Cold Recycled Mixtures and the Effects of the Active Fillers

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DNIT

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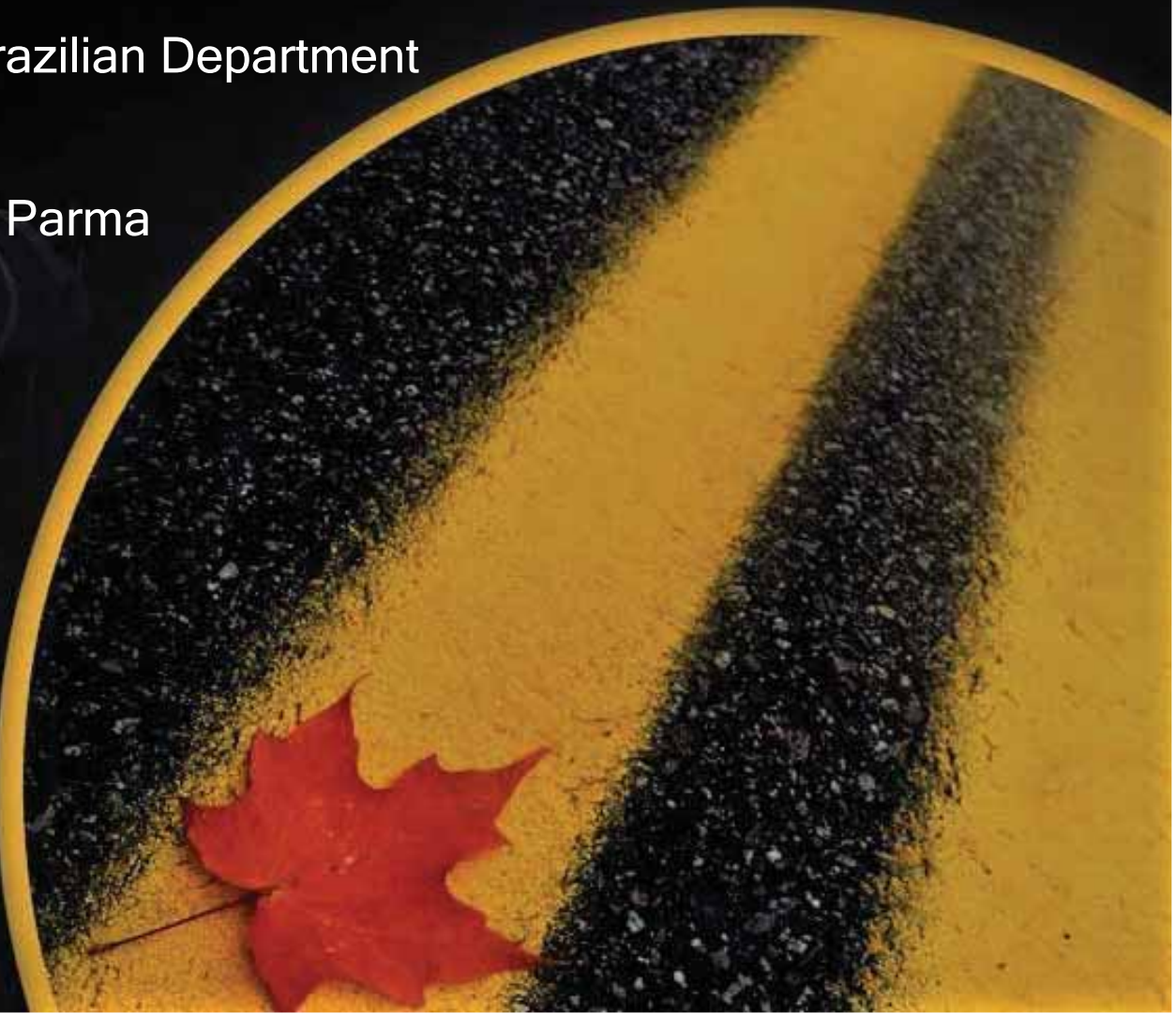
MEĐUNARODNI SEMINAR
ASFALTNI KOLNICI 2019
OPATIJA / 4. & 5. IV.



CONTENTS

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- Background
  - Pavement Cold Recycling Techniques
  - Bitumen Stabilized Materials
  - The Role of the Active Fillers
- Case Studies on Cold Recycling Mixtures
- Conclusions

COLD RECYCLING MIXTURES

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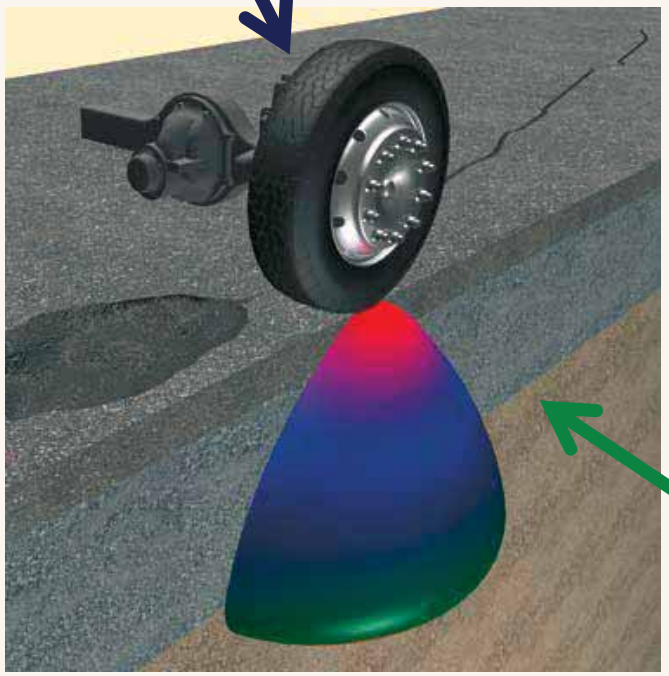
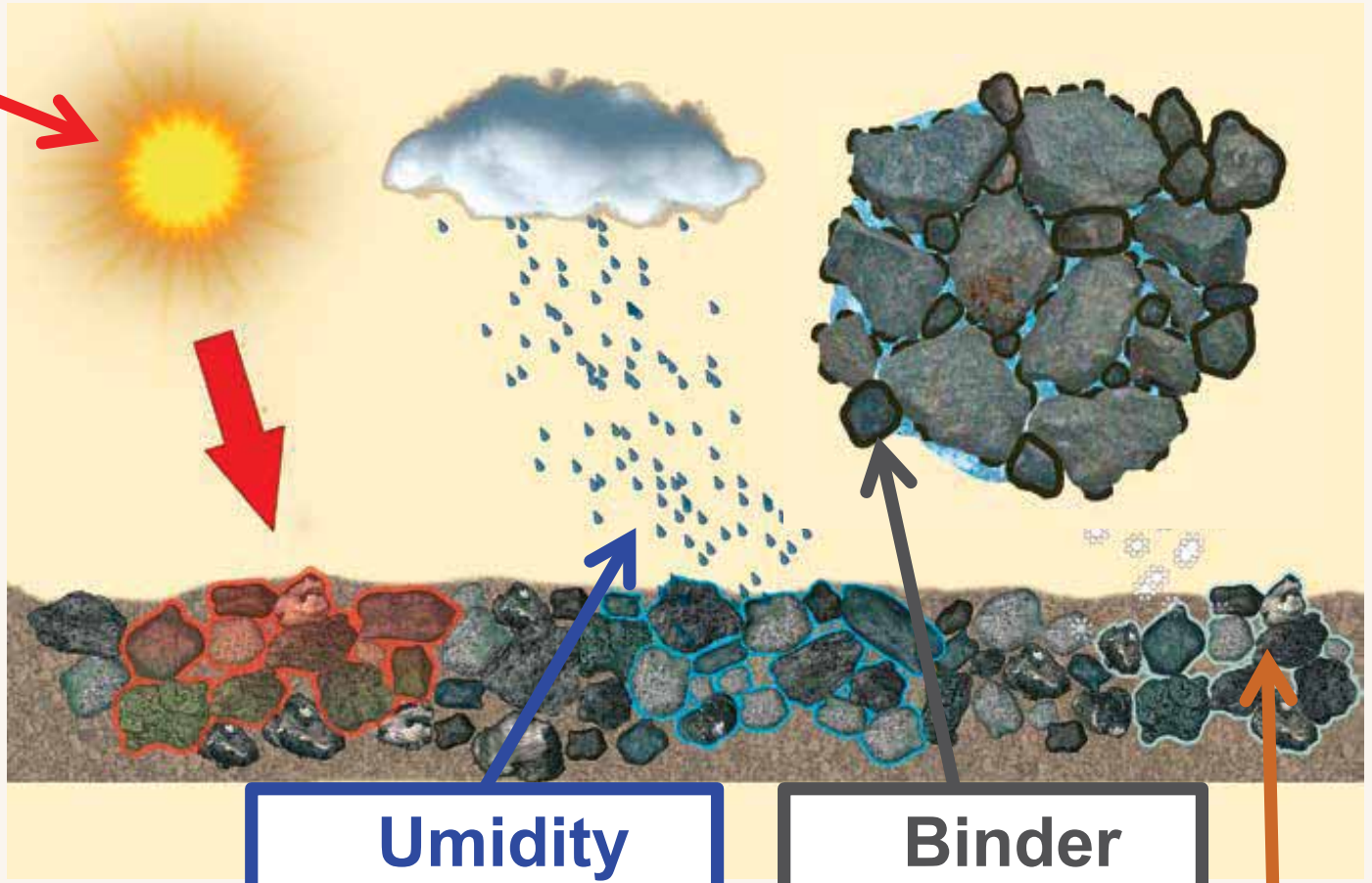
Temperature
Sun radiation

Traffic Load





Umidity

Binder

Aggregates

Original Structure

COLD RECYCLING MIXTURES

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COLD RECYCLING MIXTURES

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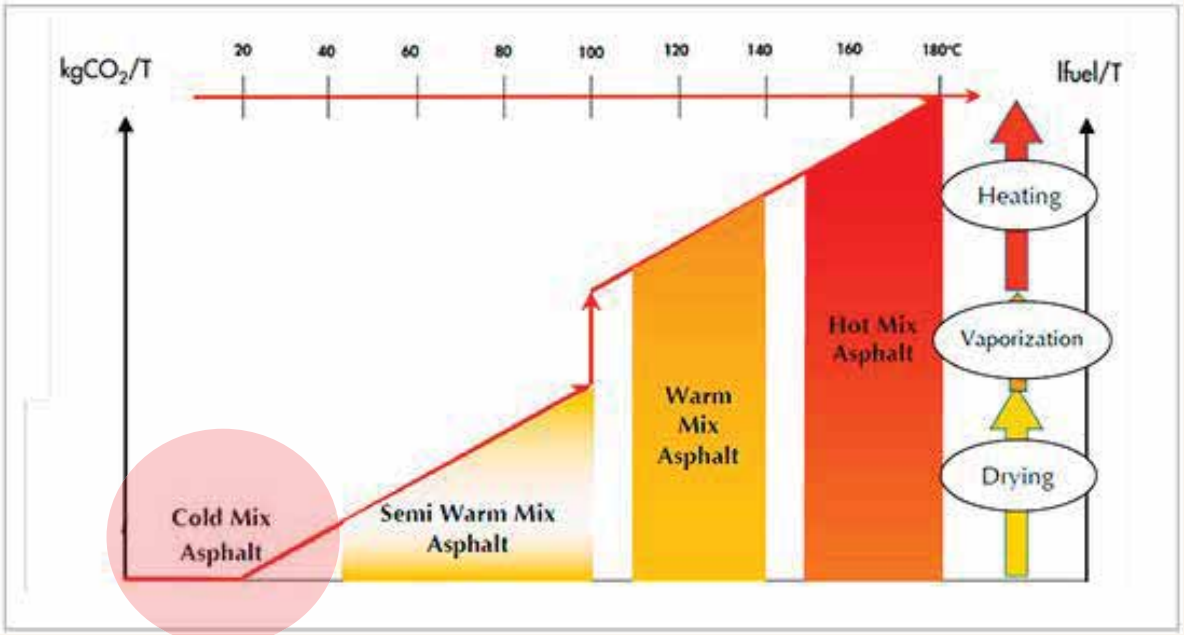
Cold Recycling Mixtures



IN PLACE

IN PLANT

COLD RECYCLING MIXTURES

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- The type of pavement distress that needs to be addressed
- The quality of material in the recycling horizon
- The required outcomes (i.e. service life expectations)
- The structural design of the recycled pavement
- The available resources (**Technical-Economical-Environmental**)

IN PLACE ?

OR

IN PLANT ?

