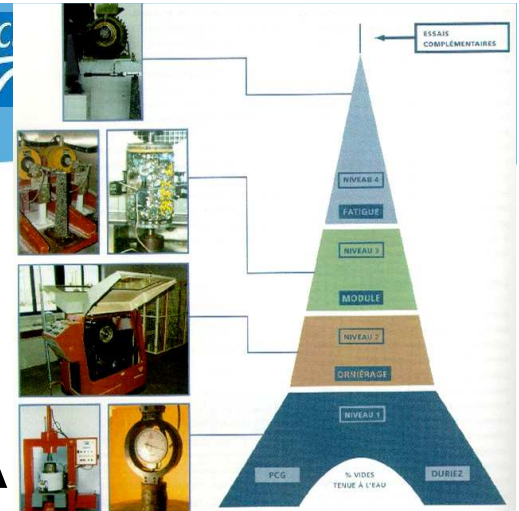
# French-Brazilian partnership



- Escola Politécnica da Universidade de São Paulo USP  
(LTP - Laboratory of Pavement Technology)
- Ecole Spéciale de Travaux Publics ESTP  
(GREMACOR Laboratory)
- Central des Ponts et Chaussées LCPC  
(Division SMIT)

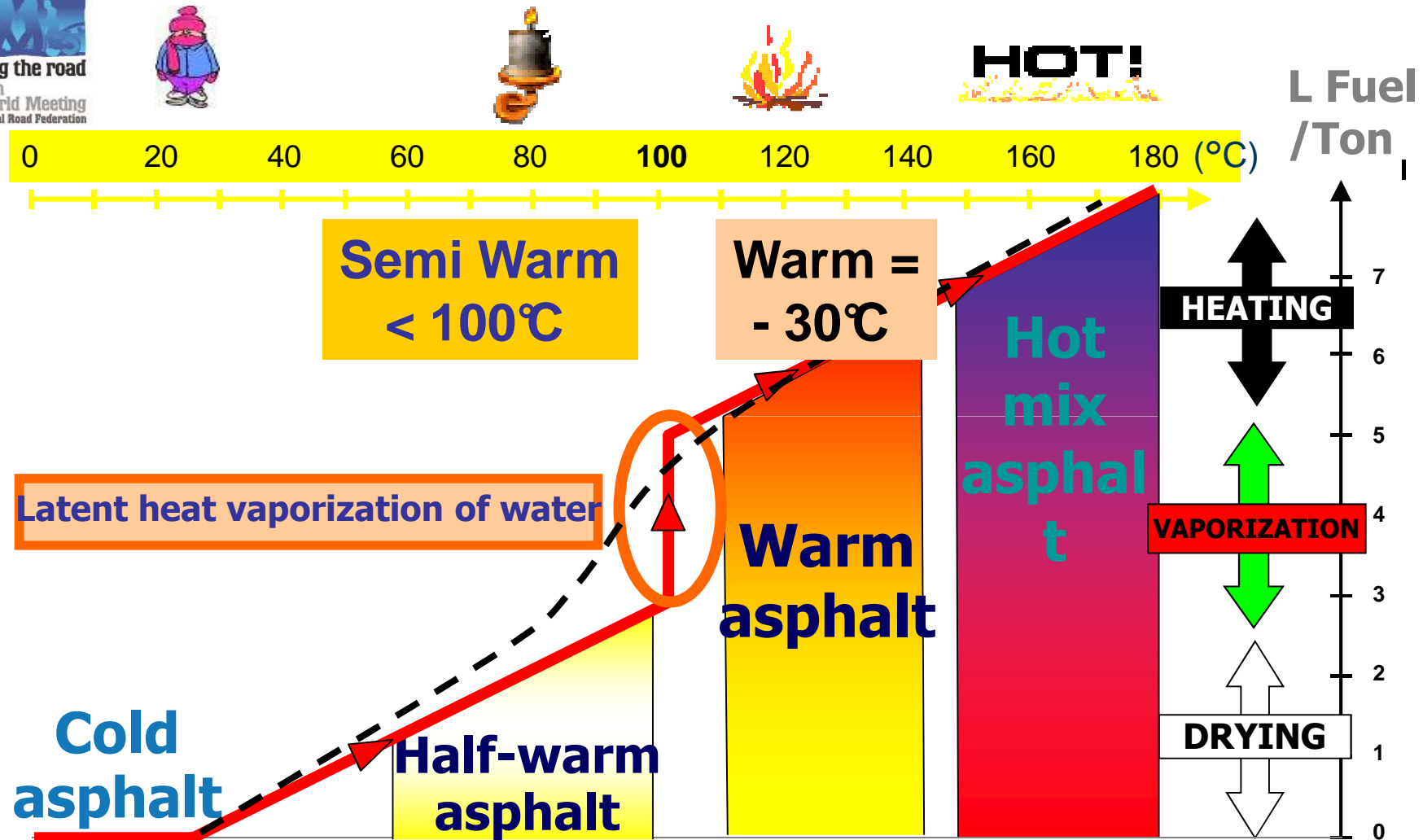


# Topic



- To compare in laboratory WAM – HMA
  - Two mix design methods:
    - French : performance
      - Gyrotory Shear Compactor (NF EN 12 697-31)
      - Water resistance: Duriez test (NF EN 12 697-12)
    - Brazilian : empirical
      - Marshall compaction (AASHTO T 166-93)
      - Moisture damage, ITS ratio (AASHTO T 283-89)
  - Estimate the Total Organic Compound emissions (TOCe)

# Terminology



# Composition of mixes

## Brasilian

Material	[%]
Stone 1/2 "	25.0
Chips	30.0
Stone powder	33.5
Artificial sand	10.0
Lime	1.5
Bitumen Content	50/70 4.4%
Additive w/w bitumen	0.3%

