Italian perspective on cold recycling with bituminous emulsion: current use, specification and research

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Parma, 11th June 2010

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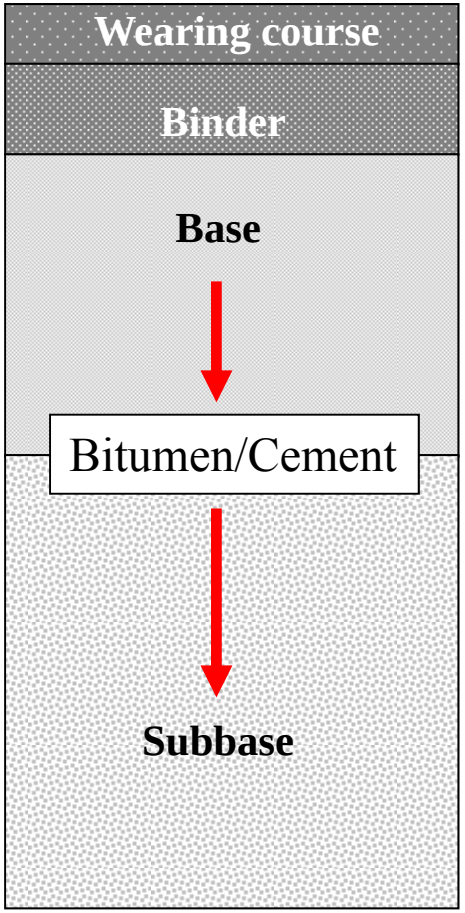
Typical compositions for cold in-place recycling in Italy

Base courses

- SBS-Modified bituminous emulsion: 3.5 ÷ 4.5%
- Cement: 1 ÷ 2%
- RA: ≥ 80%
- Mineral aggregate (crushed sand): ≤ 20%

Subbase/Foundation courses

- Bituminous emulsion: 3 ÷ 3.5%
- Cement and/or lime: 1.5 ÷ 2.5%
- RA and/or recycled materials: ≥ 80%
- Mineral aggregate (crushed sand): ≤ 20%



Bituminous emulsion characteristics

Characteristics of the bituminous emulsion	C 60 BP (over stabilized)	C 60 P (over stabilized)
Water content (EN 1428)	40%	40%
pH value (EN 12850)	3	3
Settling tendency @ 7 days	8%	8%
Breaking value (EN 13075-1)	180 g	180 g
Mixing stability with cement (EN 12848)	< 2	< 2
Application temperature	5÷80°C	5÷80°C

Characteristics of the extracted bitumen	C 60 BP (over stabilized)	C 60 P (over stabilized)
Polymer	SBS (medium)	non-modified
Penetration (EN 1426)	60 dmm	70 dmm
Softening point (EN 1427)	62°C	50°C
Fraass breaking point (EN 12593)	-16°C	-10°C
Elastic recovery @ 25°C (EN 13398)	>50%	-

A case in study: A14 Motorway

Bologna – Rimini Nord: 120 km
Six-lane dual carriageway facility

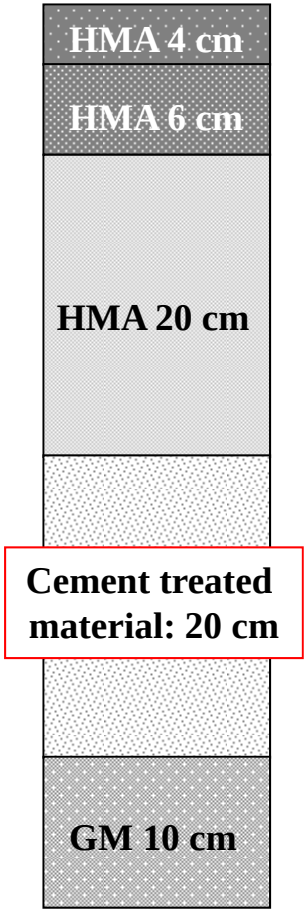
Rimini Nord – Porto S. Elpidio: 155 km
Ancona Sud – Porto S. Elpidio: 40 km
Upgrading to
six-lane dual carriageway facility

