Mure National Project (NP) follow-up
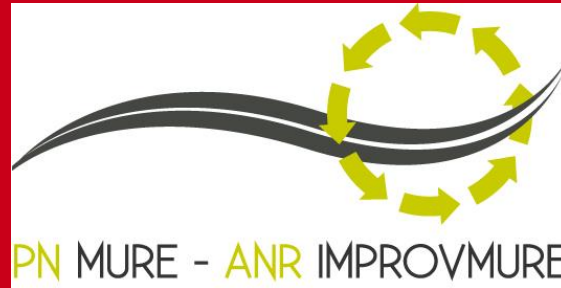
Analysis of cores from the ATMB worksite
Additional use of database in relation to laboratory tests

Sébastien Quigniot, CORE Center
Anne Dony, ESTP

ENTPE - 7 November 2023

► Reminder of the MURE NP objectives/approach

► Analysis of cores from the ATMB worksite
- Context and approach
- Coring plan
- Interpretation of binder analyses
- Findings

► Additional use of database in relation to laboratory tests
- Working group
- Creation of a coherent database
- Analysis by database
- Principle of the statistical method
- Findings and perspectives

► Reminder of the MURE NP objectives/approach

- In late 2000, development of **recycling and warm-mix asphalts BUT** inconsistent practices → need to instil confidence among stakeholders

- Improve technical/scientific knowledge

- Anticipate "multi-recycling" issues

- NP ran from **2014 to 2021**, with 4 phases and 1 ANR IMPROVMURE project, 35 partners

- Project focused on creating **experimental worksites** under various controlled conditions
  - A wearing course
  - A recycling rate (40% or 70%)
  - A production temperature for asphalt mixes ("hot mix asphalt" as a reference)
  - A process for reducing this temperature (additive or foam)
- Supplemented with laboratory studies

► Worksite type

    ► 4 sections → 4 life cycles

    ► Principle

        ▪ Formula: SCAS

        ▪ Initial RAP stock: RAP0
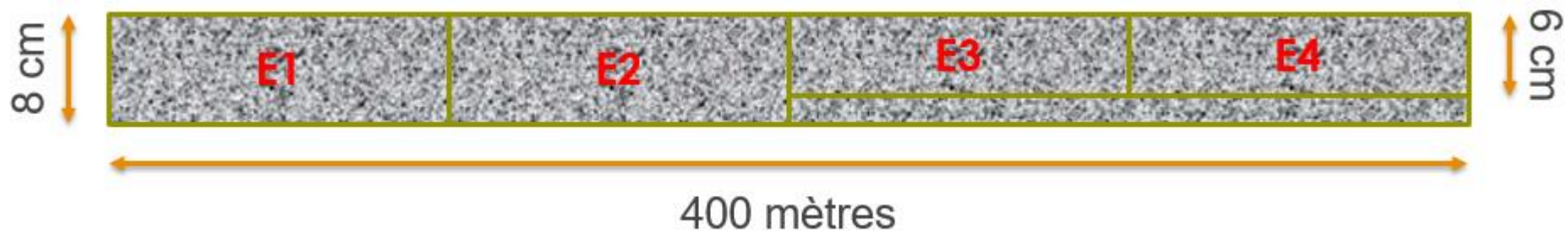
E1: control section, 1st cycle: no RAP

E2: section 2nd cycle: with RAP0

E3: section 3rd cycle: with RAP1

E4: section 4th cycle: with RAP2

► Worksite type

- 4 sections → 4 life cycles
- Principle
  - Formula: SCAS
  - Initial RAP stock: RAP0