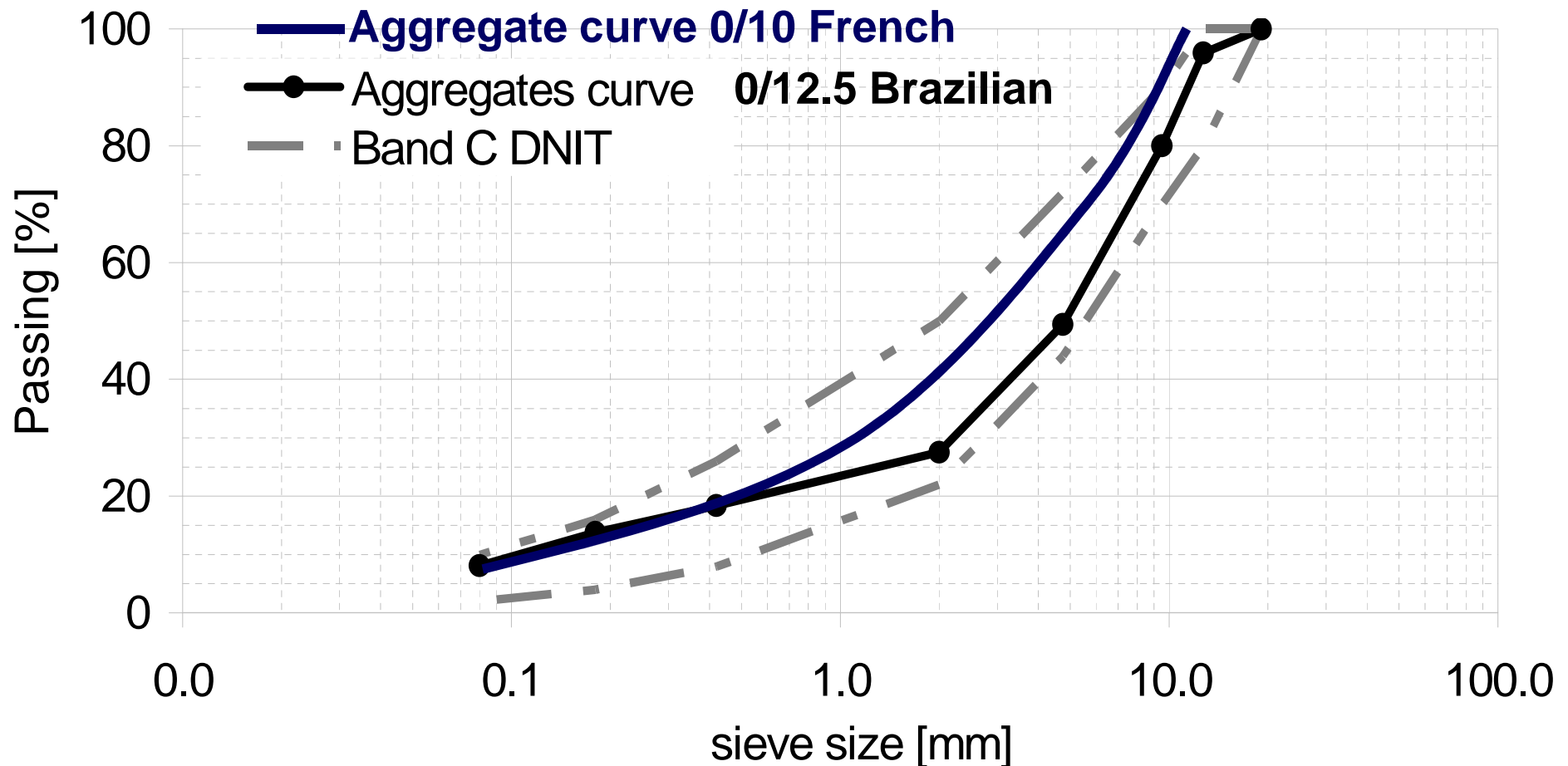
## French

Material	[%]
6/10	25.0
2/6	30.0
0/2	33.5
Filler	2
Bitumen Content	35/50 5.2%
Additive w/w bitumen	0.3%

# Composition of mixes

BBSG 0/10 Microdiorite aggregates (La Noubleau Quarry)

CBUQ 0/12.5 Granite aggregates (Sta. Isabel Quarry)



# Temperatures of mixes in °C

	France				Brazil	
Bitumen grade	BBSG 0/10 with 35/50		BBSG 0/10 with 10/20		CBUQ 12.5mm with 50/70	
	HMA	WMA *	HMA	WMA *	HMA	WMA**
Bitumen	<b>165</b>	<b>165</b>	<b>180</b>	<b>180</b>	<b>160</b>	<b>160</b>
Aggregates	<b>165</b>	<b>110</b>	<b>180</b>	<b>110</b>	<b>160</b>	<b>110</b>
Compaction / Test	<b>165</b>	<b>110</b>	<b>180</b>	<b>110</b>	<b>150-160</b>	<b>110-115</b>