Porto S. Elpidio – Taranto: 460 km
Four-lane dual carriageway facility

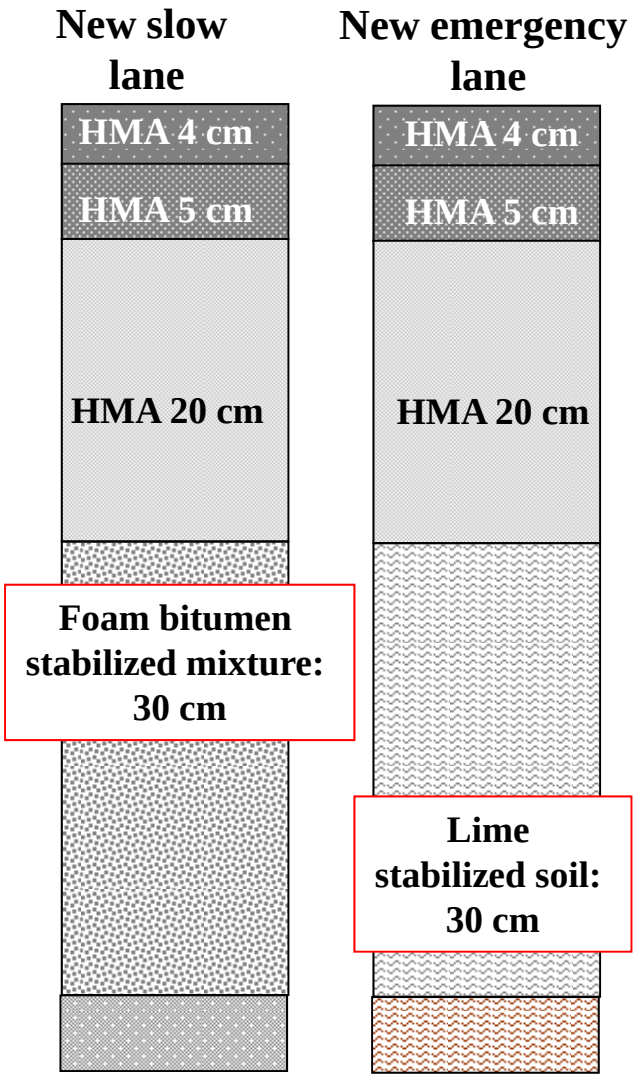
A14 Motorway, Road structure

Old structure

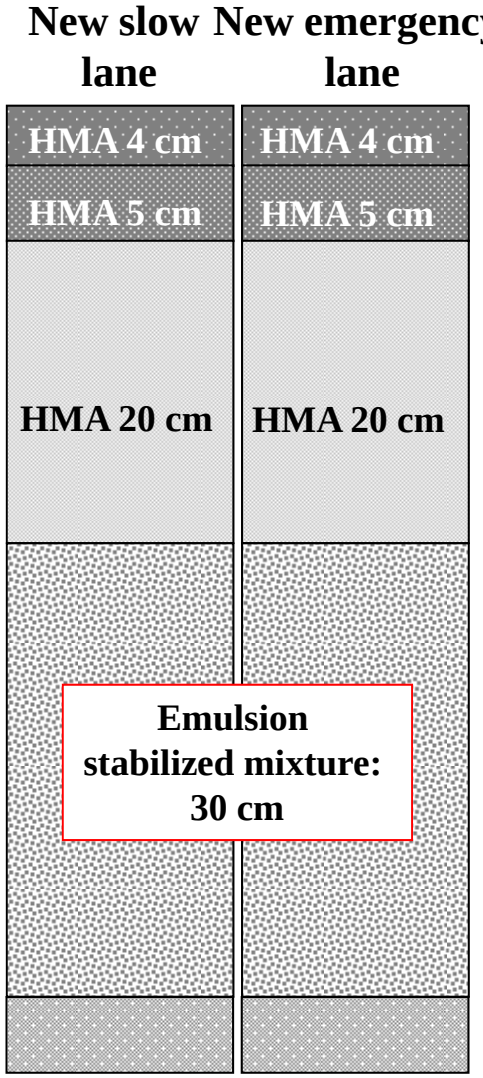
Old emergency lane



1st proposal



2nd proposal



A14 Motorway, Environmental issues

Environmental items	1st proposal	2nd proposal	HMA subbase
Recycled materials [m^3]	80,000	150,000	0
Recycled RA [m^3]	15,000	75,000	0
Soil supply [m^3]	70,000	0	0
Mineral aggregate supply [m^3]	0	0	90,000
Bitumen supply [t]	0	0	11,000
Lorry trips	20,500	2,900	44,700
Gas emission, lorry trips [t]	285	80	1,700
Fuel consumption, in-plant [t]	Negligible	Negligible	1,750
Gas emission, asphalt plants [t]	Negligible	Negligible	60