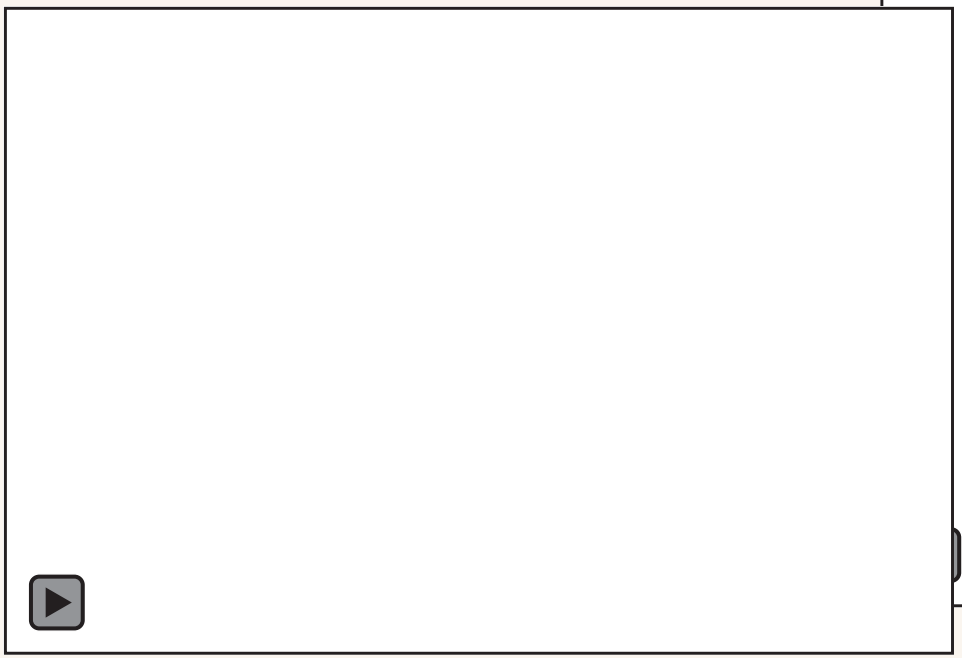
DEPENDS!!!

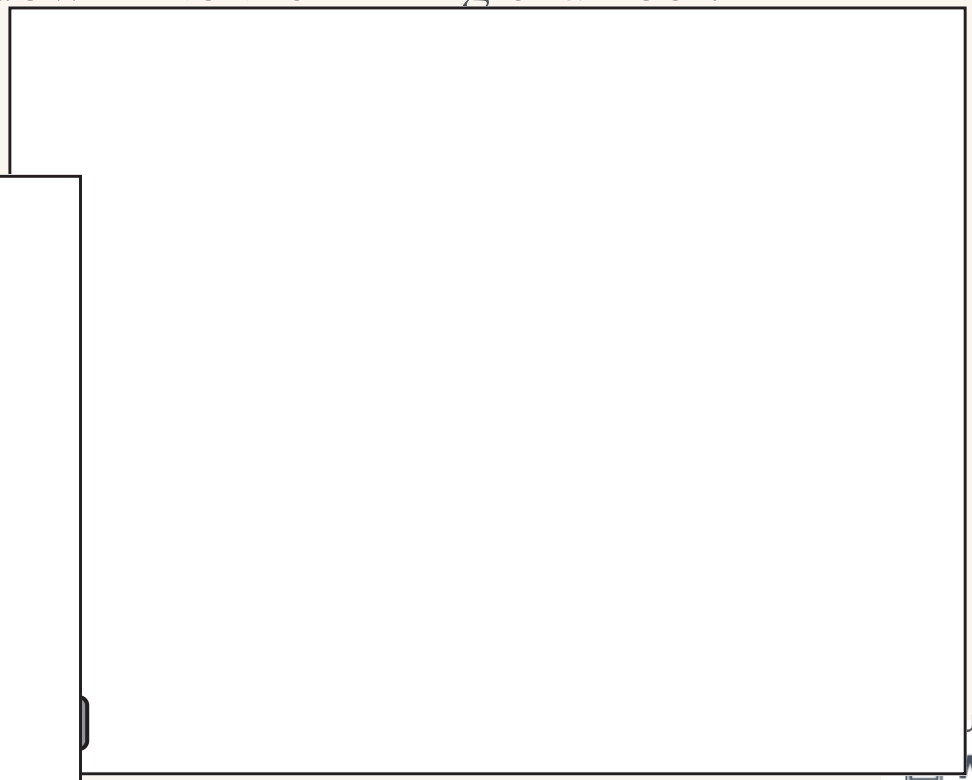
Cold Recycling Mixtures

Foam bitumen

Cold water and air are injected simultaneously into the hot asphalt.

The hot asphalt foams explosively and shoots down into the mixing chamber.





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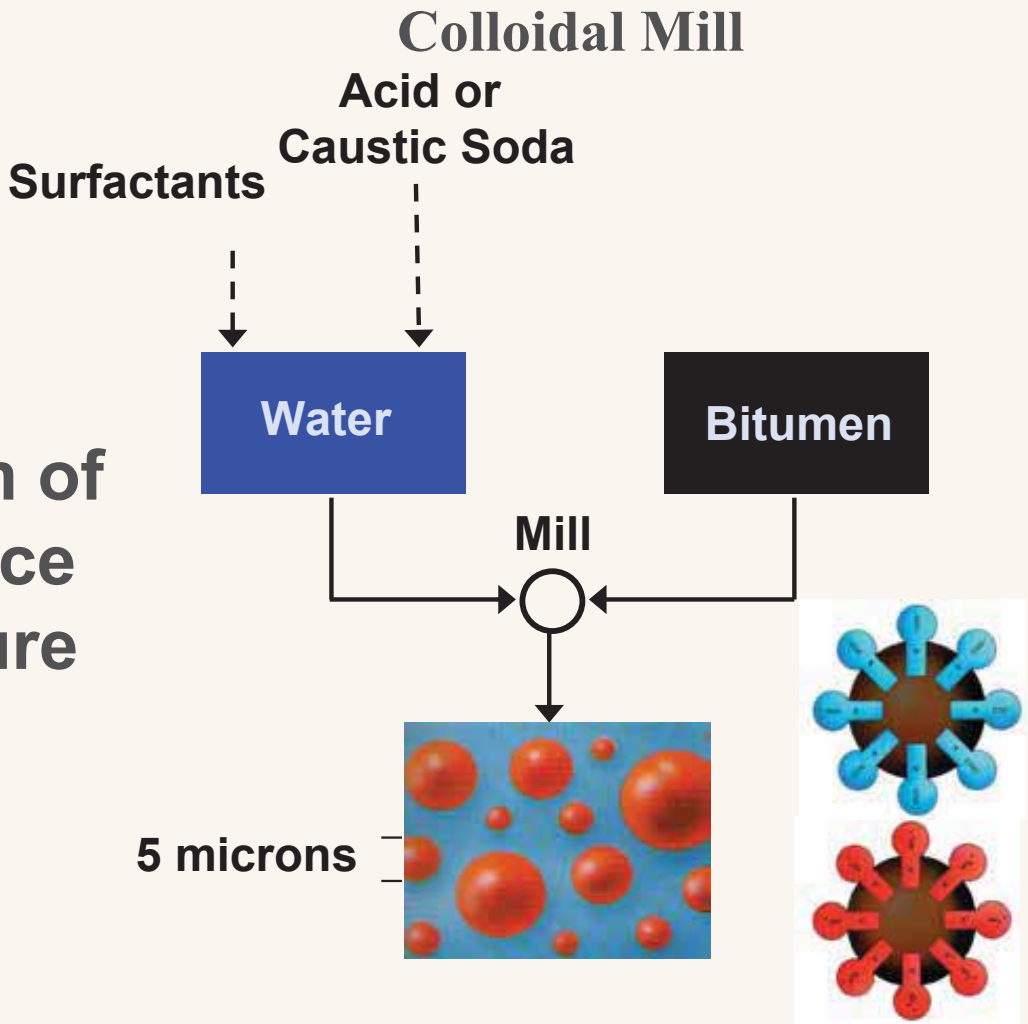
WIRTGEN

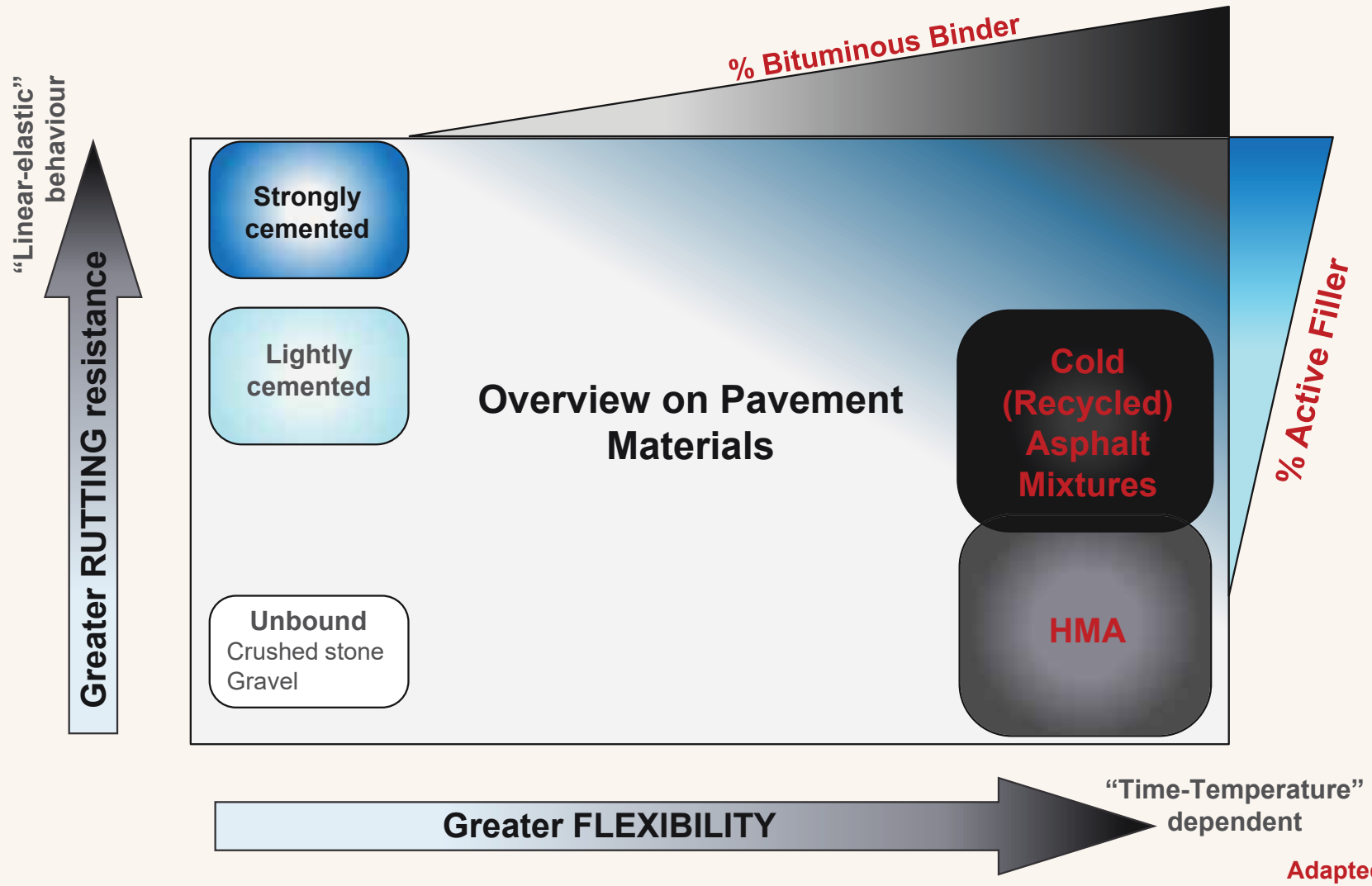
Cold Recycling Mixtures

Bitumen emulsion is a form of paint, so it "wet" the surface of all particles of the mixture of aggregates