\* With or without additive



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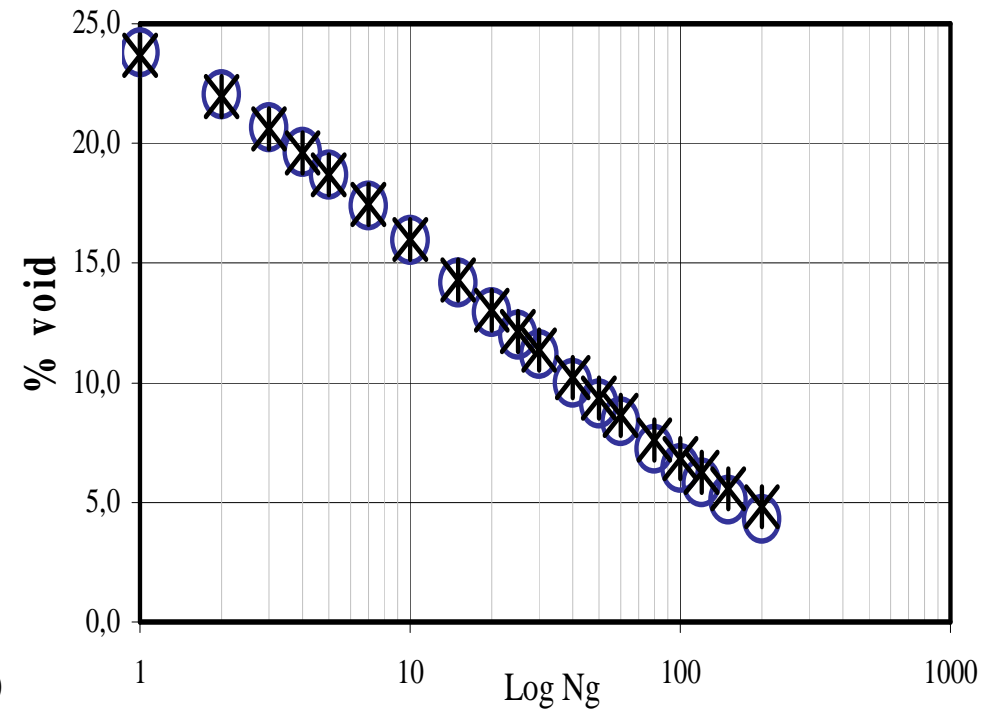
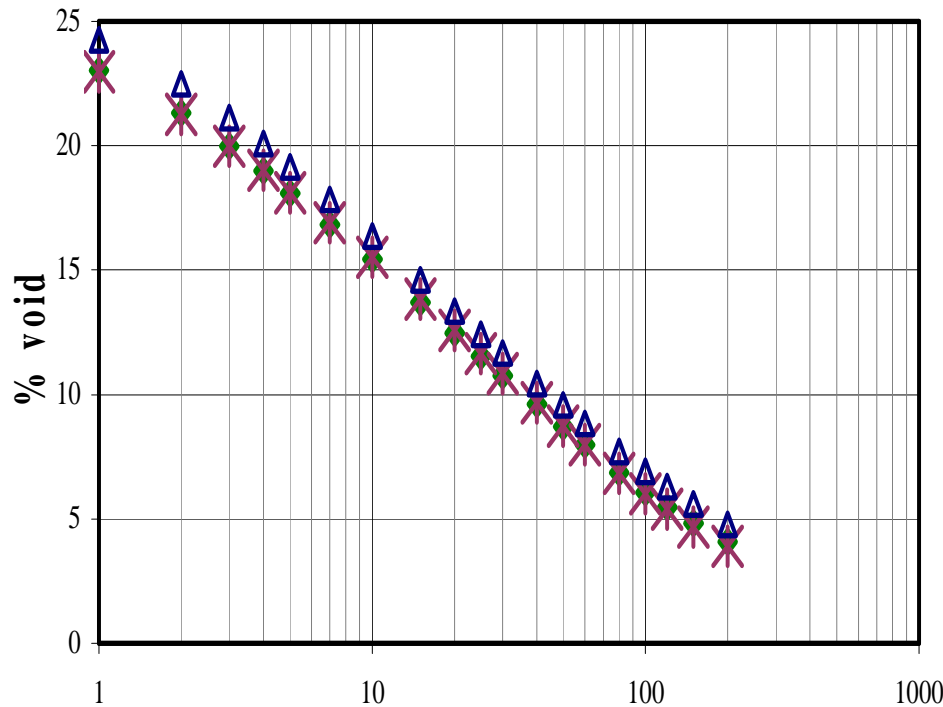
# Gyratory shear compactor

