3rd International Symposium on Asphalt Pavements & Environment

16 AUGUST 2015, SUN CITY, SOUTH AFRICA

Comprehensive evaluation on the mechanical behaviour of cement-bitumen treated materials

Andrea Grilli[1], Monica Meocci[2], Maurizio Bocci[3], Francesca La Torre[4]

[1] University of the Republic of San Marino, San Marino, andrea.grilli@unirsm.sm

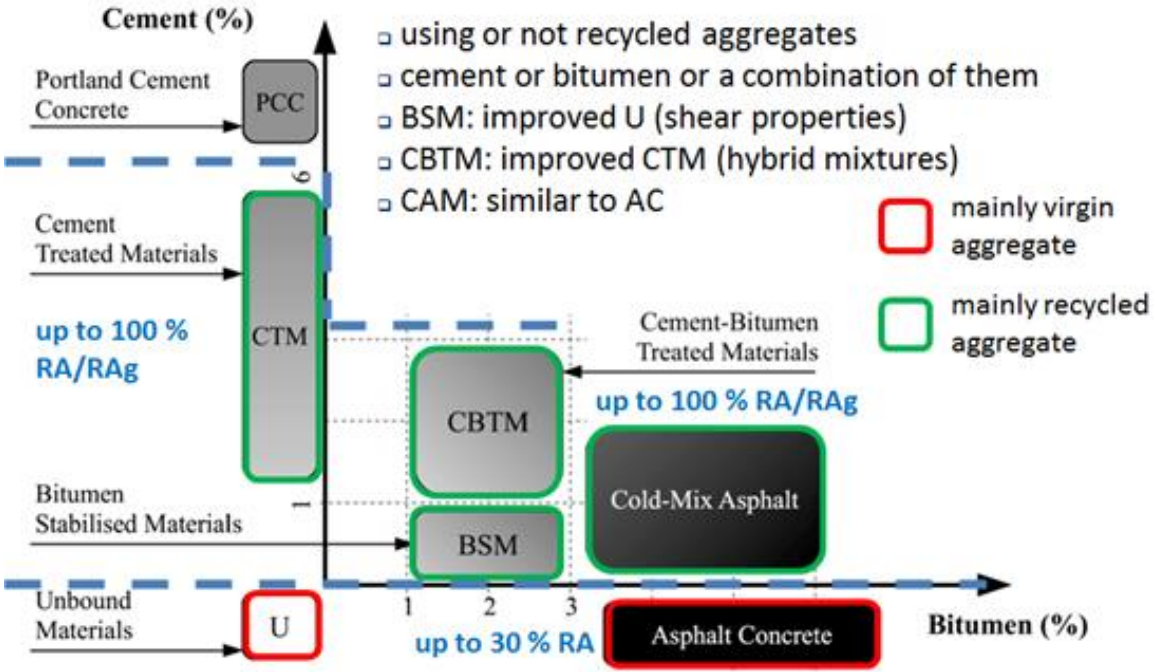
[2]University of Florence, Italy, monica.meocci@unifi.it

[3]Polythecnic of Marche, Ancona, Italy, m.bocci@univpm.it

[4]University of Florence, Italy, francesca.latorre@unifi.it

Introduction and objective

Index



Introduction and objective

Index

This paper aims at providing a comprehensive characterization of CBTM with high amount of RA divided into two fractions (course and fine fractions).

The CBTM was designed in laboratory and produced in a mix plant.

Introduction and objective

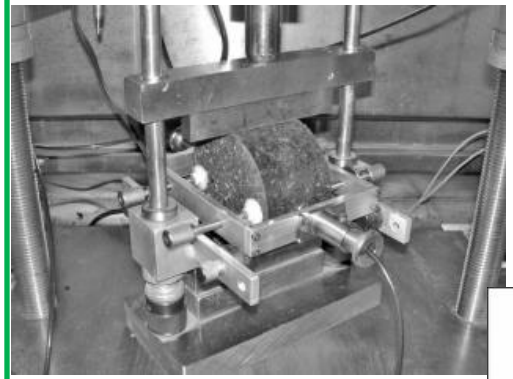
Index

Two trial section are laid down. The first one had a CBTM layer thickness of 15 cm (section 1) and the second one had a CBTM layer thickness of 20 cm (section 2).

Introduction and objective

Index

The main objective was to combine results from laboratory tests to those obtained in field test.



Constituent materials

Index

1.Introduction and objectives

2.Constituent material and mixture selection:

-Granular materials

-Bituminous emulsion

-Cement.