The water is the carrier of bitumen

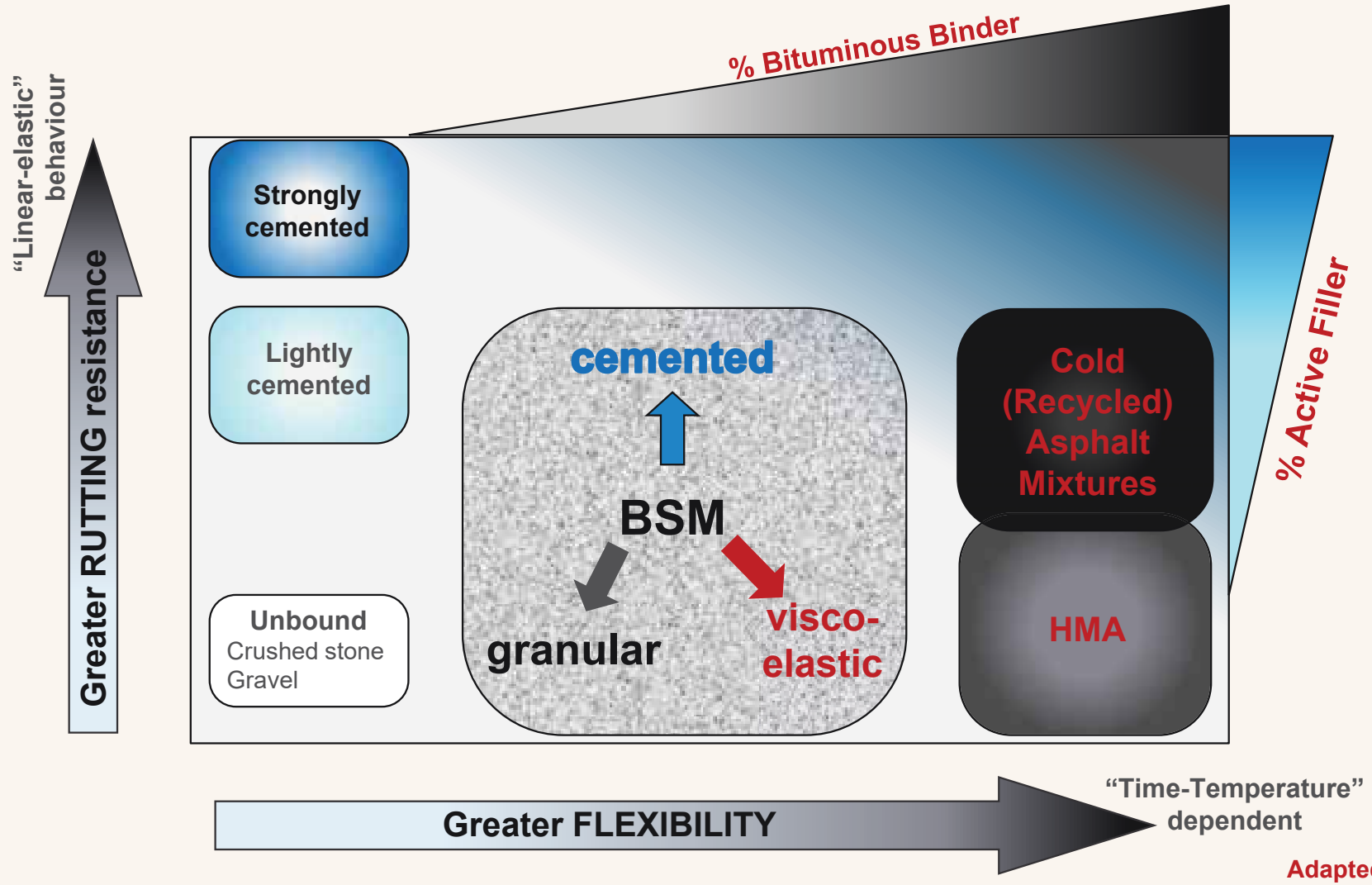
Bitumen Emulsion





Adapted of Kim Jenkins

Bitumen Stabilized Material



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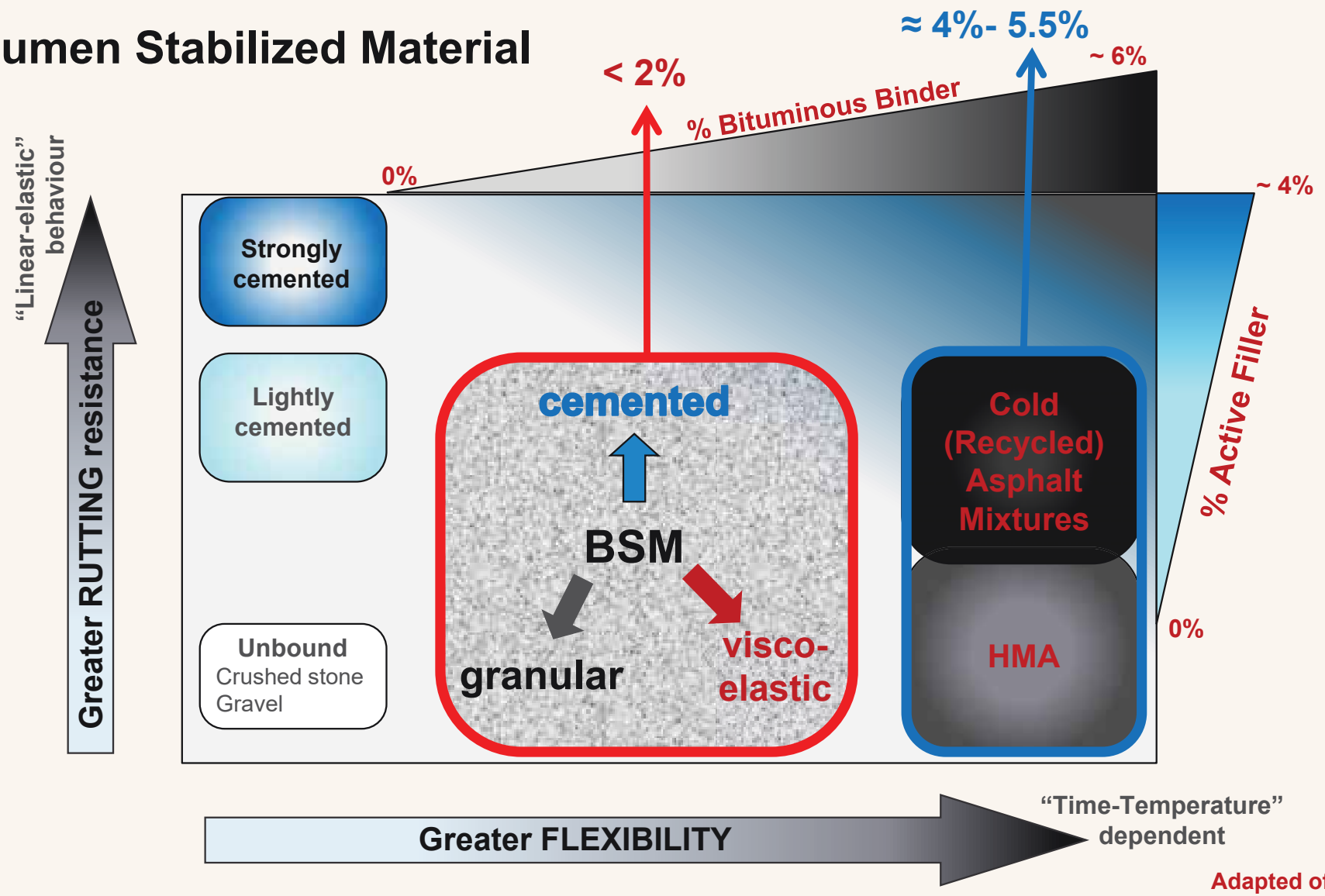
Bitumen Stabilized Material



Adapted of Kim Jenkins

BSMs are non-continuously bounded materials

The bitumen carried by fine aggregates (mainly by filler) it makes an adhesive mastic disperse inside the mixture

BSM is a very ADAPTABLE material!!!

TECNICALY, ECONOMICALY AND ENVIRONMENTALY

Foam Bitumen or Emulsion

In-Place or In-Plant Recycling

Different Structural Solutions

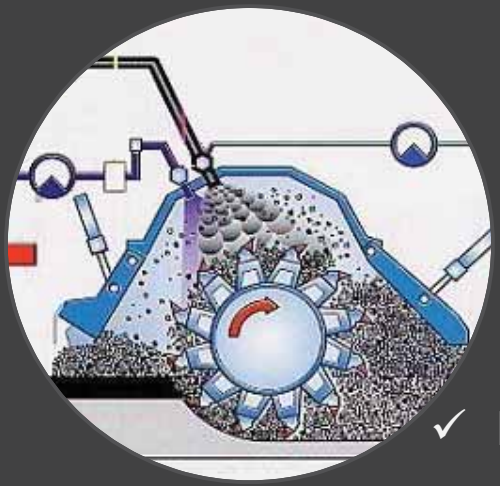
Wide range of RAP percentage, up to 100%

Use of other recycled aggregates (ex. Steel Slag)

Use of different types of Active Filler

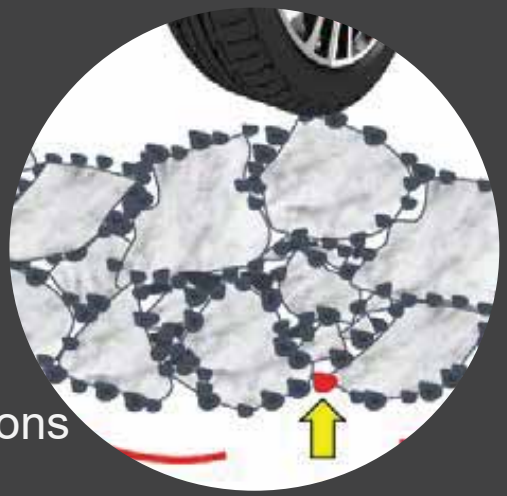
It's a Match!

CRM and BSM like each other.



Their in-commons:

- ✓ Water
- ✓ 100% RAP
- ✓ Local Materials
- ✓ Different Structural Solutions



Active Filler

THE ROLE OF THE ACTIVE FILLERS

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ASPHALT ACADEMY

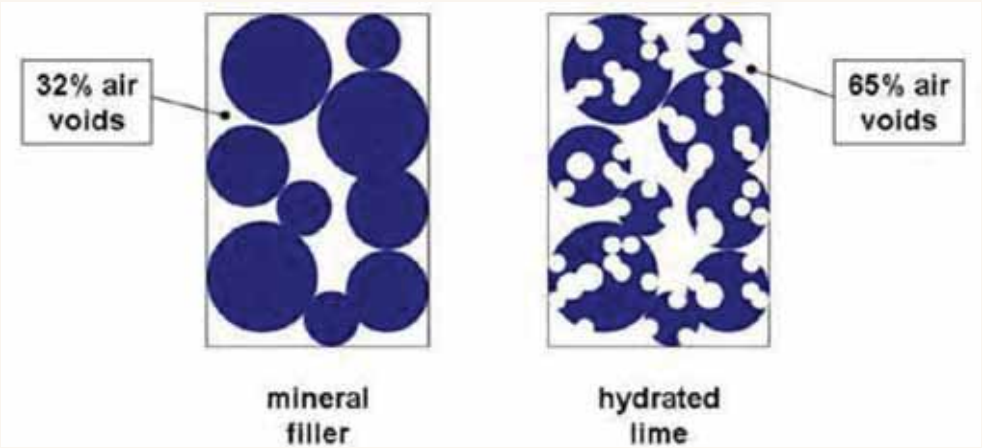
Technical Guideline:
Bitumen Stabilised Materials

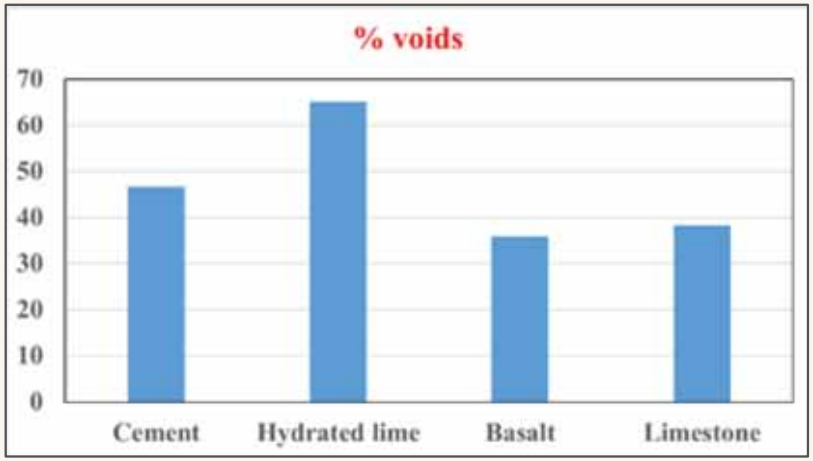
i Active filler

The term active filler is used to define fillers that **chemically alter** the mix properties. This includes fillers such as lime, cement and fly ash but excludes natural fillers such as rock flour.

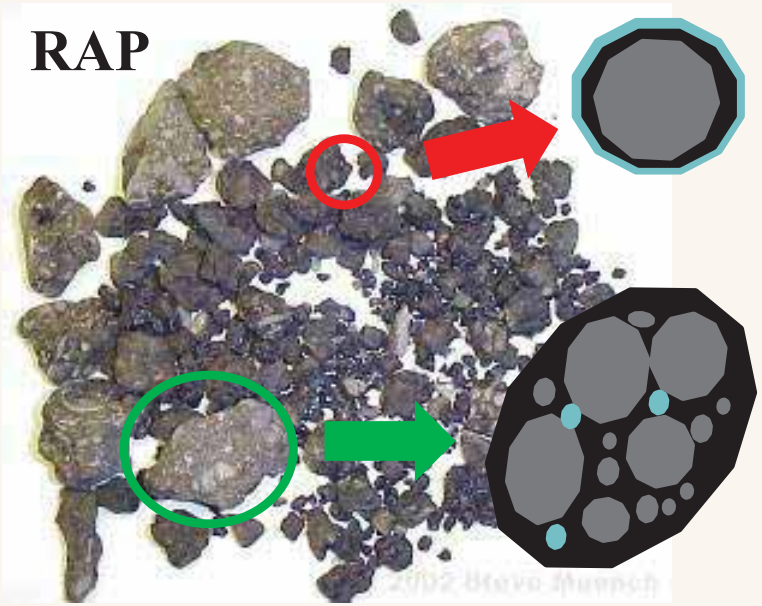
The roles of the active filler in BSM are:

- Improve adhesion of the bitumen to the aggregate
- Improve dispersion of the bitumen in the mix
- Modify the plasticity of the natural materials (soils)
- Increase stiffness & strength of mix
- Accelerate curing of compacted mix
- Control emulsion's breaking time