France



**BBSG 0/10 – 35/50 pen grade**  
**Binder content : 5.2 %**

**BBSG 0/10 – 10/20 pen grade**  
**6.0 %**



◆ hot mix    ✕ warm mix without additive    ▲ warm mix + 0.3% additive

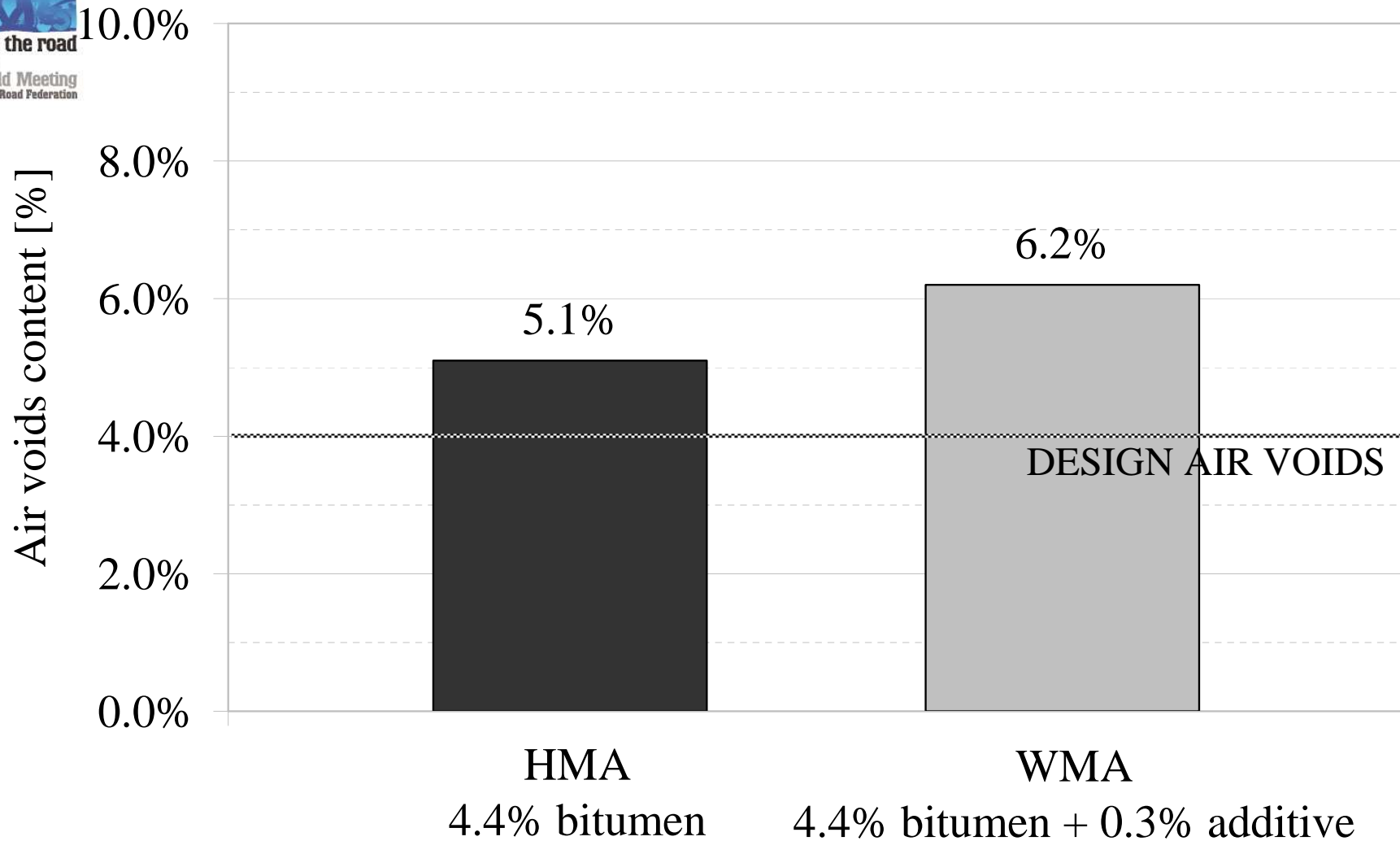
○ warm mix

✕ hot mix

**Exactly the same results: HMA – WAM with or without additive**  
**Even for two different