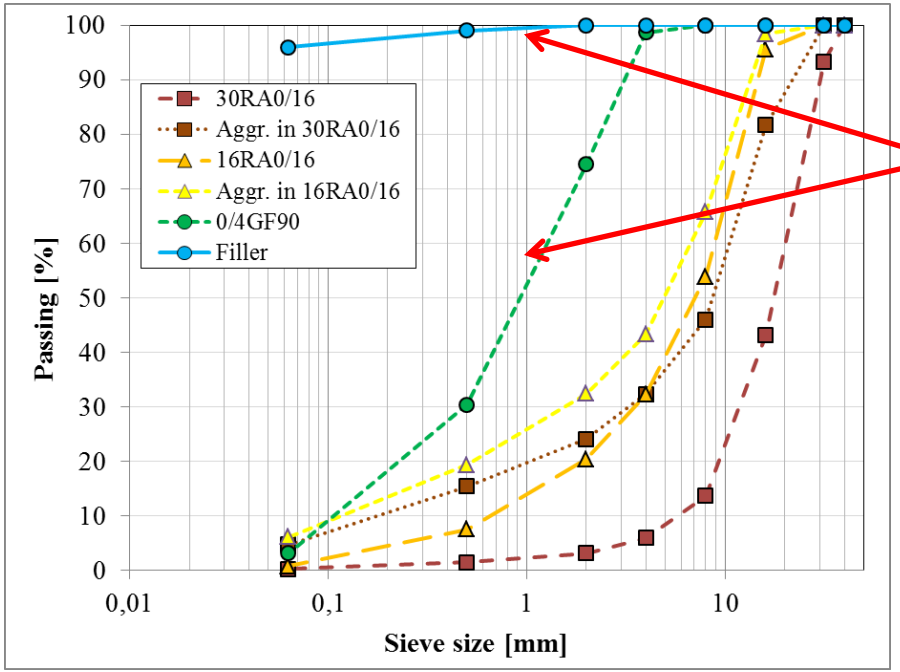
3.Experimental programme

4.Result

-Volumetric properties

-Performance properties

5. Conclusions and recommendation



the use of a limestone-crushed sand and mineral filler were required to adjust the particle size distribution of the blend.

Designation	Particle density ρ_a [Mg/m³]	Water absorption WA_{24} [%]	Flakiness index FI [%]	Shape index SI [%]
16 RA 0/16	2.50	-	7	8
30 RA 0/16	2.45	-	18	28
0/4 G_F 90	2.73	1.3	-	-

Constituent materials

Index

An over-stabilized bituminous emulsion, designated as C60B6 (EN 13808), were selected to fulfil the requirements for in-plant recycling.

Emulsion characteristics				
Characteristics	Standard	Unit	Class	Value
Polarity	EN 1430	-	2	positive
Breaking index	EN 13075-1	-	6	188
Mixing stability	EN 12848	g	2	0.5
Adhesivity	EN 13614	%	2	80
Bitumen content (100 – w)	EN 1428	%	5	59
Settling tendency @ 7 days	EN 12847	%	3	8
Characteristics of the residual bitumen				
Needle penetration at 25°C	EN 1426	dmm	3	72
Softening point	EN 1427	°C	6	45

A Portland limestone cement type II/B-LL, strength class 32.5 R (EN 197-1) was used. Its composition is a combination of clinker (65 % - 79 %) and limestone dust (35 % - 21 %).

Mixture

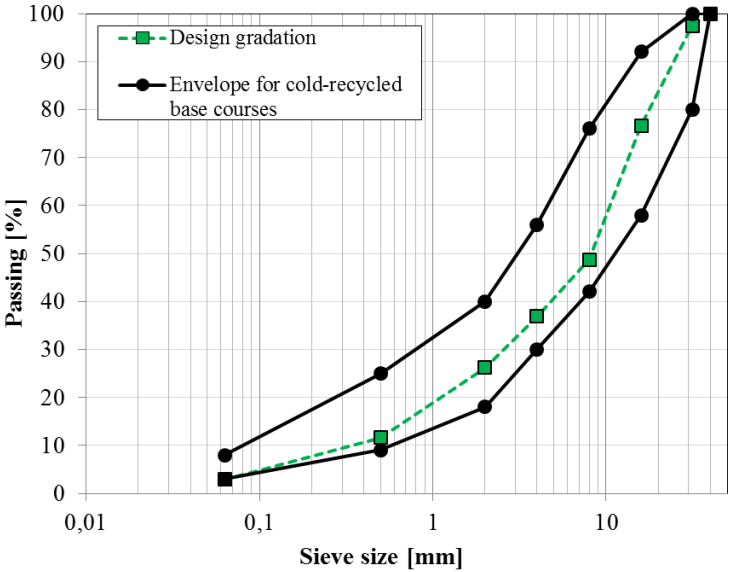
Index

Objectives:

- maximize the use of RA;
- satisfy the envelope provided by the Italian specification.

Composition:

- 38% of 30RA0/16;
- 40% of 16RA0/16;
- 20% of 0/4GF90;
- 2% of mineral filler.



Optimum water content

- 5% by aggregate weight.