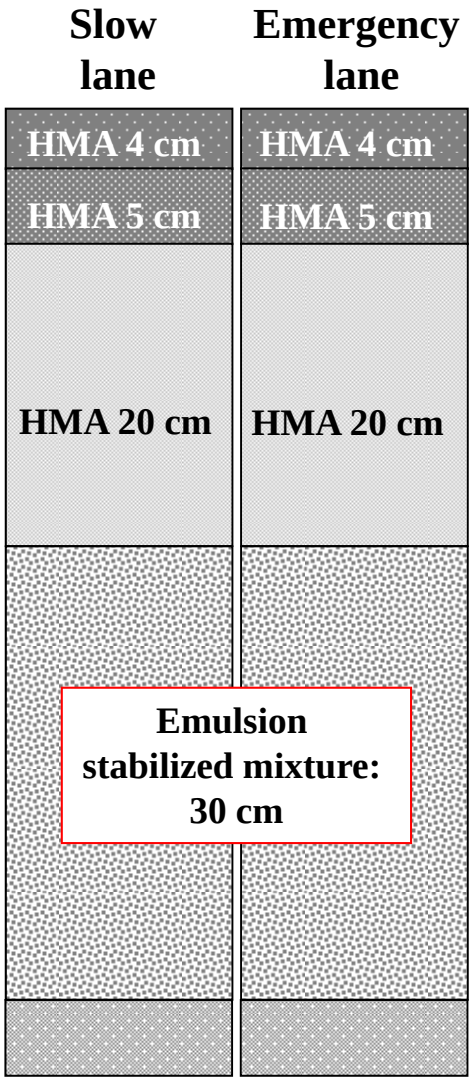
Bocci, Canestrari, Grilli, Pasquini, Lioi
"Recycling Techniques and Environmental Issues relating to the Widening of an High Traffic Volume Italian Motorway "
International Journal of Pavement Research and Technology, vol. 4, 2010

A14 Motorway, 1st proposal *vs* 2nd proposal

- Laboratory and in-situ investigations showed that the mixture treated with 2% of cement and 3% of bituminous emulsion guarantees a proper compromise between **stiffness and fatigue performance**
- The emulsion treatment technique **does not require the heating of bitumen**
- For foamed bitumen technique if the bitumen tank cools to under 160°C, it needs to be heated again at the mix-plant

Lane	Binder dosage		HWD - Elastic modulus [MPa], 21-day curing period		
	Cement [%]	Emulsion [%]	Subbbase	Foundation	Subgrade
Slow lane	2.5	3	1866	455	209
	2.5	2.5	2607	537	207
Emergency lane	**2**	**3**	**1287**	529	265
	2	2.5	762	278	178

Adopted proposal
(2nd proposal)



Santagata, Bocci, Grilli, Cardone
"Rehabilitation of an Italian Highway by Cold In-Place Recycling Techniques"
7th International RILEM Symposium, Rhodes, Greece, 2009

A14 Motorway, Specifications

Test in laboratory

- Curing method: 72 hours @ 40°C
- ITSM @ 20°C $\geq$ 3,000 MPa
- ITS @ 25°C $\geq$ 0.35 MPa

Test in-situ

- $\gamma_{in\text{-}situ} \geq \gamma_{lab}$ (80 gyrations)
- LFWD @ 25°C (after compaction) $\geq$ 70 MPa
- FWD @ 20°C (after 90 days) $\geq$ 3,000 MPa

Considerations about CBTMs

- design and construction of Cement-Bitumen Treated Mixtures (CBTMs) courses is mainly based on past experience and **often do not consider all the relevant factors** that influence their mechanical behaviour

- during the curing phase, **temperature influences the cement hydration rate, the loss of moisture in the mixture and consequently the stiffness development over time**

- during service life, **temperature influences the stiffness** of CBTMs

- knowledge of the curing and temperature sensitivity is important for design and construction control