classes of bitumen**

# Marshall air voids

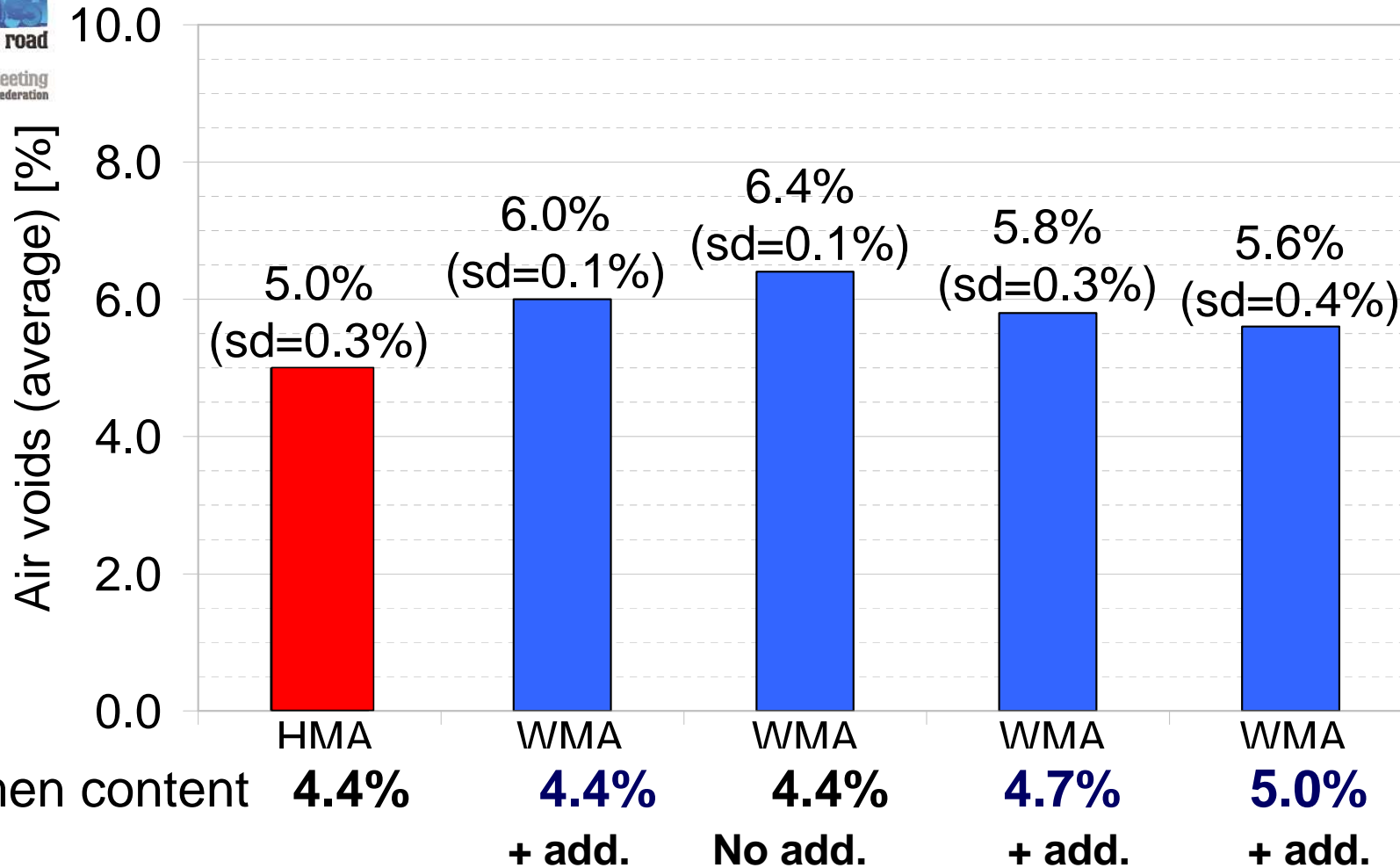
Brazil



**Little difference : HMA more dense than WAM**

# Marshall test other compositions

Brazil

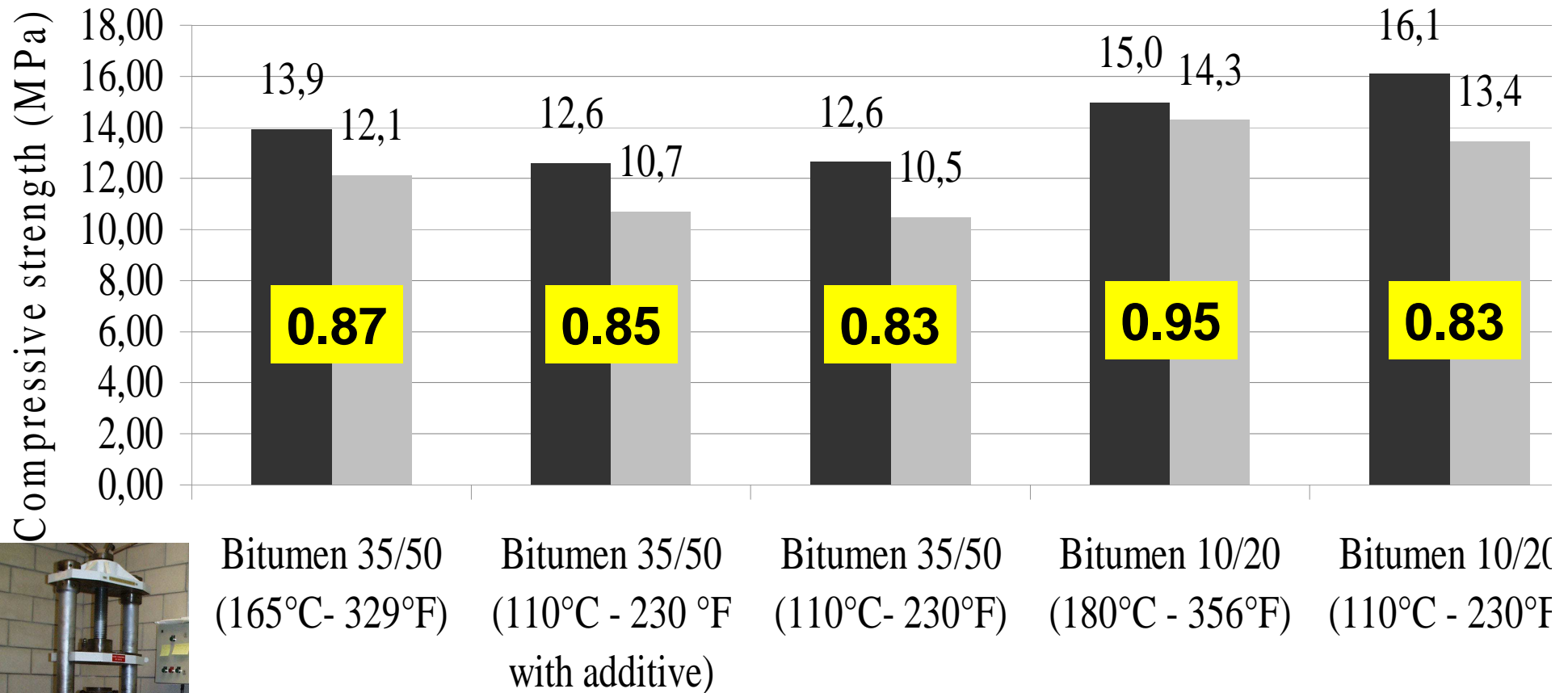


Little difference : HMA more dense than WAM, confirmed with others compositions, even by increasing binder content