Performances of design mixture:

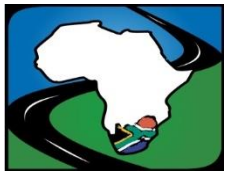
Mixture	ITS@25°C [MPa]	ITSM@20°C [MPa]	ITSM@40°C [MPa]
2C3.5E	0.36	3113	1569
Specification	≥ 0.35	≥ 3000	≥ 1500

Experimental programme

Index

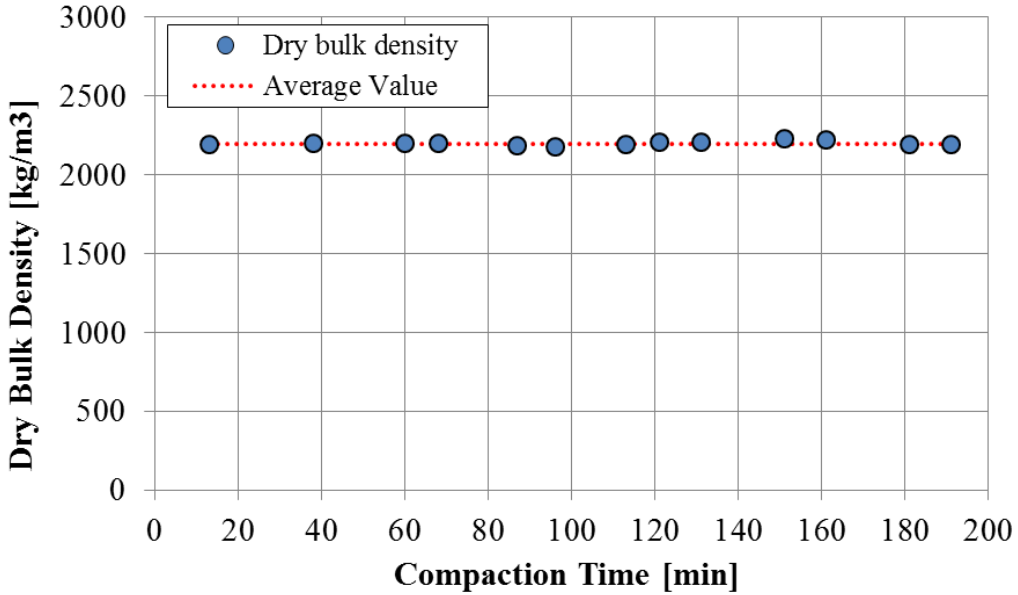
1. test on specimens compacted through a GC;
2. tests on cores taken from the trial sections (30 and 90 days);
3. tests in field.

LAB. SPECIMENS	CORES	PAVEMENTS
DRY BULK DENSITY ITS ITSM 72 hours at 40 °C 72 hours at 40 °C and 10 days at 20 °C	DRY BULK DENSITY ITS ITSM 30 and 90 days	LWD 1, 3 hours; 1, 7, 14, 21, 30 days FWD 30 and 90 days



Analysis of results

Index



The average dry bulk density was 2200 kg/m^3 and the coefficient of variance was less than 1 %.

NOTE: after 3 hours from the mixing the selected over-stabilized bituminous emulsion acted as lubricant ensuring a long period for transportation, laying and compaction phases.

Analysis of results

Index

For ITSM and ITS values a statistically analysis was performed to evaluate the data distribution.

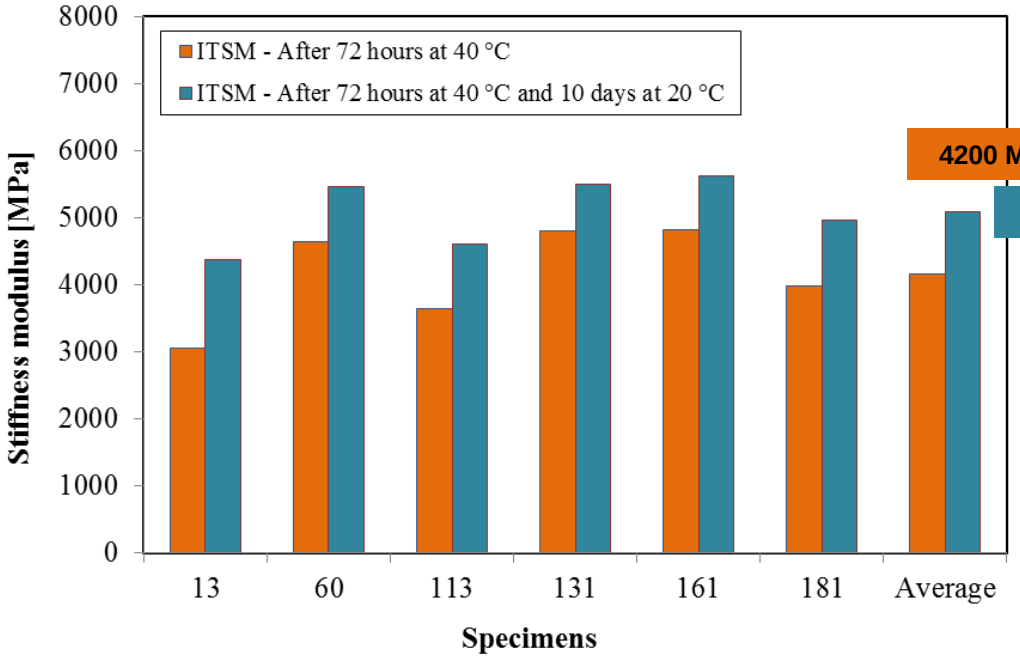
Parameter	ITSM (72h@40°C)	ITSM (72h@40°C+10d@20°C)	ITS (72h@40°C)	ITS (72h@40°C+10d@20°C)
Sample size	6	6	5	5
Average value	4156.5	5088.2	0.45	0.69
Standard Deviation	538.13	428.57	0.0665	0.0843
T-student value	2.5579		4.9583	
dof	10		8	
p-level	0.0285		0.0011	
Standard Deviation of performance increase	217.80		0.03	