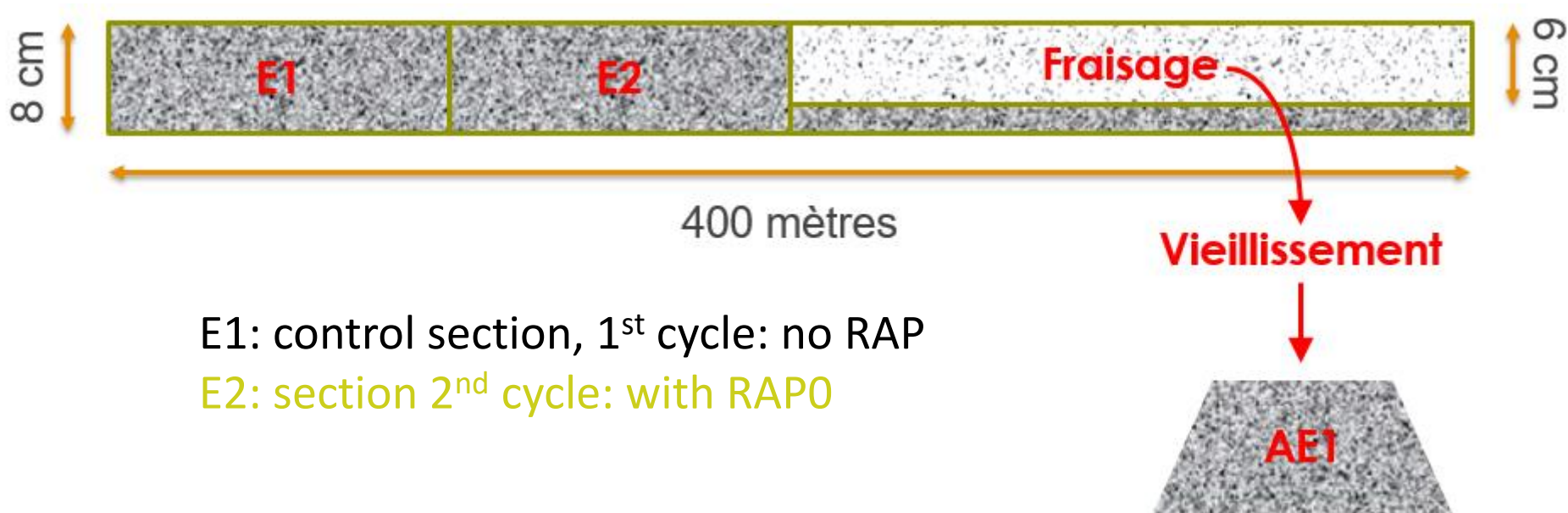E1: control section, 1st cycle: no RAP
E2: section 2nd cycle: with RAP0

► List of worksites completed

Location	Year	% RAP	Specific characterics	Multi-recycling year
Rue du Canal, Villeurbanne	2015	40%	Warm additive	2017
RD313 Ronno (69)	2015	40%	-	-
RD909 Moriat (63)	2015	40%	Warm foam	-
Abbé Roland roadbed (74)	2016	70%	RAP with polymers	2017
Passy service area – Le Fayet (74)	2016	70%	Warm foam AMA with polymers	-
Av. de la Saudrune, Portet sur Garonne (31)	2016	40%	Warm foam PMB	-
			PMB	2018
RD1215E, Arsac (33)	2016	30% 50%	Warm foam with regenerator	-
RD908 Neuilly-sur-Seine (92)	2018	40%	Warm foam	-

► MURE NP/DVDC NP interactions

End of 2021: Need for more in-depth use of asphalt mix and binder data.
- MURE NP Partners ~ DVDC NP partners
- Common group of experts between the two NPs
- Transfer of surplus from the MURE budget
- ManCo approval
- Findings sent to MURE partners

Monitoring of worksites recorded as an expense in the balance sheet
Cerema
Core sampling on R70 worksites.