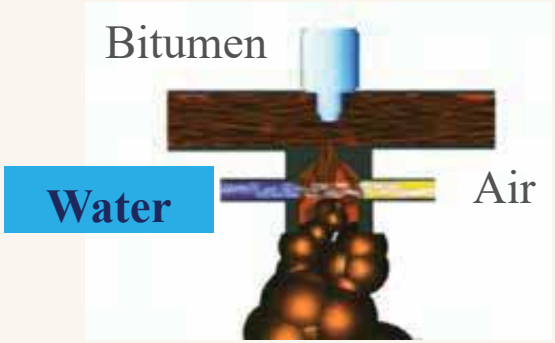


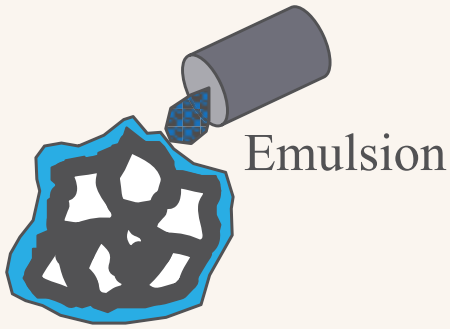
THE ROLE OF THE ACTIVE FILLERS

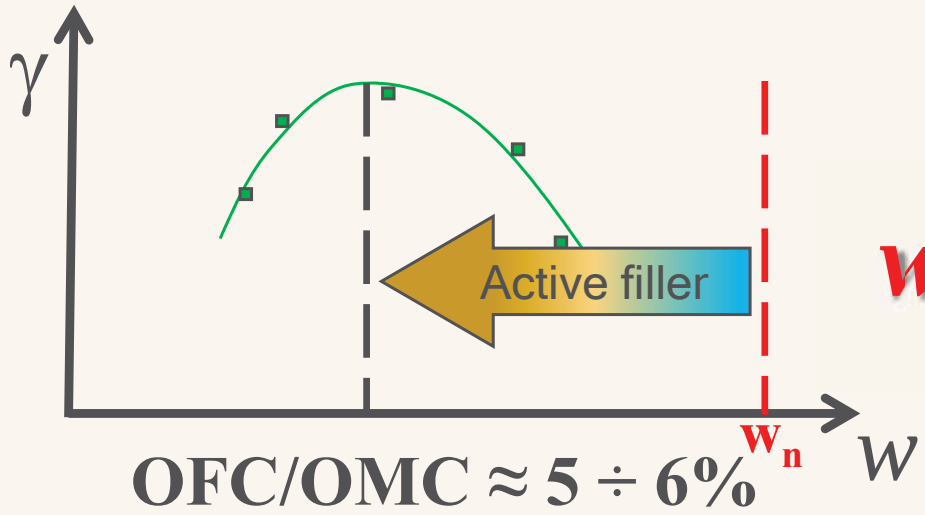


WATER

from milling process
or from exposition at
rain during storage







$w_{total} >> OFC$

THE ROLE OF THE ACTIVE FILLERS

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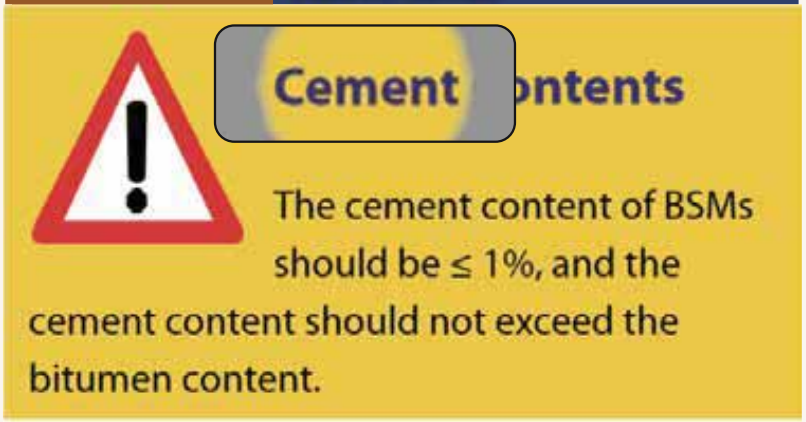
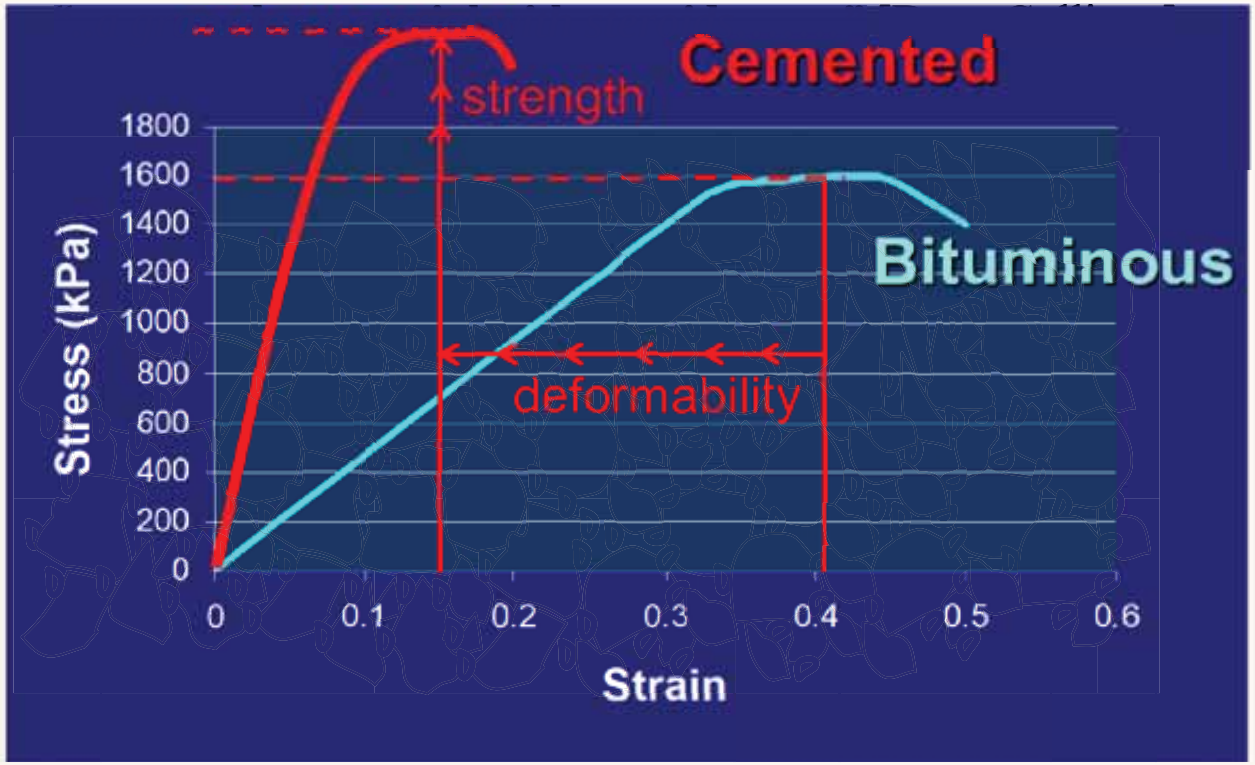


Most usual Active Filler on BSM

A Bitumen Stabilized Material is an half bounded material: a material with a behavior "at half way" between a granular material and a bounded material



BUT

…with high amount of cement the Bitumen Stabilized Material loses the characteristics of a granular material: it becomes a Cement Bound Material

THE ROLE OF THE ACTIVE FILLERS

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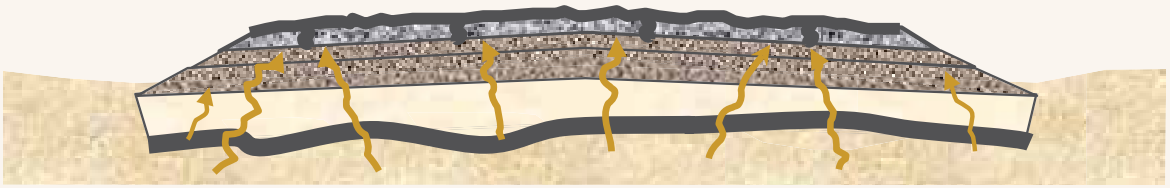
Can we use the lime as active filler to have only one lay down phase?
Can make sense a «combined lime-bitumen stabilization»?

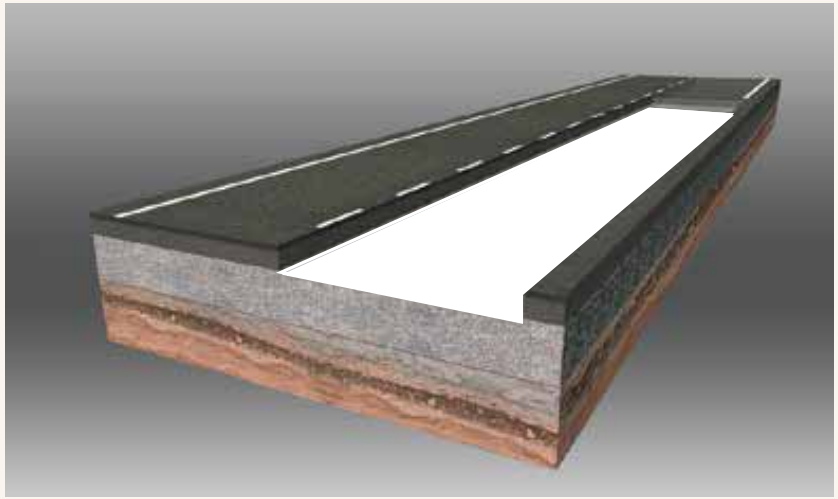
1. Lime to stabilize the clay

2. Cement as active filler

3. mixing, foaming, …..

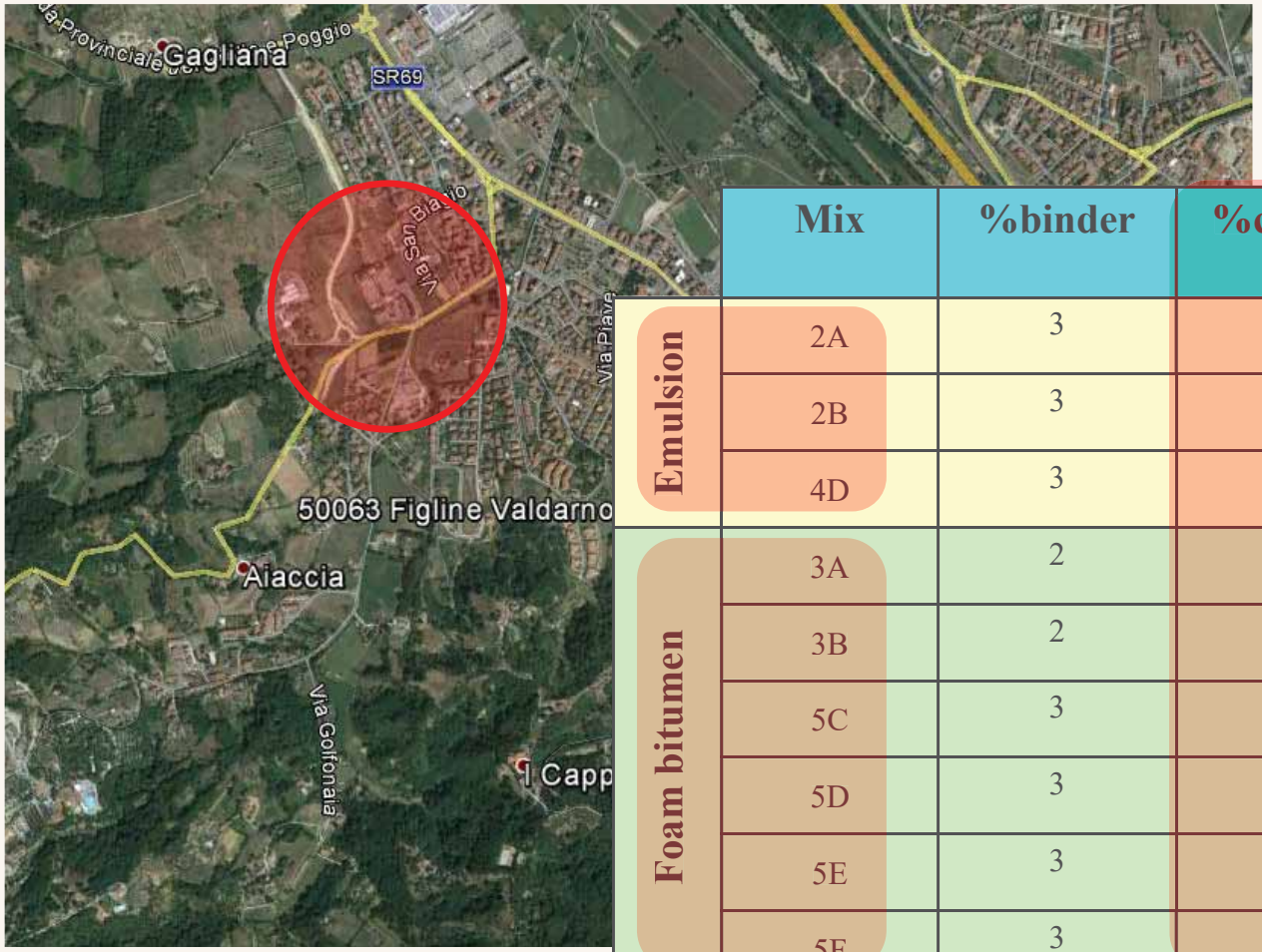
Rising of clay particles:
it requires to join lime stabilization and
cold in place recycling





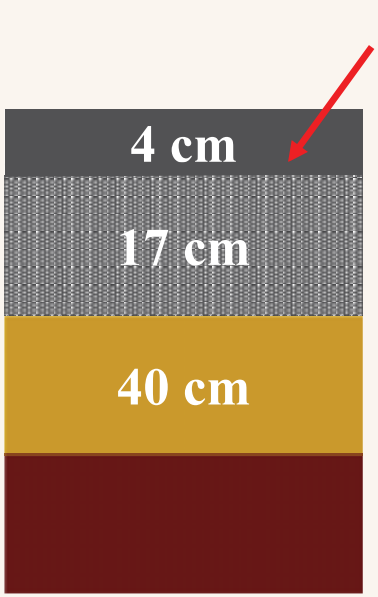
STUDY CASE 1

TRIAL SECTION - FLORENCE (ITALY)