The t-student test defined the results as statistically representative

Analysis of results: lab. specimens

Index

1.Introduction and objectives
2.Constituent material and mixture selection:
-Granular materials
-Bituminous emulsion
-Cement.
3.Experimental programme
4.Result
-Volumetric properties
-Performance properties
5. Conclusions and recommendation

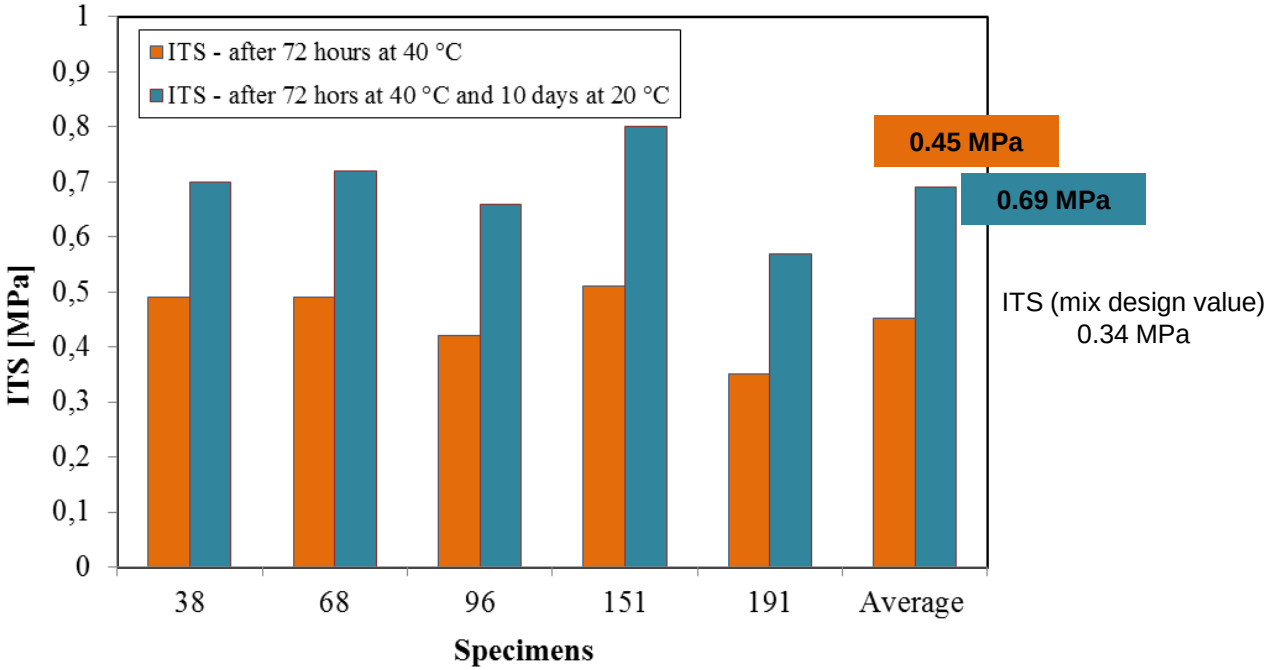


ITSM (mix design value) 3012 MPa

ITSM increased on average by about 20% if the curing period is extended.

Analysis of results: lab. specimens

Index



ITS increased on average by about 50% if the curing period is extended.

Analysis of results: cores

Index

Cores	ITSM@20°C [MPa]	ITS@25°C [MPa]
15 cm thick layer	4561	0.39
20 cm thick layer	3386	0.32

29

Cores	ITSM@20°C [MPa]	ITS@25°C [MPa]
15 cm thick layer	5234	0.43
20 cm thick layer	4190	0.35