► Context and approach:

- Findings at end of 2021: Appearance of cracks on the ATMB worksite → role of bituminous binder in the defects observed?
- Coring operation on the two R70 worksites (September 2021)

- Selection of analyses and testing laboratory in line with the NP (GT5)

  - Coring operations carried out by EUROVIA (Serge Duplaix)
  - Extraction/recovery of binders: CEREMA AUTUN (Adso Arghyris)
  - Penetrability/RBSP (Ring and Ball Softening Point)/FraasT/G*(15°C/10 Hz): CEREMA AIX (Virginie Mouillet)
  - Carbonyl index by IR spectroscopy: ESTP (Anne Dony)

  - Analysis/interpretation of results: A.Dony/S.Faucon Dumont (Labotech)/ V.Mouillet

Zones	Sampling zone pathologies	Process	Bottom of cores	Interface	
Passy service area – Le Fayet (74)	cracks/ fragmentation	foam R0	CBGM	debonded/debonded	2 couches BB
			UGM	debonded/debonded	
Passy service area – Le Fayet (74)	healthy	foam R0	CBGM	bonded/bonded	
			CBGM	bonded/debonded	
Passy service area – Le Fayet (74)	cracks/ fragmentation	foam R70	UGM	bonded/debonded	
			UGM		
Passy service area – Le Fayet (74)	healthy	foam R70	CBGM	bonded/bonded	
			CBGM	bonded/debonded	
			CBGM	bonded/debonded	
ABBE ROLAND car park E1	healthy	hot R0	UGM	debonded	1 couche BB sur GNT
ABBE ROLAND car park E2 cycle 1	healthy	hot R70	UGM	debonded	
ABBE ROLAND car park E3 cycle 1	healthy	hot R70	UGM	debonded	
ABBE ROLAND car park E4 cycle 2	healthy	hot R70	UGM	debonded	
ABBE ROLAND car park E5 cycle 3	healthy	ABBE ROLAND car park E5 cycle 3	UGM	debonded	

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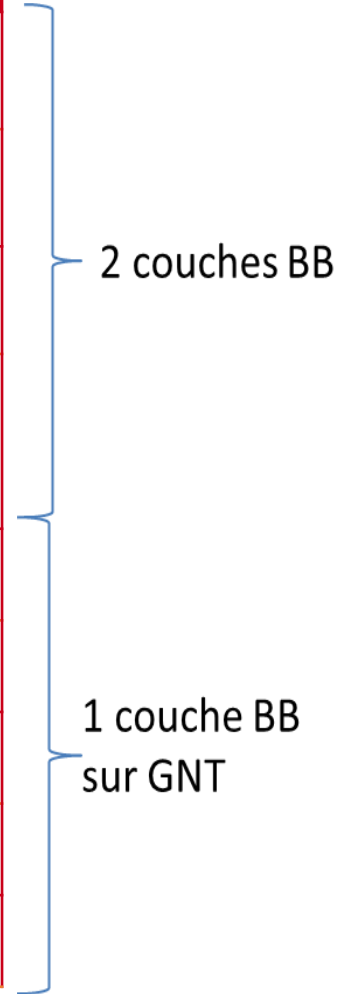
►Worksite: Passy- Le Fayet service area - Foamed warm-mix asphalts with 0% RAP (bitumen 35/50) and 70% RAP (bitumen 160/220)

Across the 2 zones: **healthy** zones and **cracked** zones.

- In 2016: comparable conventional characteristics

- After 5 years: no significant difference between healthy and cracked zones.

  - **Foamed warm-mix asphalt R0**: little change in terms of conventional characteristics, increase in G* and Ico → slight hardening and oxidation of the binder.
  - **Foamed warm-mix asphalt R70**: binder softer than initial binder with G* ~ and Ico < → heterogeneity of different sampling zones.

►Worksite: ABBE ROLAND car park - Hot mix asphalts with multi-recycling

- No cracked zones
- Logical evolution of conventional and rheological characteristics: slight hardening of binder and increase in G*
- **BUT** complexity of Icos: systematic decrease … at odds with the ageing process (tests repeated with same method of testing and analysis)

- Various factors to consider: high recycling rate, sampling in areas ≠, by laboratories ≠ and undoubtedly variable asphalt mix treatment methods.

➢ Findings and perspectives:

- Define the **potential role of binders** in the defects observed on worksites with high RAP levels, with warm or hot processes and/or multi-recycling → need to go through the stages of **coring** and **extraction/recovery**, followed by the testing previously defined by the MURE NP.