	Mix	%binder	%cement	%lime	%mineral filler
Emulsion	2A	3	1.0	2.0	1.5
	2B	3	1.0	0	3.5
	4D	3	2.5	0	2.0
Foam bitumen	3A	2	1.0	2.0	1.5
	3B	2	1.0	0	3.5
	5C	3	2.5	2.0	0
	5D	3	2.5	0	2.0
	5E	3	0	2.0	2.5
	5F	3	0	3.0	1.5

TRIAL SECTION - FLORENCE (ITALY)



Protective tack coat

Wearing course

Base - Cold Recycled Mixture (bituminous emulsion/foam bitumen)

Subbase – lime stabilized soil

Subgrade

Thanks to a particular work plan the wearing coarse was layed down 10 months after wearing course

All mixtures had the curing process without traffic load

First LWD/FWD test campaign directly on CRM layer

COLD RECYCLING STUDY CASES

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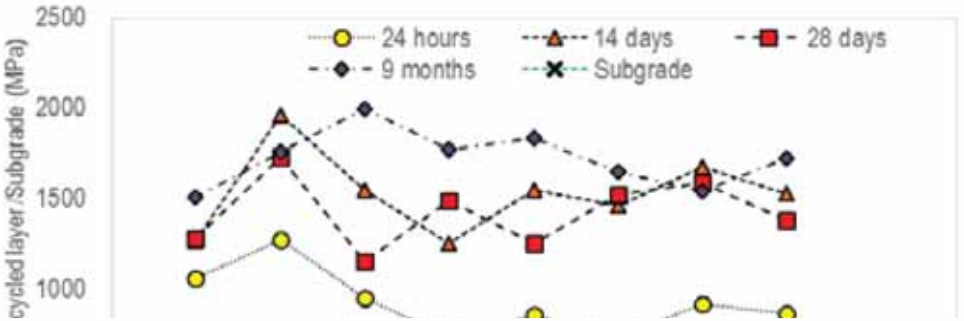
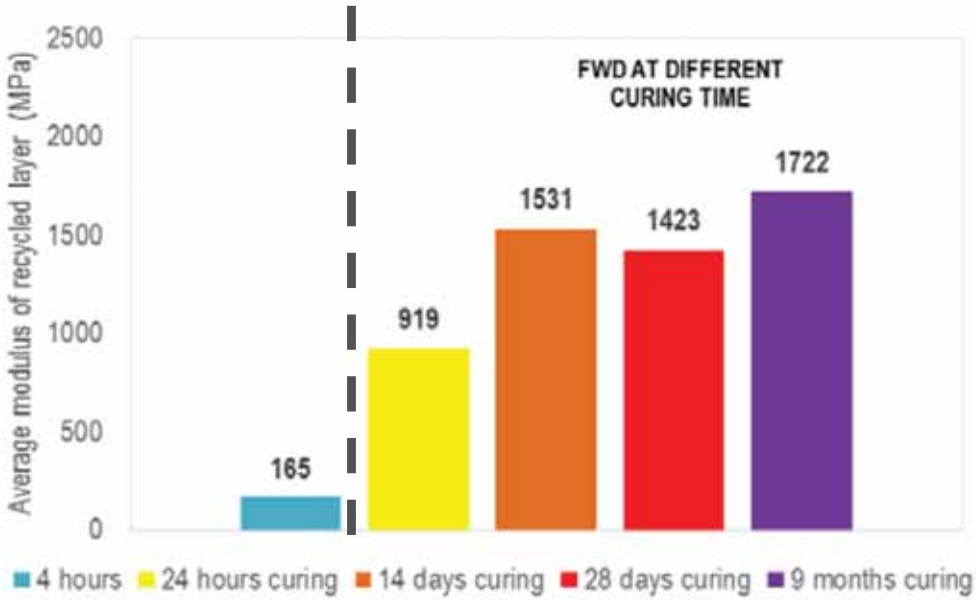
LWD & FWD TESTS RESULTS

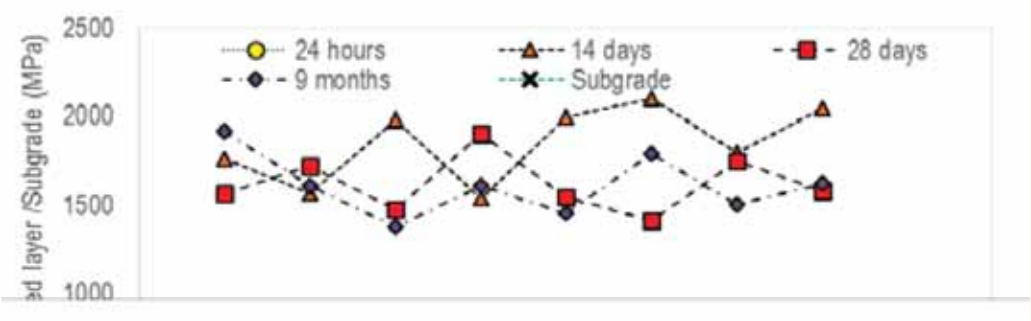
MIX 5D_3%FB_2,5%C_0% L_2% MF

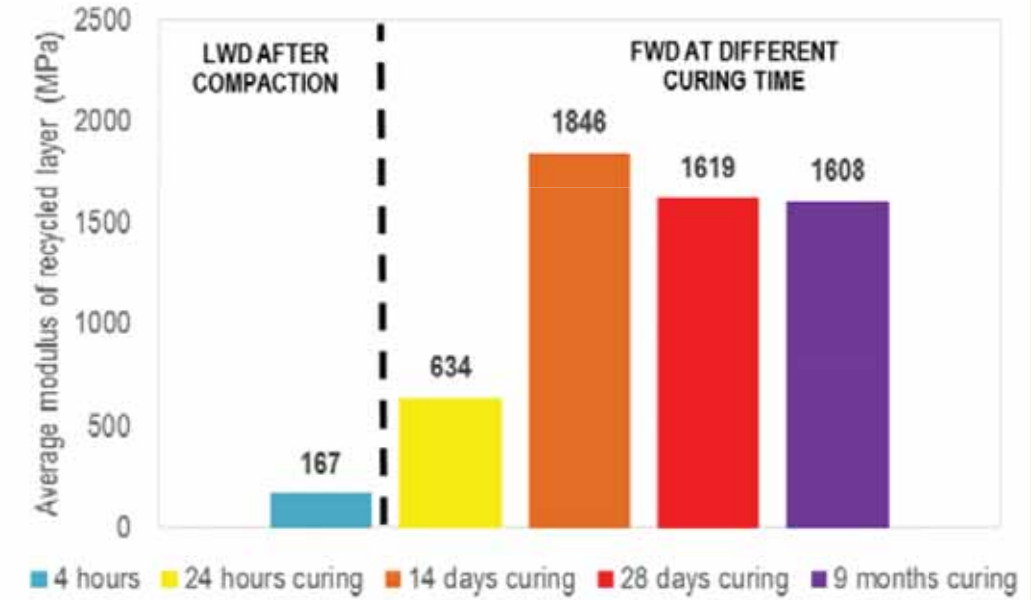




LWD & FWD TESTS RESULTS

MIX_5E_3%FB_0%C_2%L_2,5%MF





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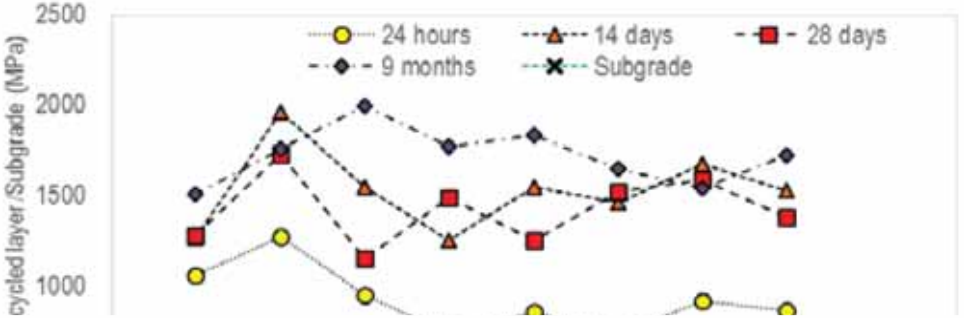
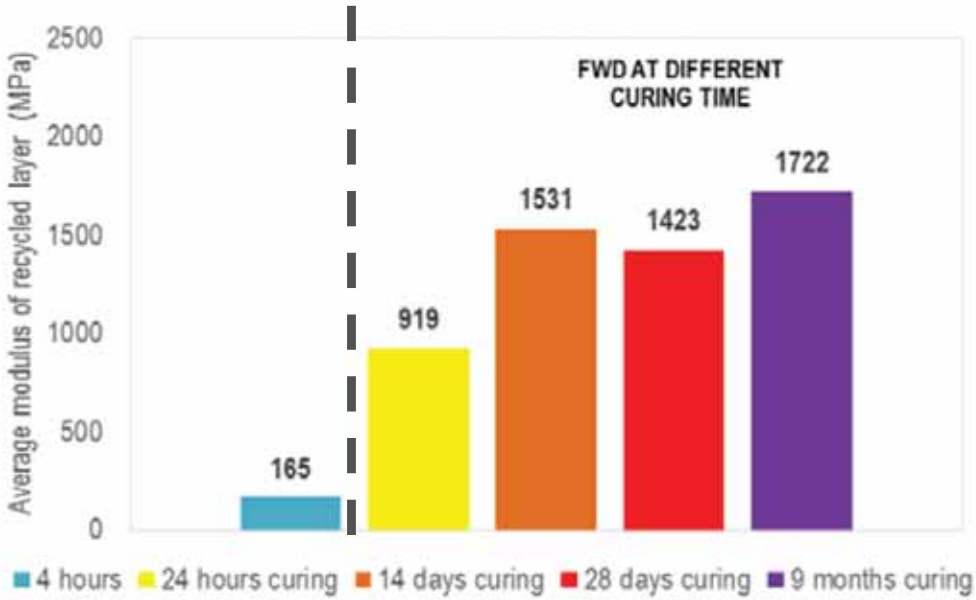
LWD & FWD TESTS RESULTS