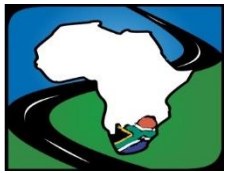
90

Mix Design values

	ITSM@20°C [MPa]	ITS@25°C [MPa]
Mix Design	3012	0.34

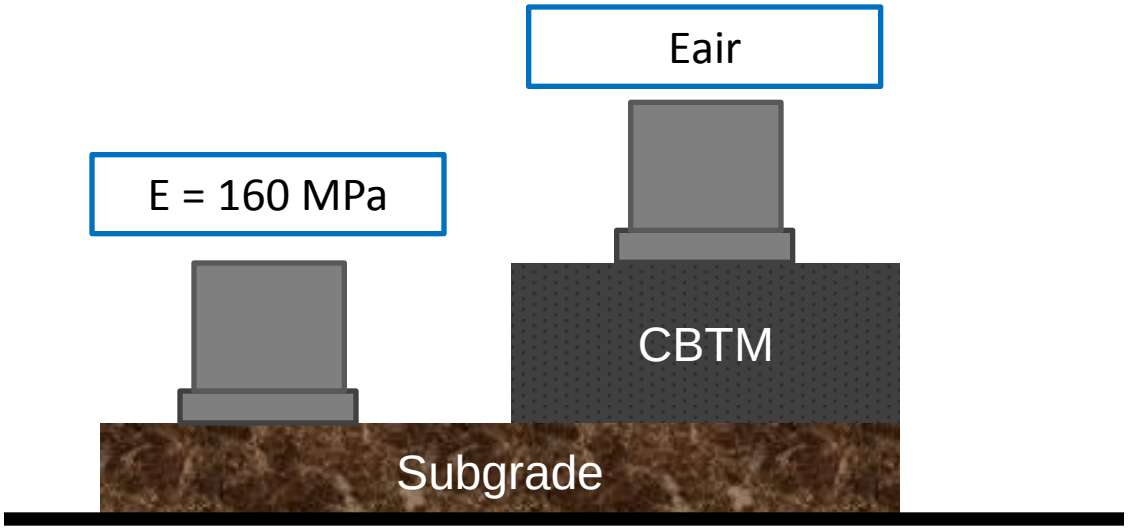
ITSM and ITS increase at 90 days of about 15% and 10 %, respectively as compared to the 29 days values.

This finding highlights that the curing process was not finished after 29 days from the construction.