- **No difference** between the healthy zones and the cracked zones.

- NB: some inconsistencies in results ... despite the suitability of the tests

  BUT variety of coring zones and different sample processing practices, etc.

- **Longer-term monitoring** is required to provide more precise responses.

► Working group:

- Jacques-Antoine Decamps (Vinci Construction)
- Anne Dony (ESTP- Coordinator)
- Stéphane Faucon Dumont (Labotech)
- Virginie Mouillet (Cerema Méditerranée/DIMA Project Aix)
- Aurelia Nicolai (Spie Batignolles Malet)
- Sébastien Quigniot (Colas CORE)
- Julien Van Rompu (Eiffage Infrastructure)

► Creation of a coherent database

- 12 elements from the ANR IMPROVMURE project, provided by CEREMA Aix and the EIFFAGE PhD thesis:
  - Production in lab only

- 28 elements from the MURE NP provided by GT5 :
  - On-site production with tests carried out by different labs
  - Production in lab (single procedure) with tests carried out by the same lab

- 9 provided by UGE (ex IFSTTAR) :
  - Semi-industrial lab production (UGE Nantes mixer)
  - A single laboratory for all analyses

Consolidated table of 24 columns (15 with test results and 9 information columns) * 56 rows (asphalt mix formulas)

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► Creation of 3 sub-databases

MURE NP results
- Database of 28 individuals: binder characteristics, water sensitivity, asphalt mix modulus

MURE NP + ANR IMPROVMURE (CEREMA) results
- Database of 40 individuals: binder characteristics, asphalt mix modulus

MURE NP + ANR IMPROVMURE (UGE) results
- Database of 23 individuals: binder characteristics, fatigue life of asphalt mix

Statistical analysis

► Principle of the statistical method

Univariate analysis

- Summary of variables + identification of suspect points
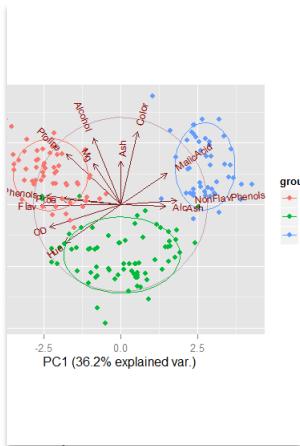
Bivariate analysis

- Linear links

Multivariate analysis

- Description of multidimensional table with analysis of correlation structure and classification technique
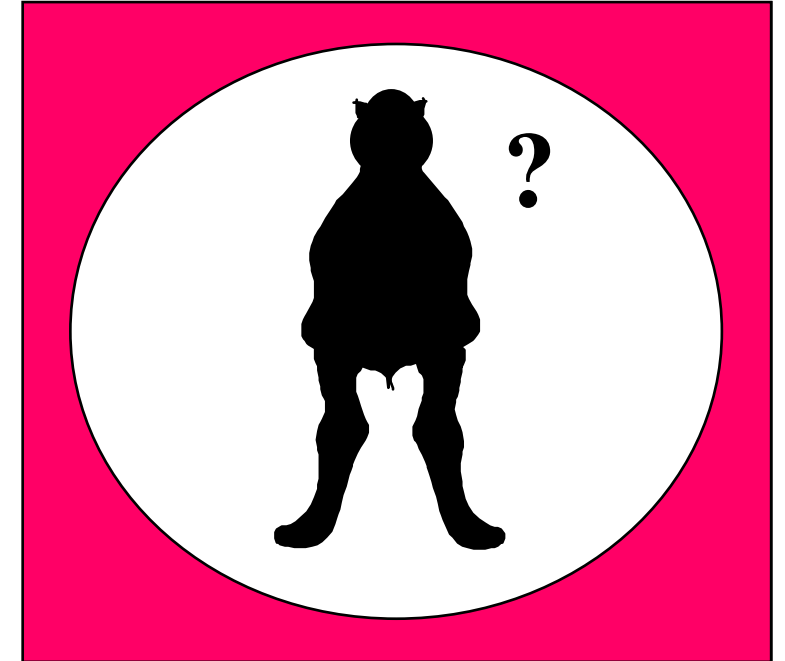
▶ Principal Component Analysis (PCA)