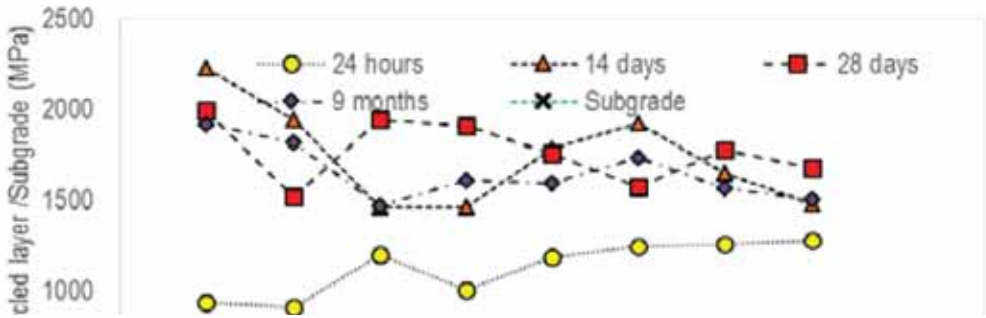
MIX 5D_3%FB_2,5%C_0% L_2% MF

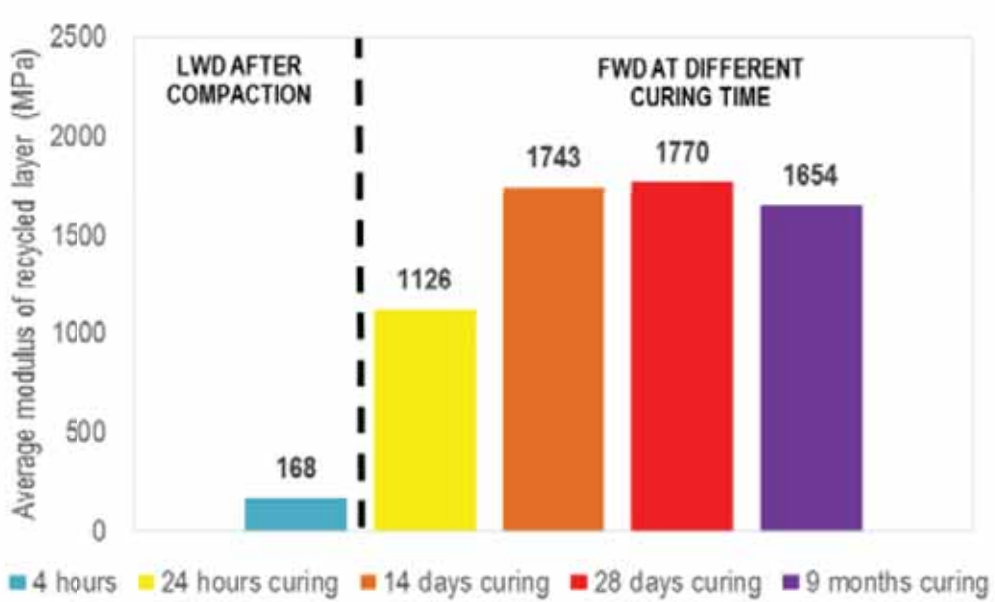




LWD & FWD TESTS RESULTS

MIX_3B_2%FB_1%C_0%L_3.5%MF





COLD RECYCLING STUDY CASES

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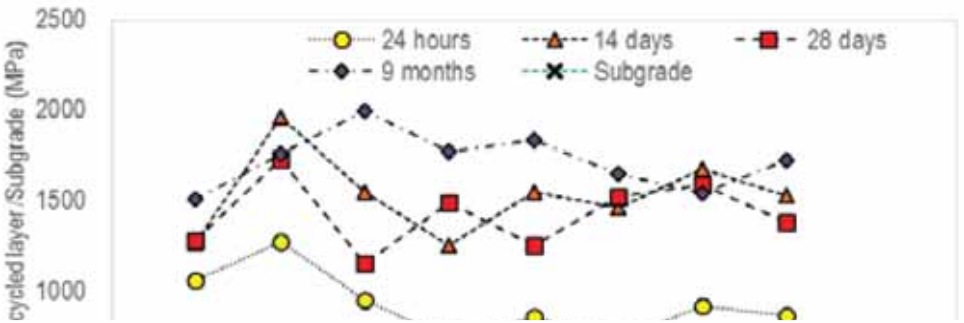
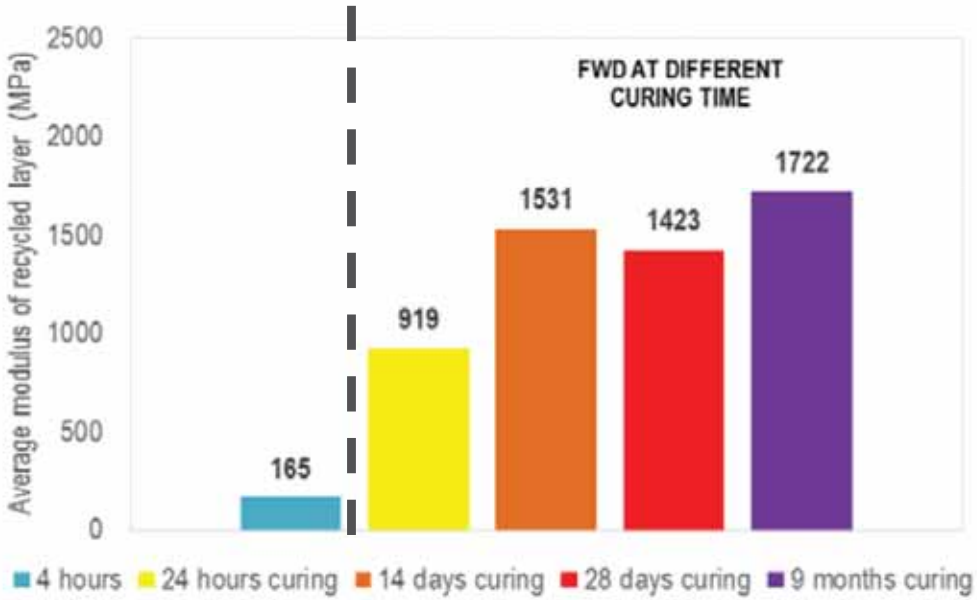
LWD & FWD TESTS RESULTS

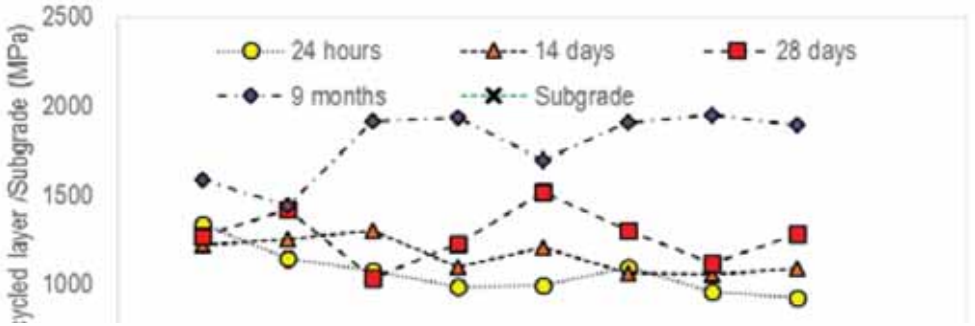
MIX 5D_3%FB_2,5%C_0% L_2% MF

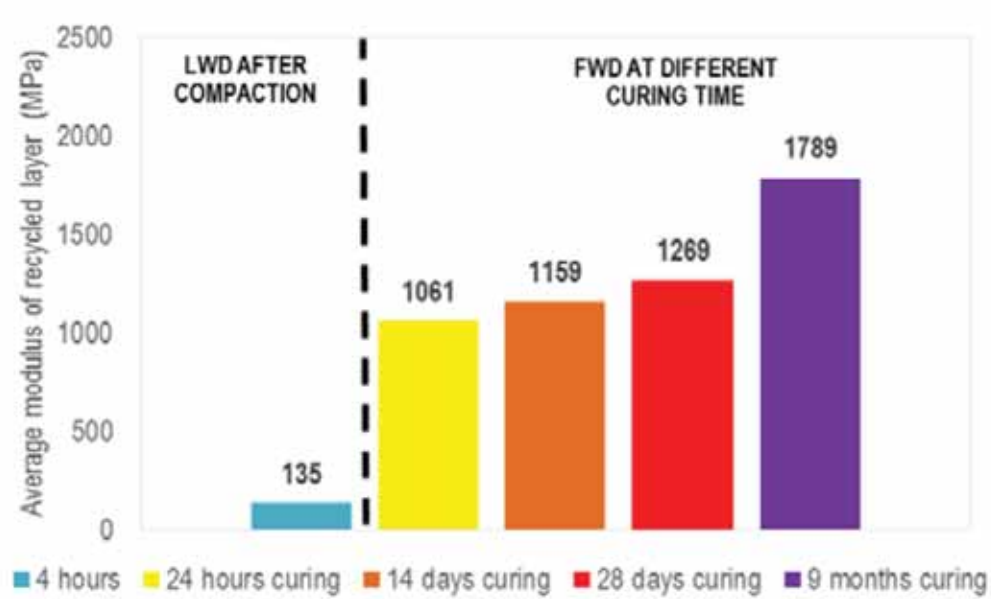




LWD & FWD TESTS RESULTS

MIX_5C_3%FB_2.5%C_2%L_0%MF





COLD RECYCLING STUDY CASES

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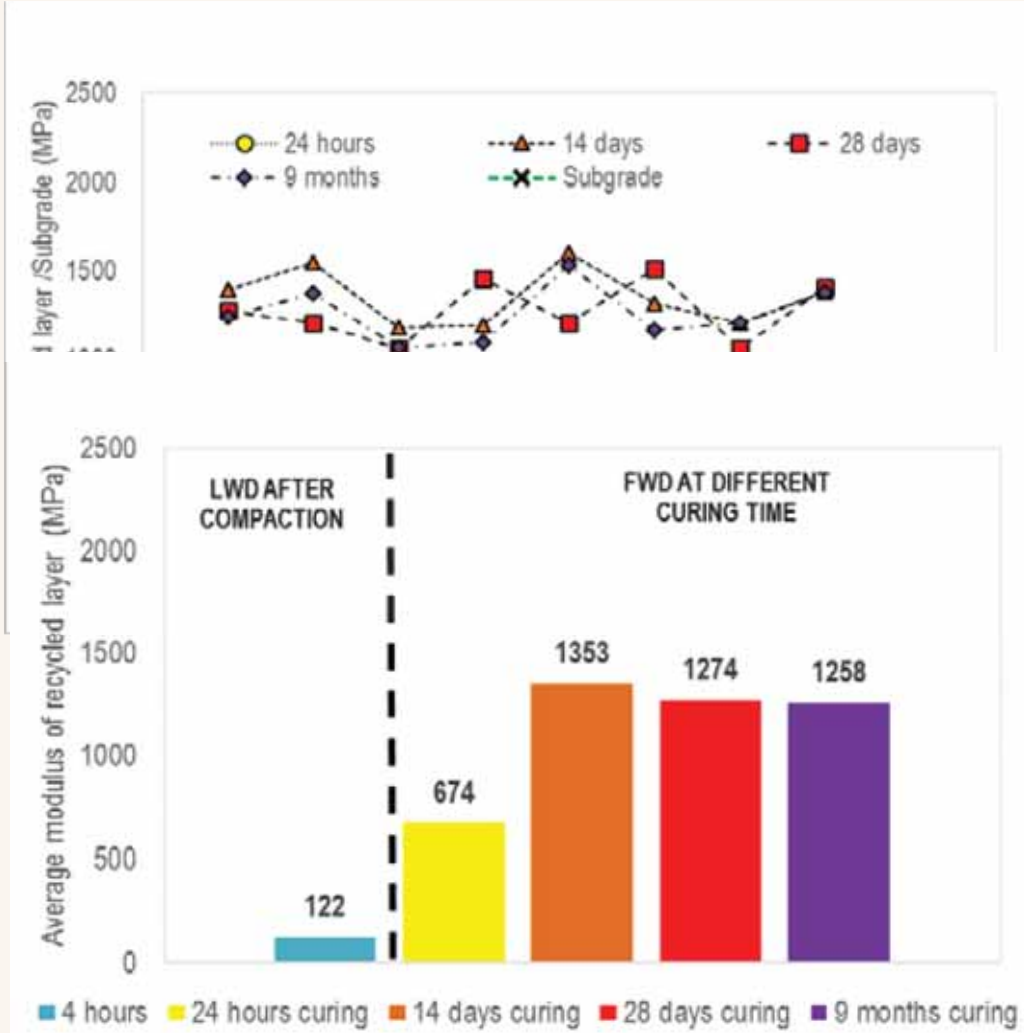
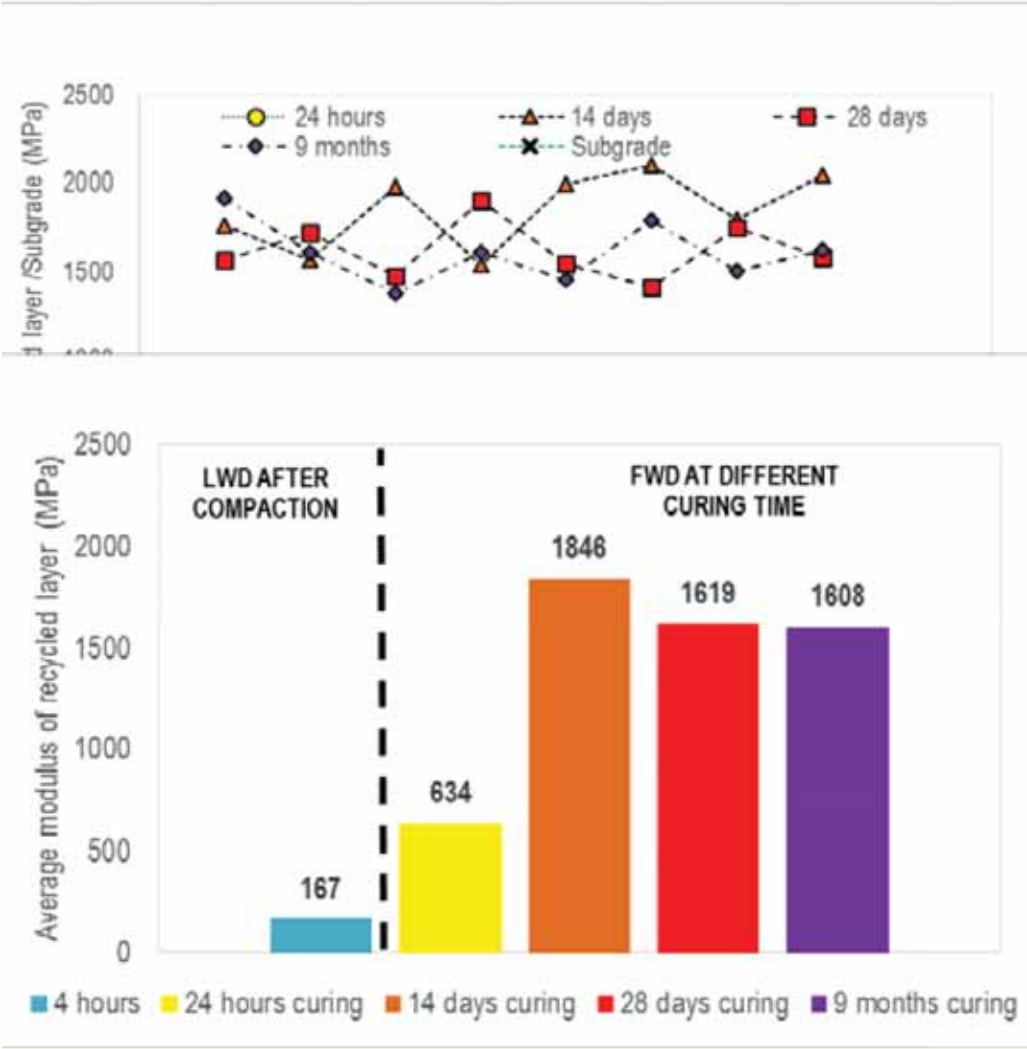
LWD & FWD TESTS RESULTS