# Duriez results

France

HMA, WMA with or without additive, 35/50 or 10/20 bitumen



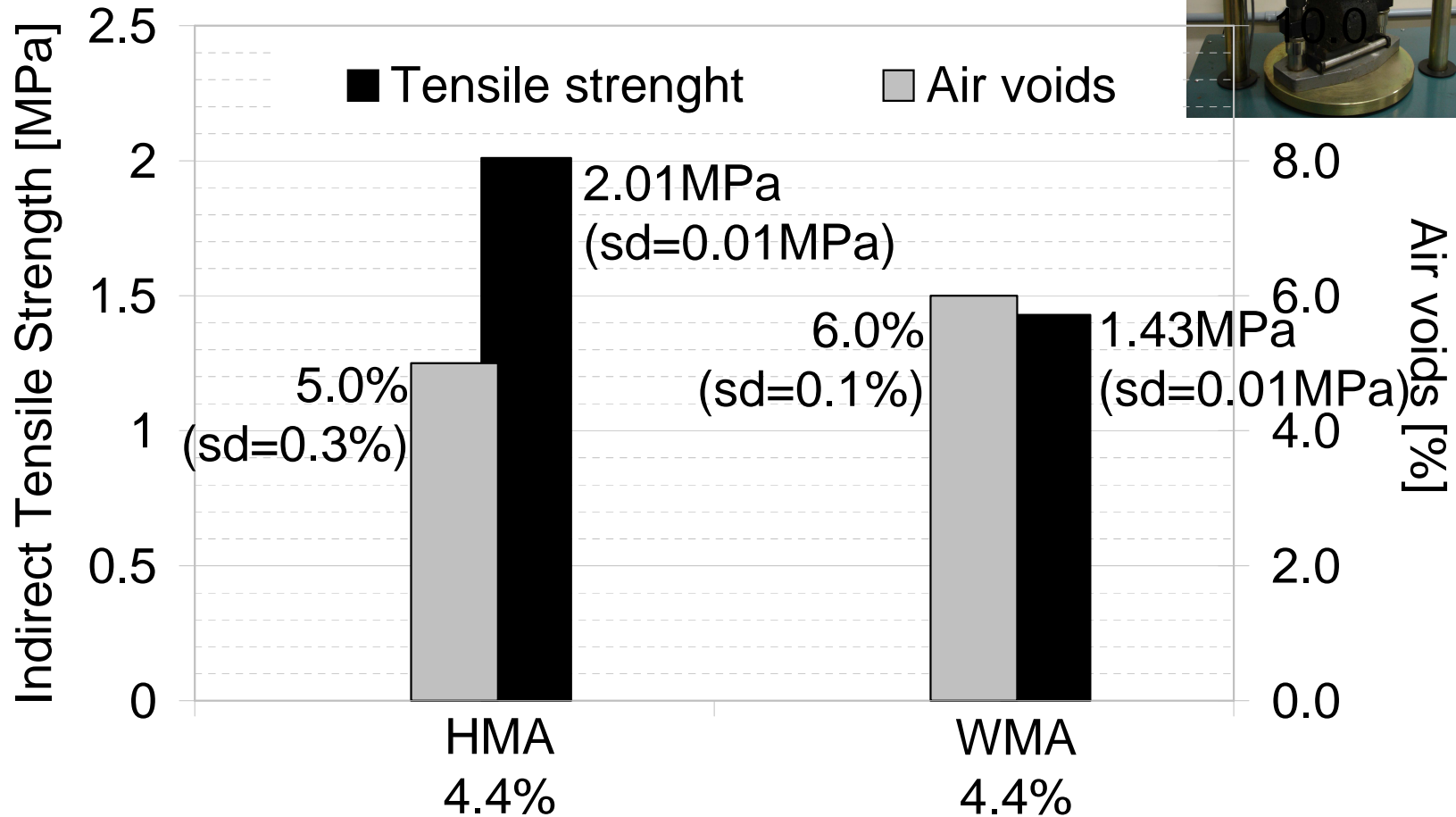
■ Air

■ Water

Water temperature 25°C during 7 days

# Indirect tensile strength

Brazil



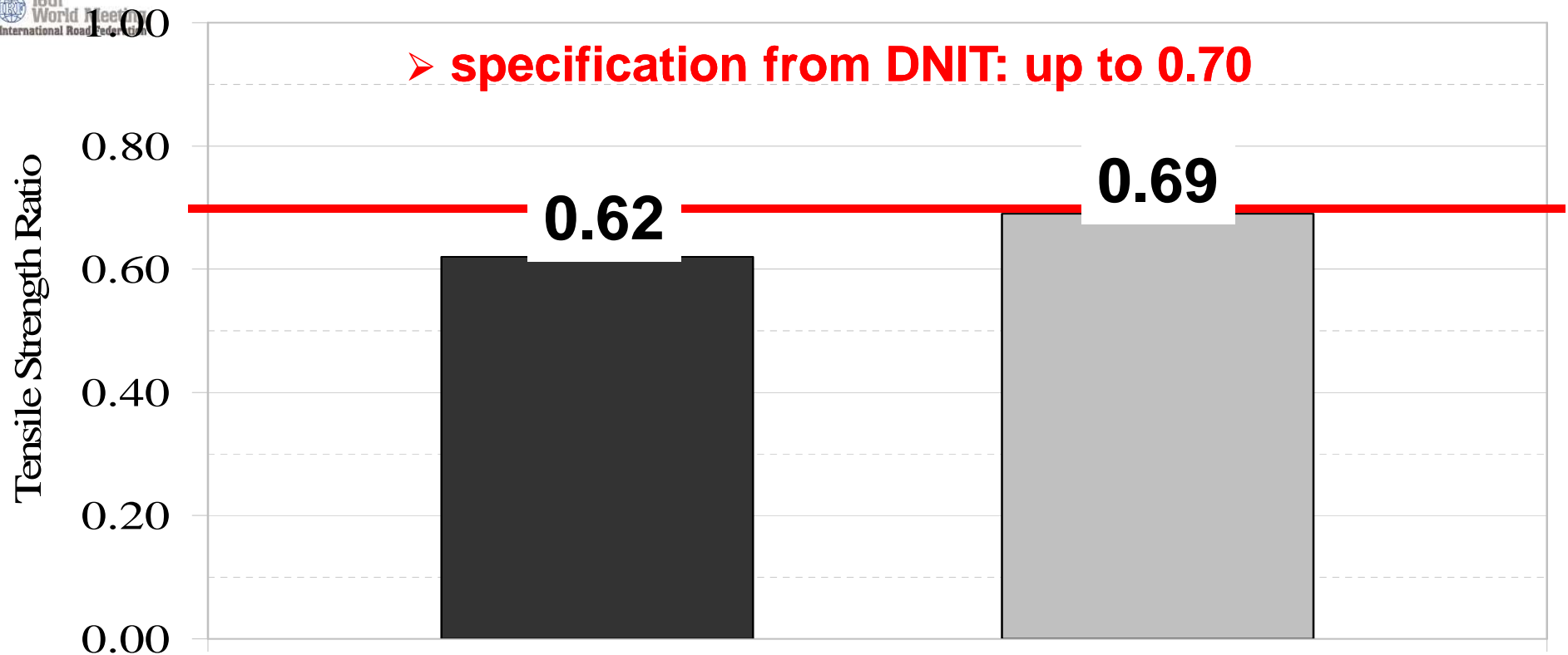
Low dispersion of individual results

+ 0,3% additive

# Water resistance test

Brazil

## Tensile strength ratio from moisture-induced damage



HMA

4.4% bitumen

WMA

4.4% bitumen + 0.3% additive

**Slightly difference : WMA > HMA, but limit**

**Water temperature 60°C during 1 day**



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# LCPC Asphalt fumes generator

LCPC  
Laboratoire Central  
des Ponts et Chaussées



ESTP  
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## Objective

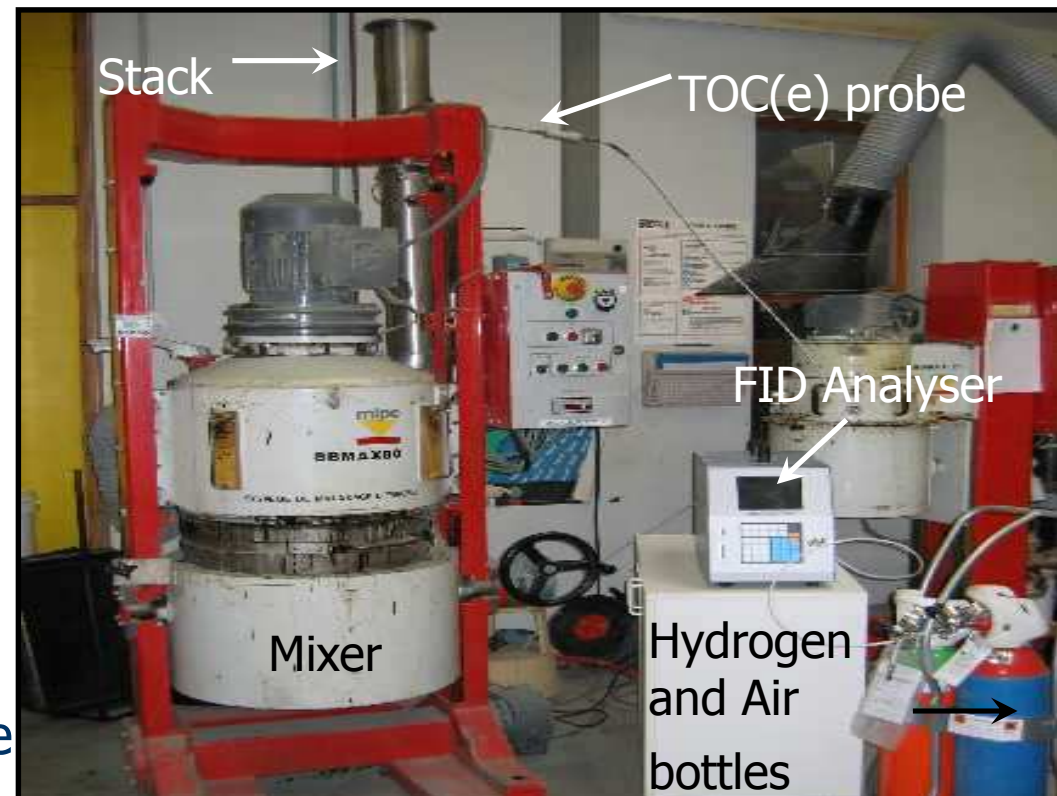
**Environmental** Assessment and ranking of **bituminous mixes** in lab  
Efficient laboratory tool to study and **forecast** asphalt fumes