Analysis of results: test in field - LWD

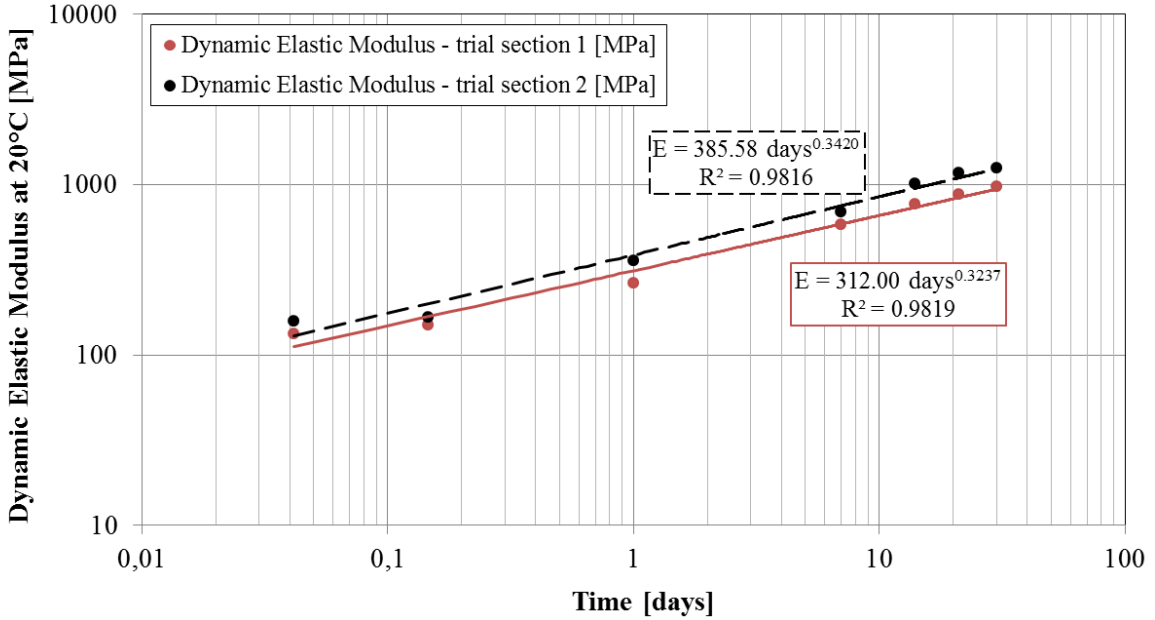
Index



$$E_{ref} = E_T \, 10^{[-0.00815 \cdot (Tref - T)]}$$

Analysis of results: test in field - LWD

Index



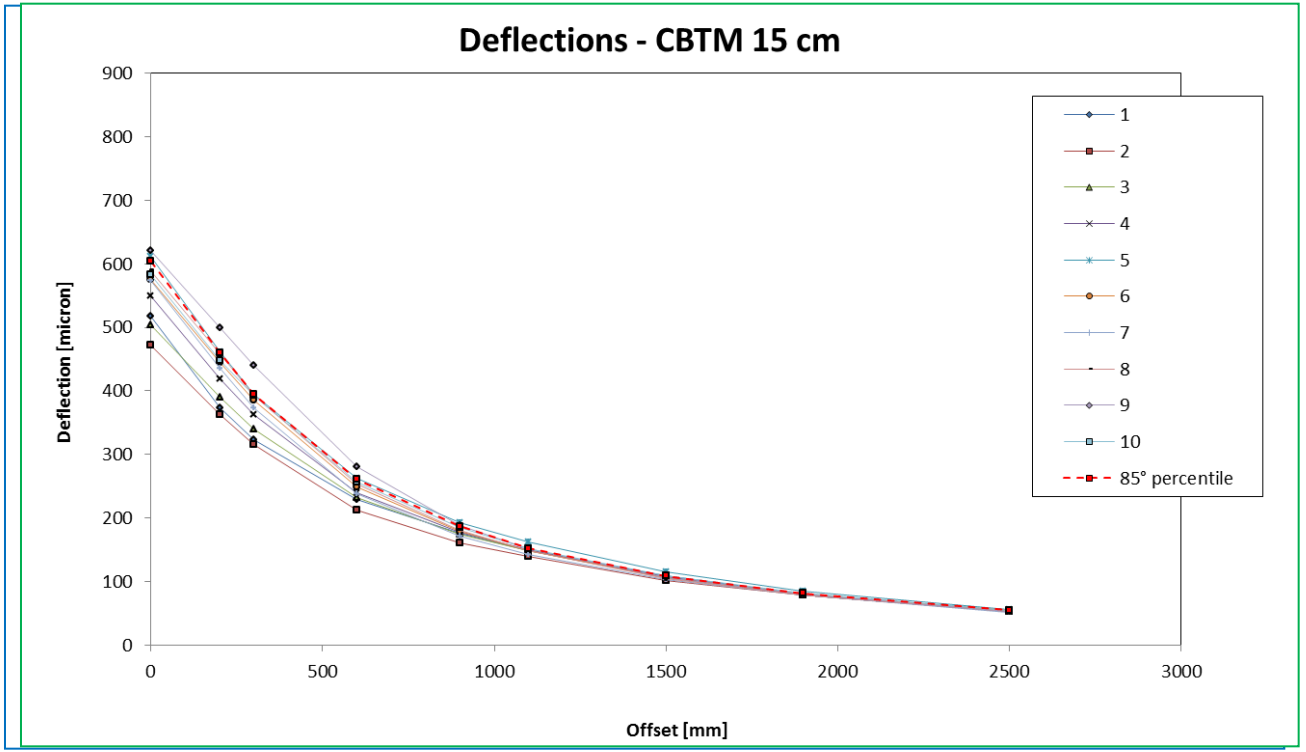
The evolution of the dynamic elastic modulus were described through a power law.

Parallel evolutions highlighted a similar curing process.

Parameters+	15 cm thick layer	20 cm thick layer
R^2	98%	98%
Test on residual (p-value) 95%	0.00975	0.010954