MIX_5F_3%FB_0%C_3%L_1,5%MF



LWD & FWD TESTS RESULTS

MIX_5E_3%FB_0%C_2%L_2,5%MF

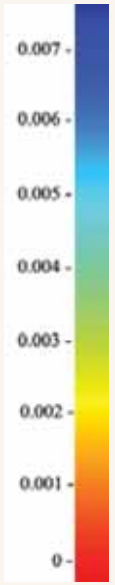


HORIZONTAL FULL FIELD STRAIN MAPS

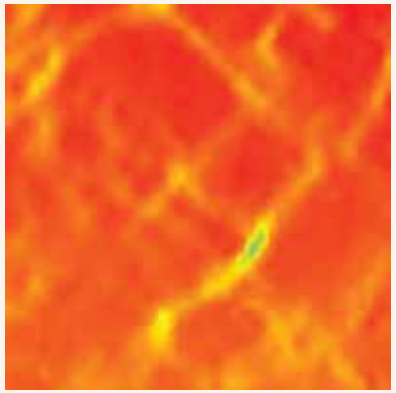
Fracture Energy test

Foam bitumen mixtures

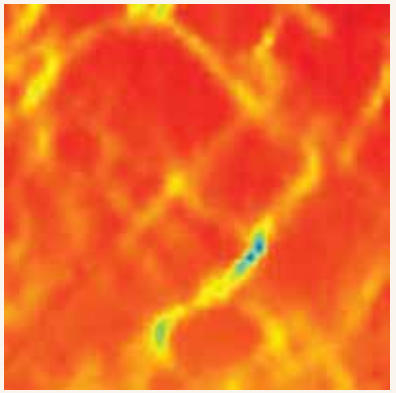
MIX	% foam bitumen	% cement	% hydrated lime
3A	2	1	2
3B	2	1	0
5C	3	2.5	2.0
5D	3	2.5	0
5E	3	0	2.0
5F	3	0	3.0



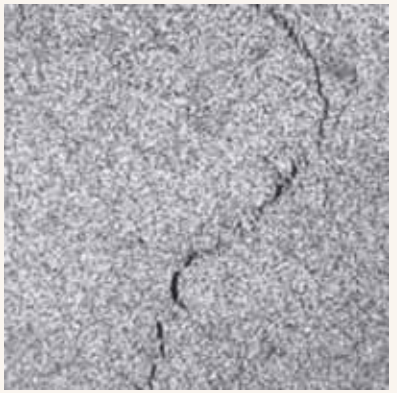
with lime



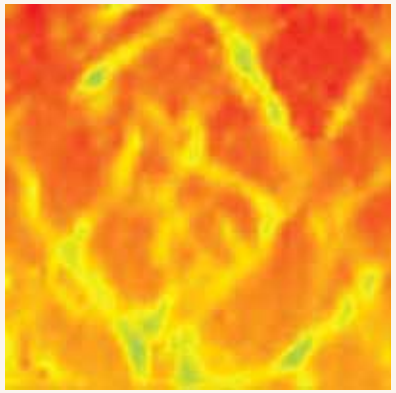
Mix 3A – macrocrack



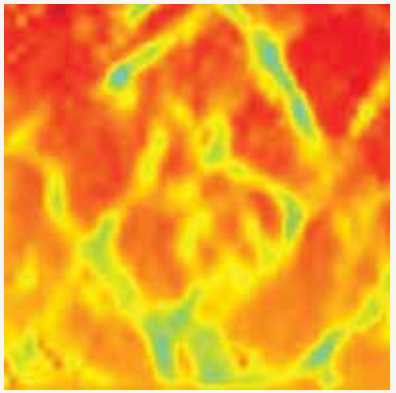
Mix 3A – peak load



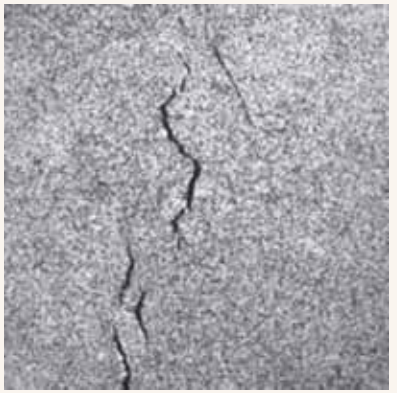
Mix 3A – visible cracks



Mix 5D – macrocrack



Mix 5D – peak load



Mix 5D – visible cracks

without lime

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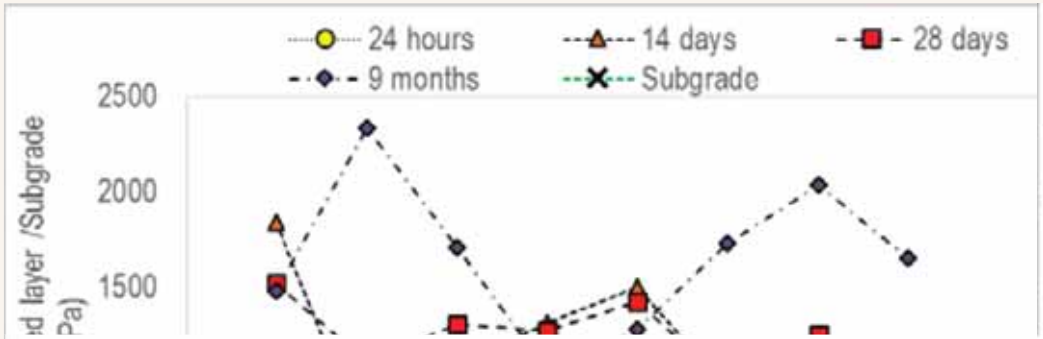
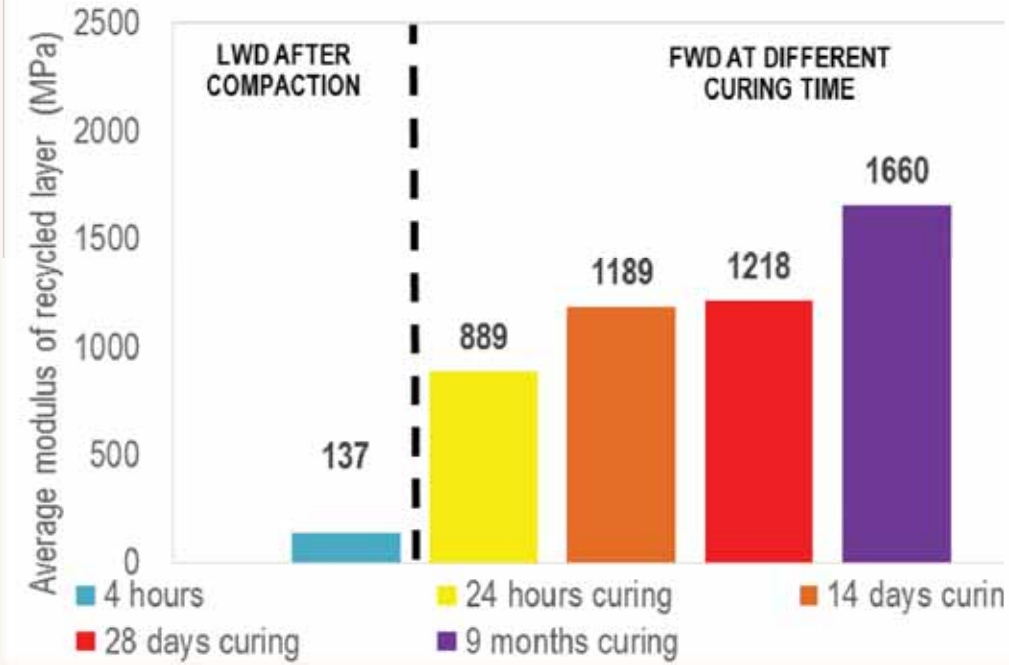
LWD & FWD TESTS RESULTS