## Functions

- Generate fumes
- Collect / Sample
- Analyse

## Parameters studied

- Mix design
- Binder
- Process
- Manufacturing temperature





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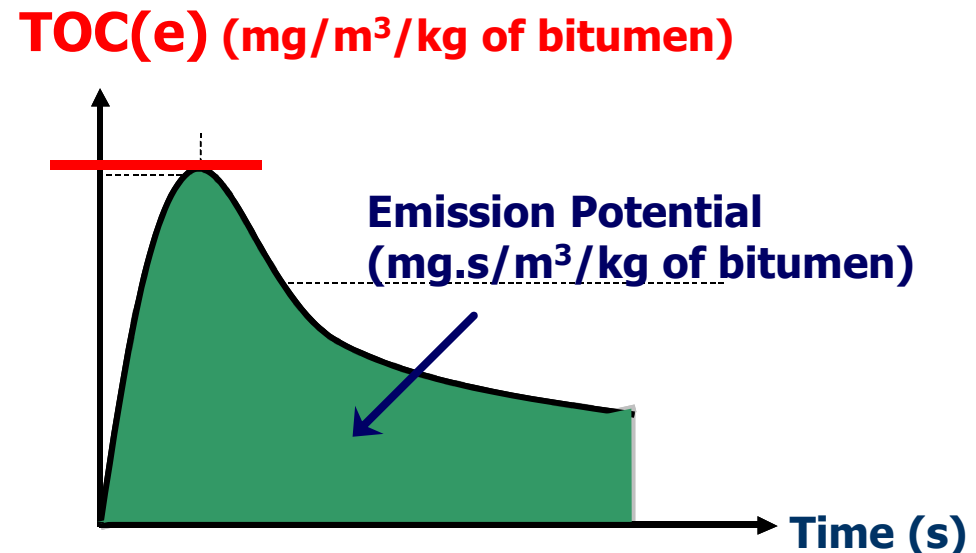
# Analytical systems to measure asphalt emissions



## Evaluation and separation of TOC by a Flame Ionization Detector (FID)

- Evolution of Total Organic Compounds TOC(e) emissions according to time at a stirring velocity of 20 rpm

One studied indicator = Emission Potential 



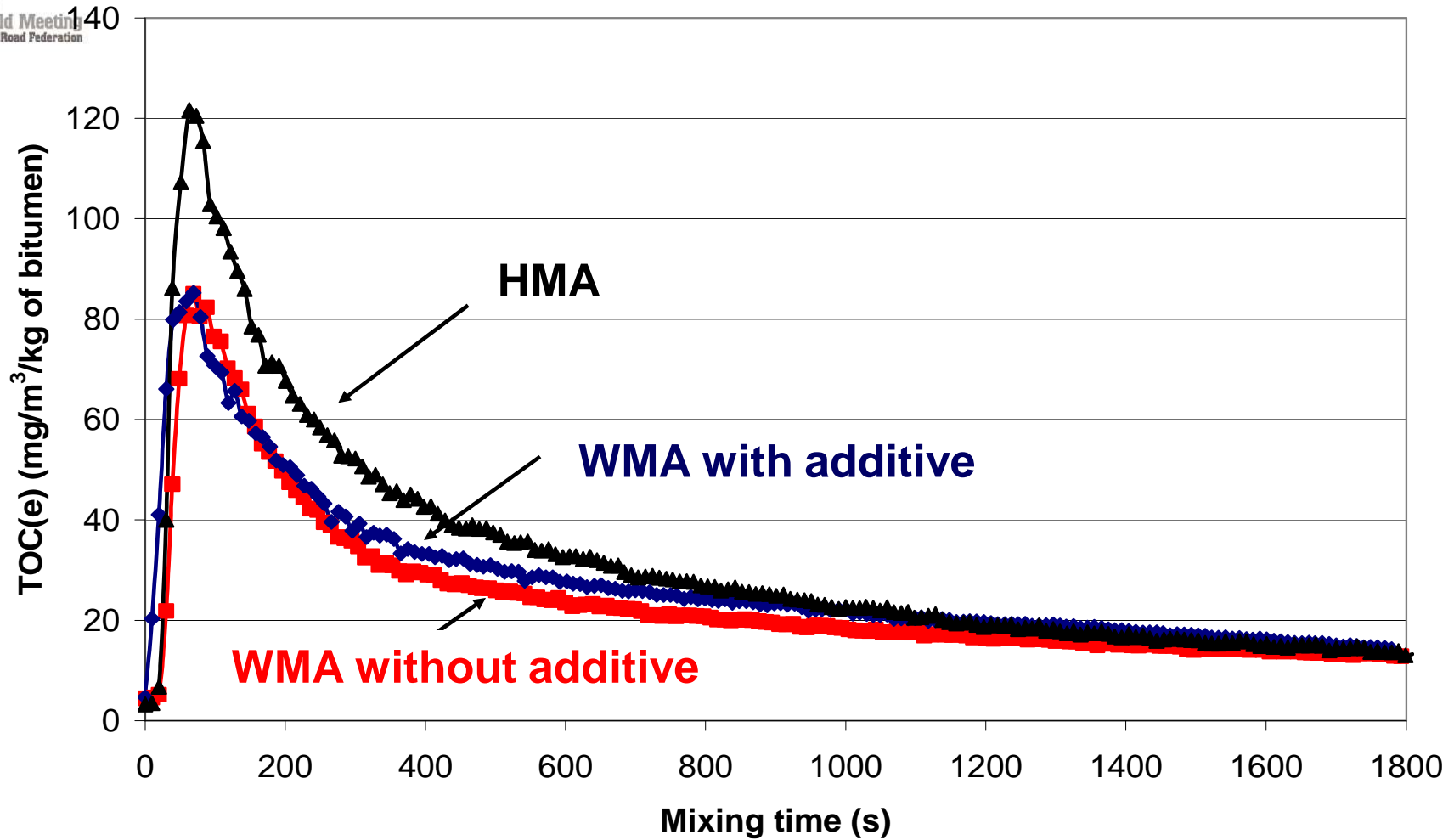
The emission Potential (EP) is calculated by integrating the area under TOC(E) curve according to time