Analysis of results: test in field - FWD

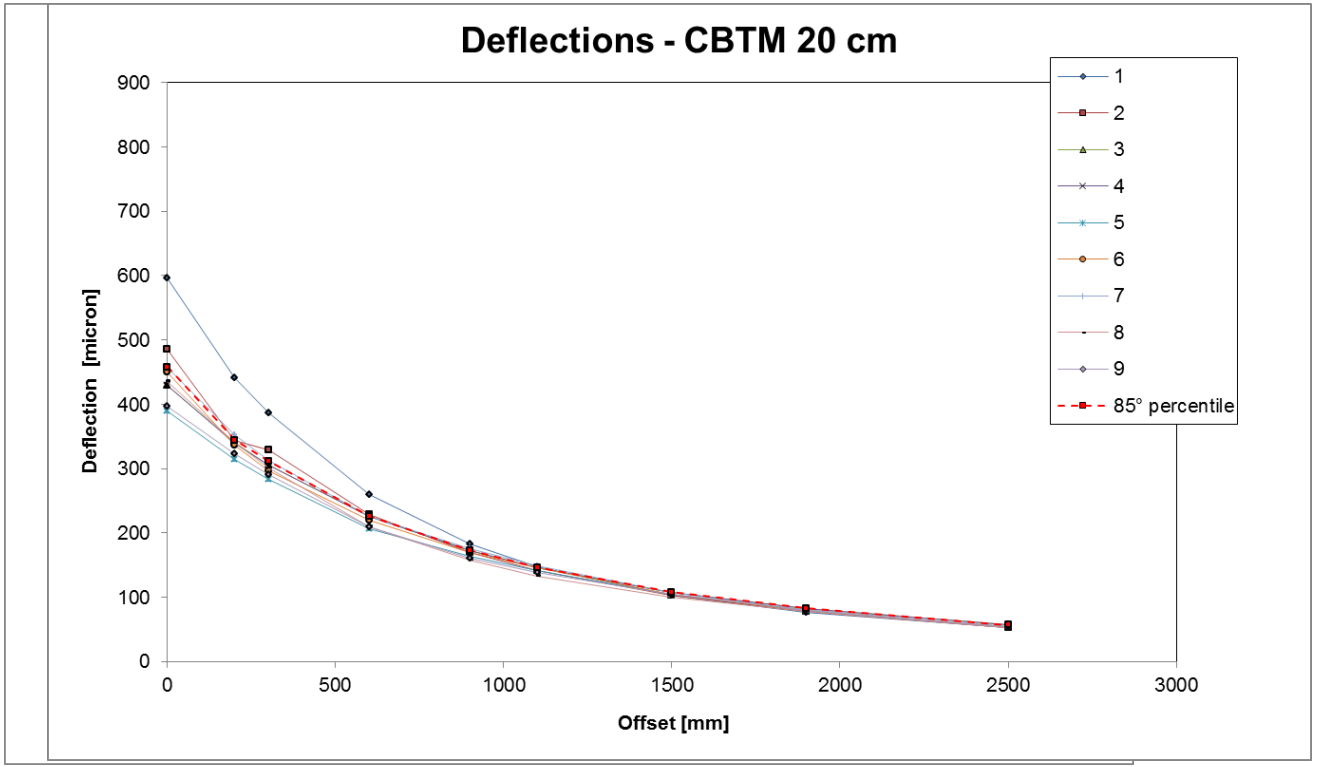
Index



29 days 90 days

Analysis of results: test in field - FWD

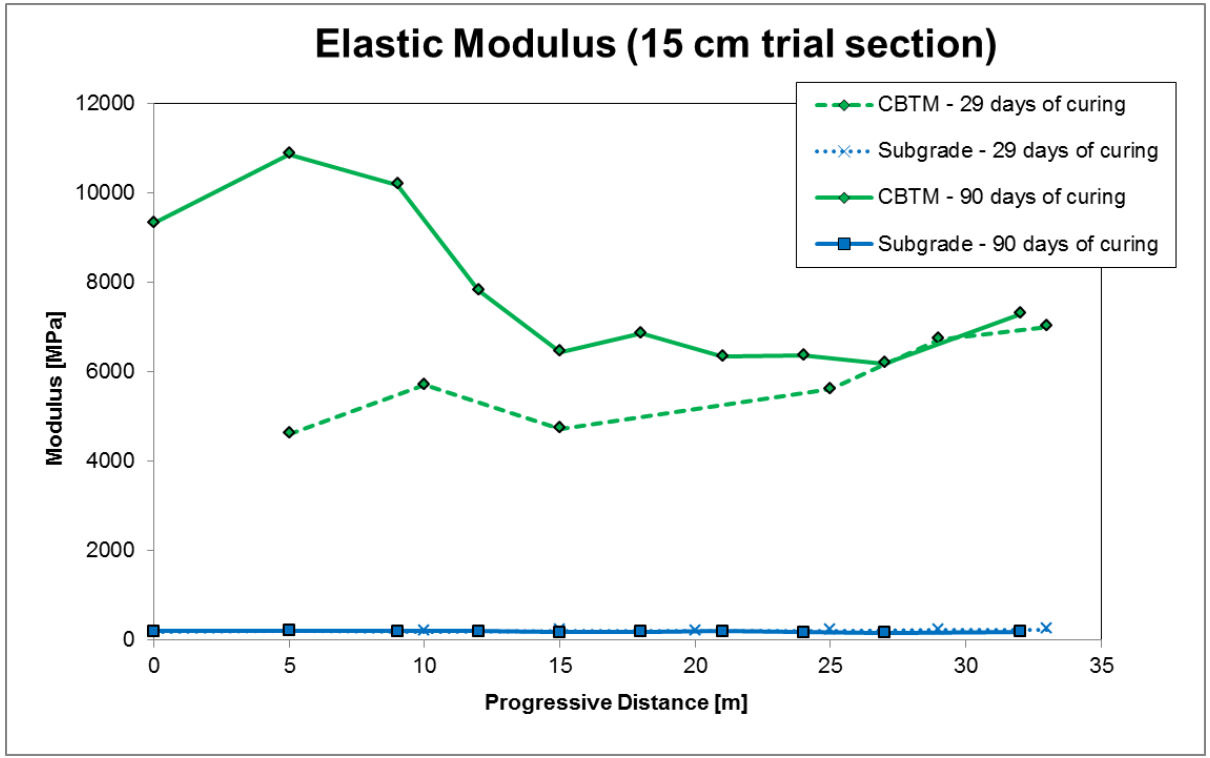
Index



29 days 90 days

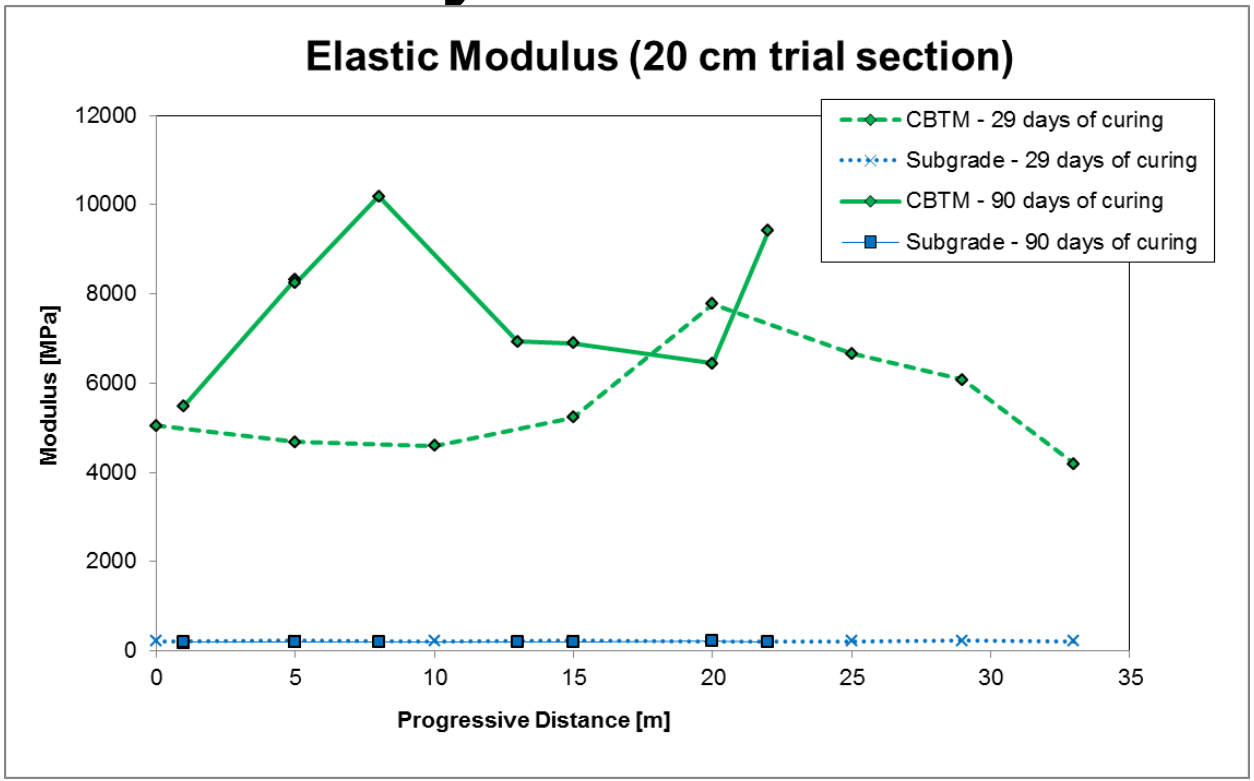
Analysis of results: test in field - FWD

Index



Analysis of results

Index



Analysis of results: LWD vs FWD

Index

Thicker base course reduces the general deformation of the pavement confirming the LWD results.

Trial section	Curing period [day]	CBTM@20°C [MPa]	Subgrade [MPa]
1	29	5246	201
	90	6587	186
2	29	4442	221
	90	6643	198

The evolution of the dynamic elastic modulus were described through a power law.
Parallel evolutions highlighted a similar curing process

In conclusion…

Index

- The commonly used accelerated curing process (72 hours at 40 °C) did not allow the definitive mixture strength and stiffness to be reached;
- Cores extracted after 90 days showed ITSM and ITS values higher of about 10 % than those measured on cores extracted after 29 days. This finding highlighted that the curing process was not completely finished after 29 days from the construction (average air temperature of about 19 °C and humidity of 73 %);
- Considering the trial section 1 (CBTM layer with thickness of 15 cm), it can be noticed that the ITSM values attained on cores extracted after 29 and 90 days were rather similar to those attained on lab-compacted specimens subjected to accelerated curing and extended accelerated curing, respectively;

In conclusion…

Index

- The evolution of the dynamic elastic modulus were properly described through a power law attaining a good regression factor;
- The elastic modulus of CBTM layer increased from 29 to 90 days of curing time;
- The results allowed the validation of the mixture containing 80 % of RA divided into two fractions (30 RA 0/16 and 16 RA 0/16) and its production/construction procedures. Even if a large RA particle size was included (nominal maximum size of 30 mm), the trial section 1, with a CBTM layer thickness of 15 cm, showed the most favourable mechanical properties.

Future developments and recommendations

Index

The mechanical evaluation illustrated is not yet complete.

I am still ongoing performance evaluations of the mixture when subjected to cyclic loading:

-Fatigue test
-Permanent deformation test (wheel tracking apparatus).


HAMM
HD 140
Thanks for
the attention