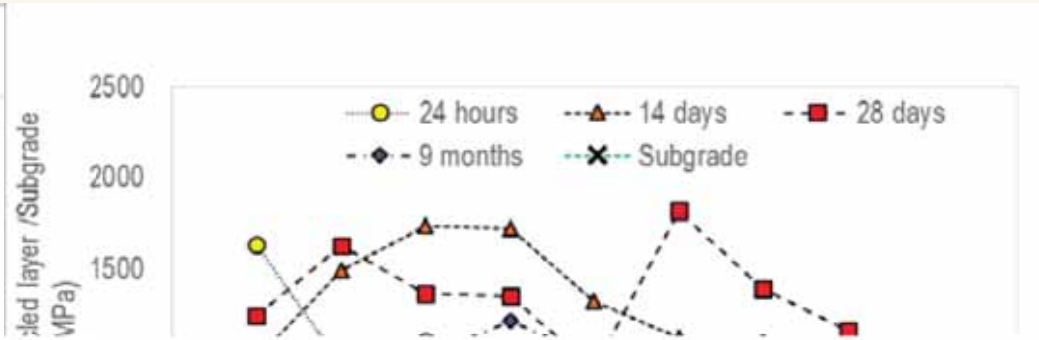
MIX 4D 3%BE - 2.5% C-0% L – 2% MF

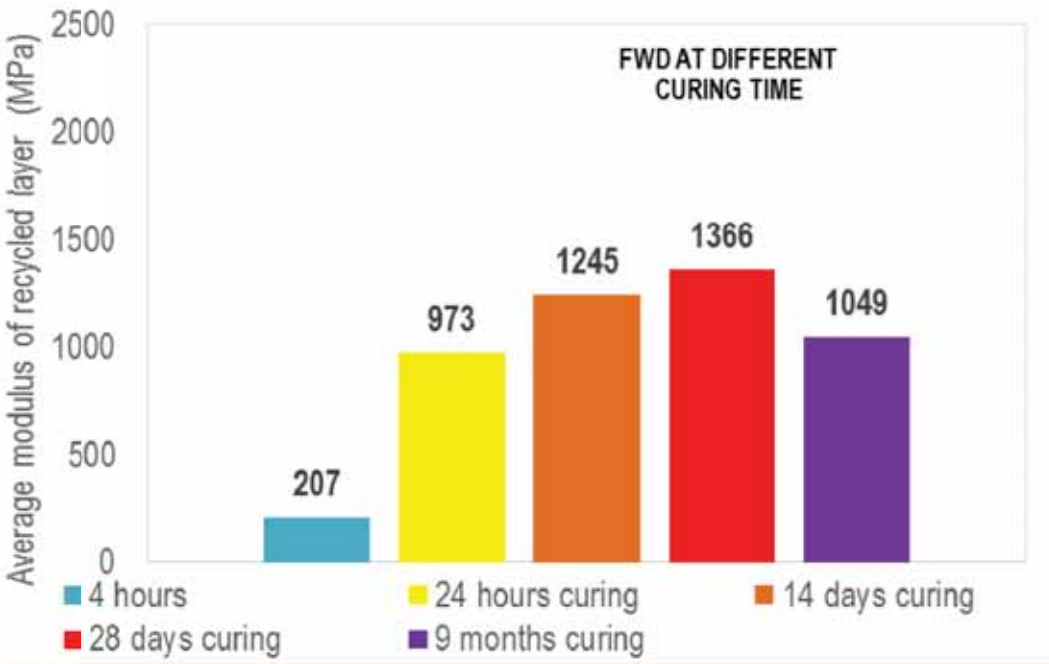




LWD & FWD TESTS RESULTS

MIX 2A 3%BE-1%C-2% L-1,5% MF



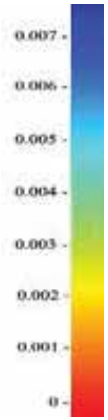


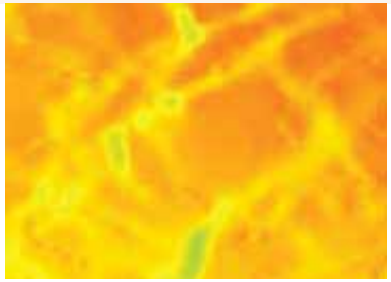
HORIZONTAL FULL FIELD STRAIN MAPS

Fracture Energy test

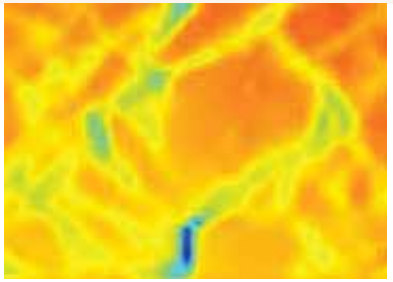
Bituminous Emulsion mixtures

MIX	% bitumen emulsion	% cement	% hydrated lime
2A	3	1	2
2B	3	1	0
4D	3	2.5	0

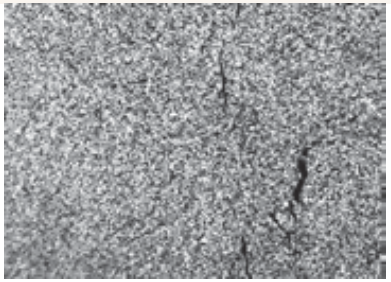




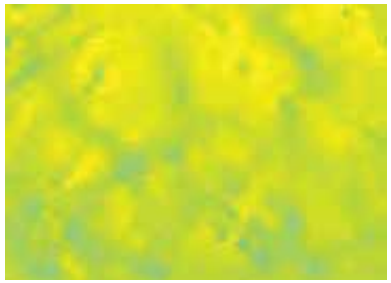
Mix 2A – macrocrack



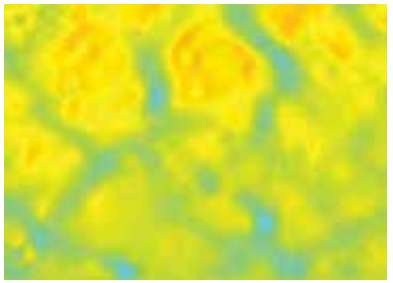
Mix 2A – peak load



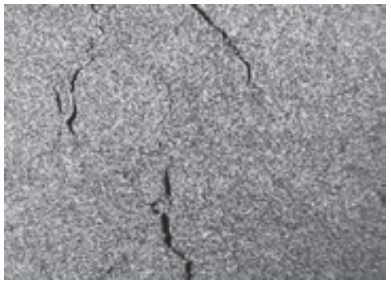
Mix 2A – visible cracks



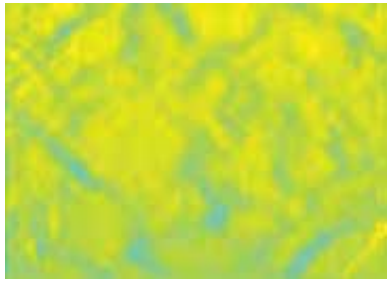
Mix 2B – macrocrack



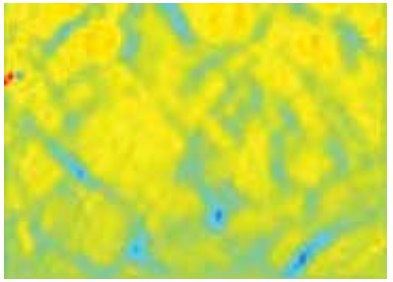
Mix 2B – peak load



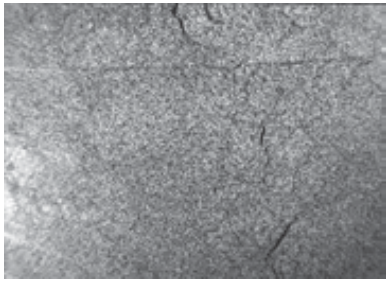
Mix 2B – visible cracks



Mix 4D – macrocrack



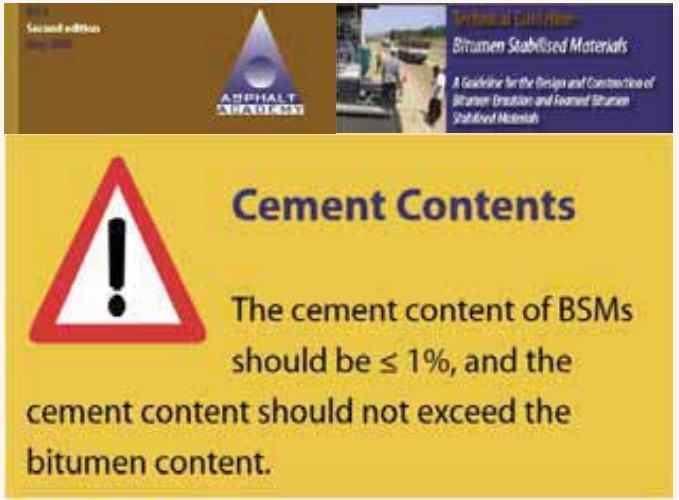
Mix 4D – peak load

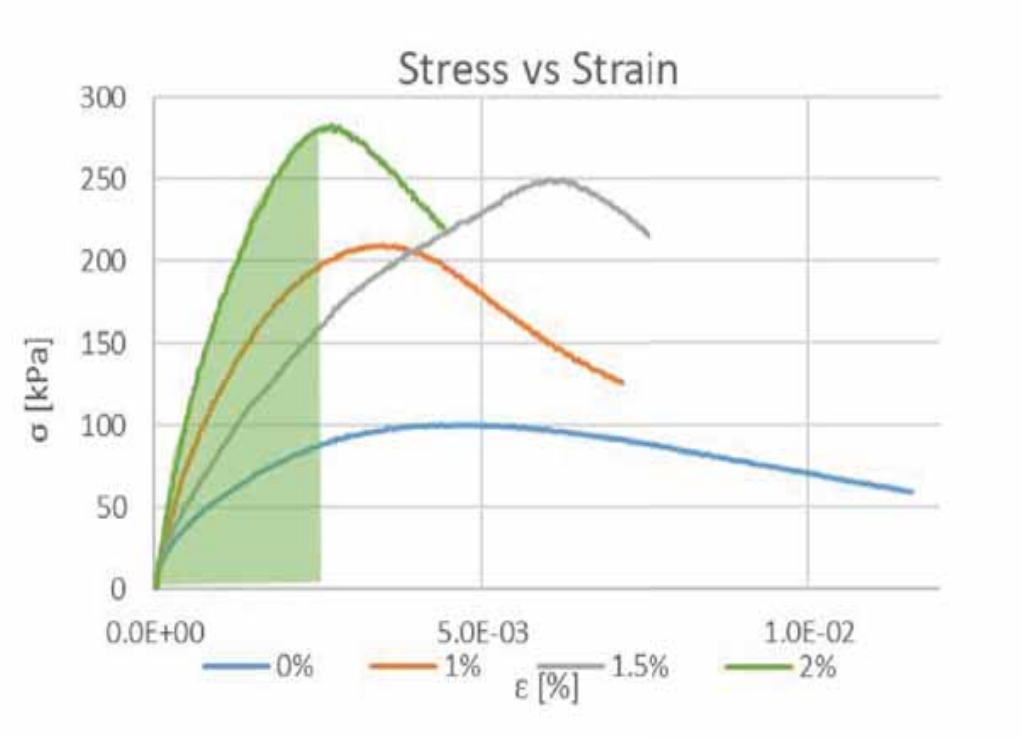


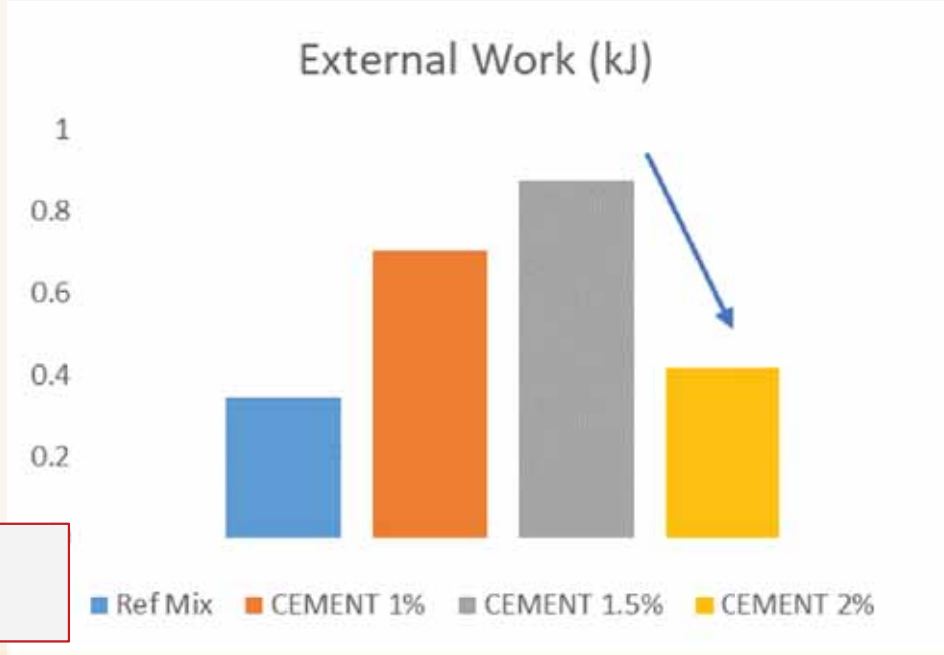
Mix 4D – visible cracks

Study Case 2
Amount of cement

BSM

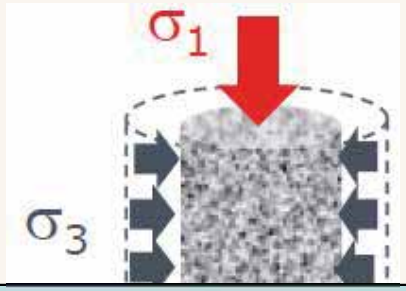


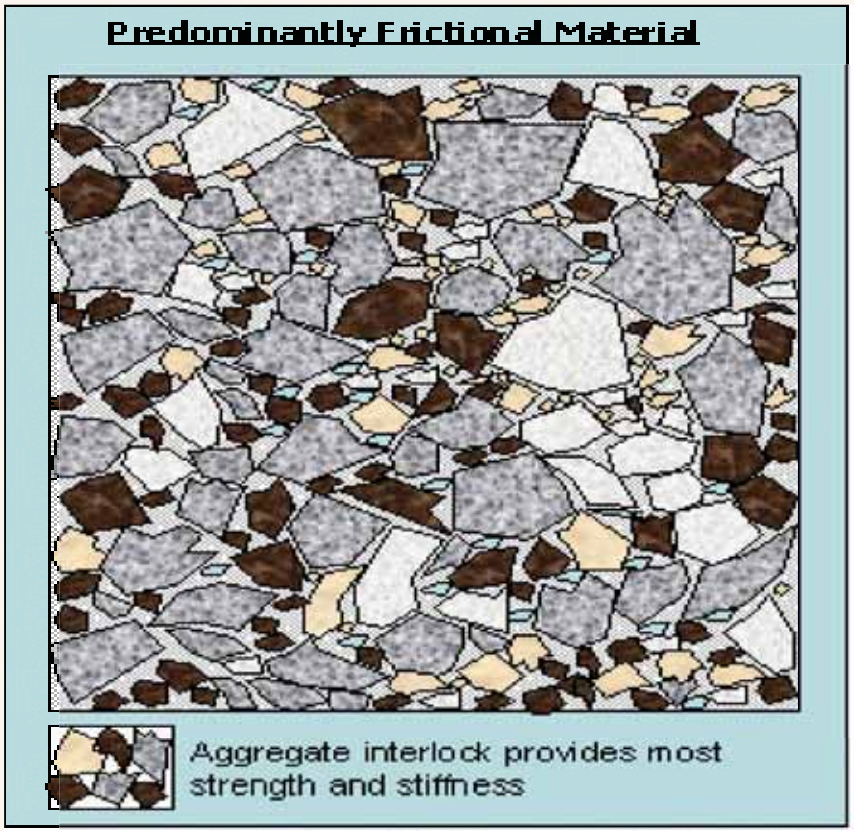


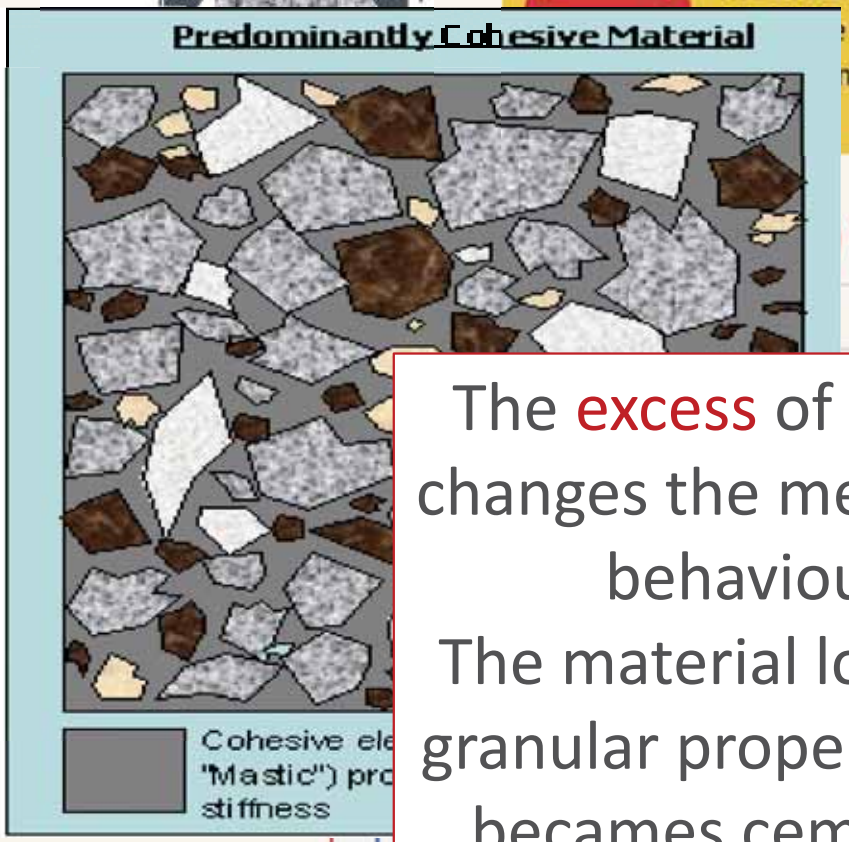


% Cement → Mixture turns Brittle

Study Case 2
Amount of cement







The excess of cement changes the mechanical behaviour:
The material looses its granular properties and becames cemented.

CONCLUSIONS

- BSM is a material that suits Cold Recycling Techniques
- Active fillers have limited influence on bearing capacity
- Active fillers have influence in the redistribution of the stress after crack initiation
- Lime can be used instead of cement or together with cement as an active filler for bitumen stabilized materials
- Moderate amount of cement + lime may represent the optimal blending for bitumen stabilized mixtures
- % of cement as active filler must be carefully designed

Thank you!
Hvala vam!
Grazie!
Obrigada!

DNIT

Università di Parma

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ASFALTNI KOLNICI 2019
OPATIJA / 4. & 5. IV.