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# Emissions of fumes





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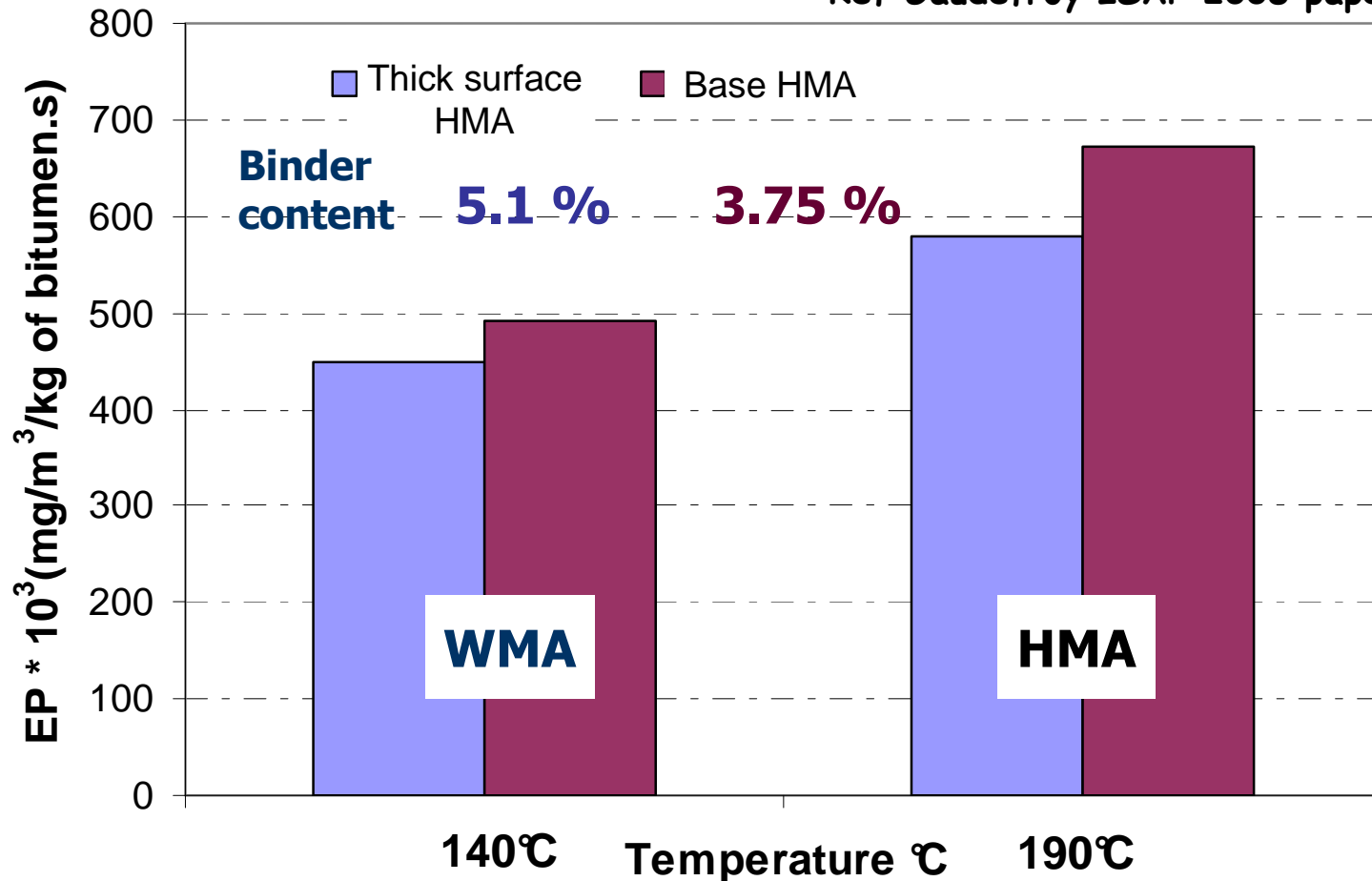
# TOCe results



	Manufacturing temperature °C/[°F]	Additive content (% w/w binder)	TOC(e) max (mg/m <sup>3</sup> /kg)	Emission Potential (mg.s/m <sup>3</sup> /kg)
WAM without	110/ [230]	0.0	<b>85.0</b>	<b>44.0</b> 10 <sup>3</sup>
WAM + additive	110/ [230]	0.3	<b>85.2</b>	<b>50.3</b> 10 <sup>3</sup>
HMA	160/ [320]	0.0	<b>121.6</b>	<b>58.3</b> 10 <sup>3</sup>

# Temperature and mix design influence (others results)

Ref Gaudefroy ISAP 2008 paper 110



Increase of Temperature = Increase of TOC(e) emission

Increase of Bitumen content = Decrease of TOC(e) emission



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# Conclusions



- Workability
  - GSC: no link with temperature
    - ➔ no relevant to test WAM / HMA
  - Marshall: some little differences
- Water resistance:
  - Duriez test: no difference (but with a good aggregate)
  - Marshall + ITS: no difference (limit in specifications)
- Emission TOC
  - Better result (low emission) with WAM,
    - no significant difference with or without additive



# Conclusions (next)



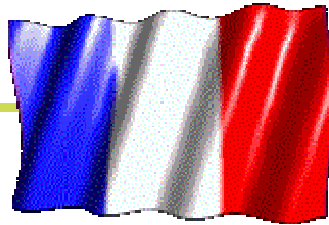
- WMA durable trend in France
  - Increasing use with promising results
- Still research needs
  - Need specific test to assess workability, and water resistance with sufficient reliability at low temperatures
  - Need of a global environmental assessment tool (like for other techniques)
  - Existing tool for fume assessment in lab to correlate to field
  - Need for job sites surveys
    - To assess durability under traffic
    - To check and/or improve performance based specifications



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# Thank you for your attention !



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