PCA: technique used to represent multidimensional tables

- <u>Variables</u>: structure of linear links
- <u>Individuals</u>: observation of homogeneous groups and atypical individuals

Dimensionality reduction

- Information synthesis

→

New axes called Principal Components (CPs)

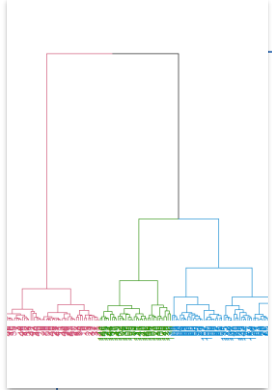- Linear combination of variables

→

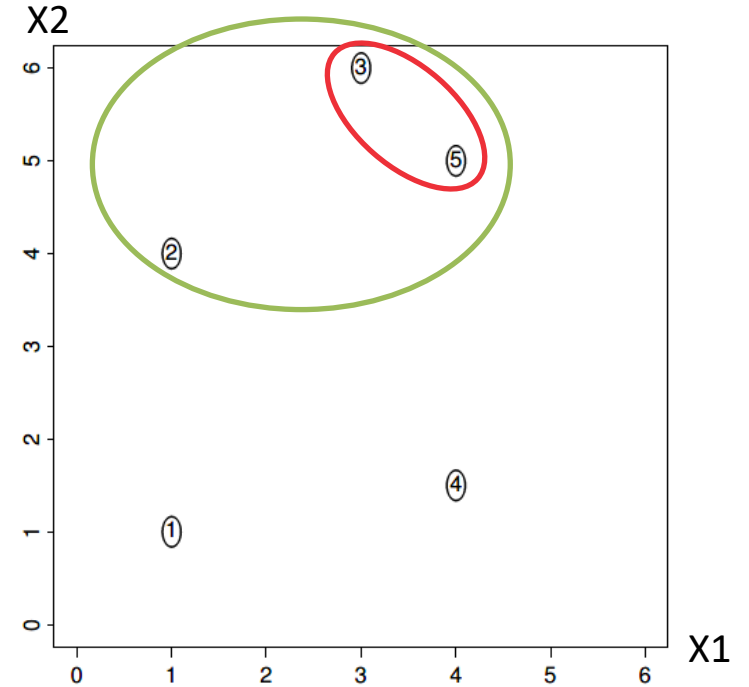**Graphic visualisation of 2 or 3 PCs**

- Minimises information distortion

► **Agglomerative Hierarchical Cluster Analysis (AHCA)**

AHCA: iterative classification technique

- Allocation into classes (groups) of individuals with common characteristics

Composition
- Step 1: each individual forms a group

Comparison
- Merge the 2 most similar groups (the least dissimilar)

Iterations
- End of algorithm: formation of a single group

► Summary
- Partial statistical analysis of the database because of:
  - missing data due to tests not carried out according to the study program
  - varied methodologies depending on the test or place of production (laboratory/worksite)

- Findings (⚠ **valid strictly within the context of this analysis**)
  - No proven effect in terms of multi-recycling of asphalt mixes
  - Production effect: laboratory vs. worksite
  - Effect of ageing protocol: RILEM vs. MURE NP in-situ
  - Effect of aggregates on the mechanical performance of asphalt mixes (modulus & fatigue)

► Perspectives
- Establish a common statistical strategy (in the form of a charter) in advance of the project
  - Test homogeneity: operating procedure, methodology
  - Data storage: cloud, file format
  - Standardise the database input parameters

Sébastien Quigniot
CORE Center by COLAS
sebastien.quigniot@colas.com

Anne Dony
ESTP
adony@estp.fr