Experimental program

Temperature influence on curing

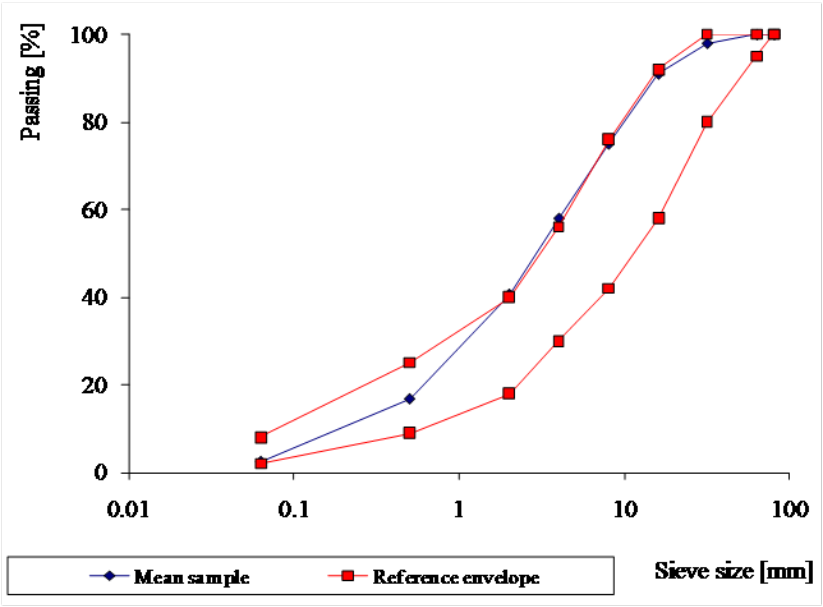
1. 28 days at 40°C (summer temperature)
2. 63 days at 20°C (spring and autumn temperature)
3. 56 days 5°C (winter temperature) and further 14-day-cure period at 40°C.

The same specimens for each series were tested weekly for ITSM evaluation at 20°C after a conditioning of 4 hours

Temperature influence on stiffness

4. at the end of the curing phase ITSM tests and UPT were carried out at four different temperatures: 5, 20, 40, 50°C

Materials

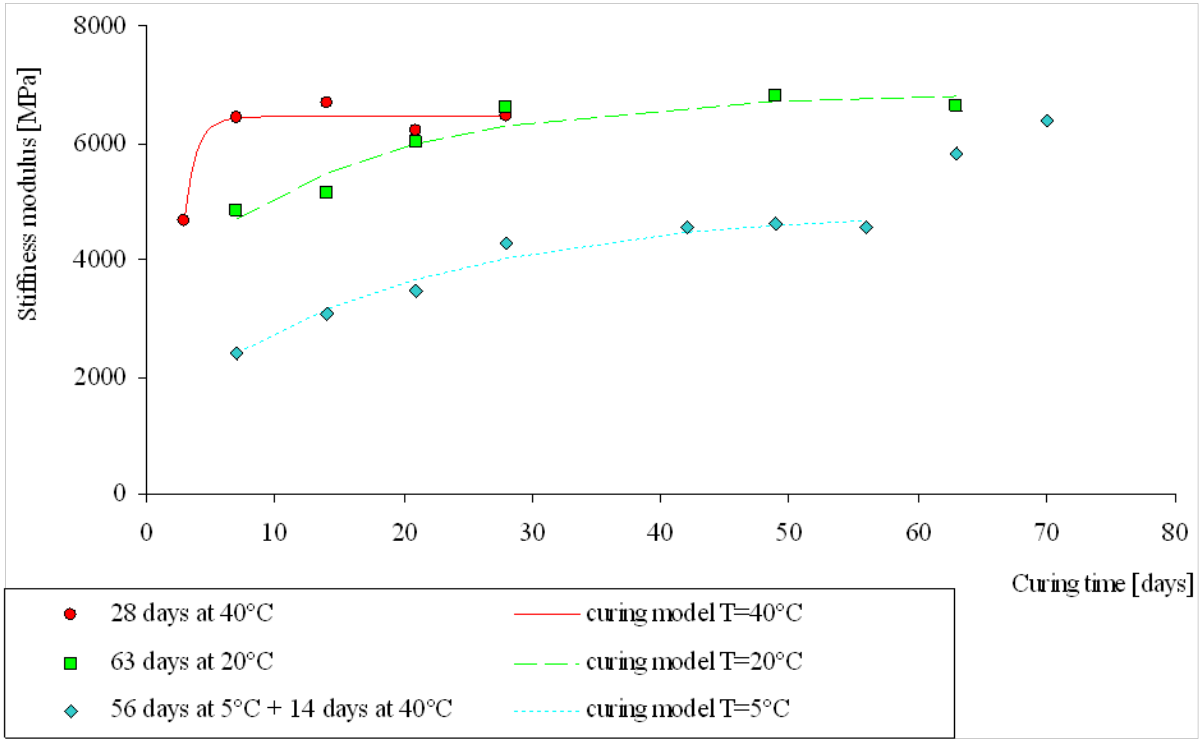


Characteristics of the bituminous emulsion	C 60 P (over stabilized)
Water content (EN 1428)	40%
pH value (EN 12850)	3
Settling tendency @ 7 days	8%
Breaking value (EN 13075-1)	180 g
Mixing stability with cement (EN 12848)	< 2
Application temperature	5÷80°C

- batches were taken behind the recycler before adding binders
- 50% RA, 50% cement treated and unbound materials
- 2% of cement, 3% of bituminous emulsion

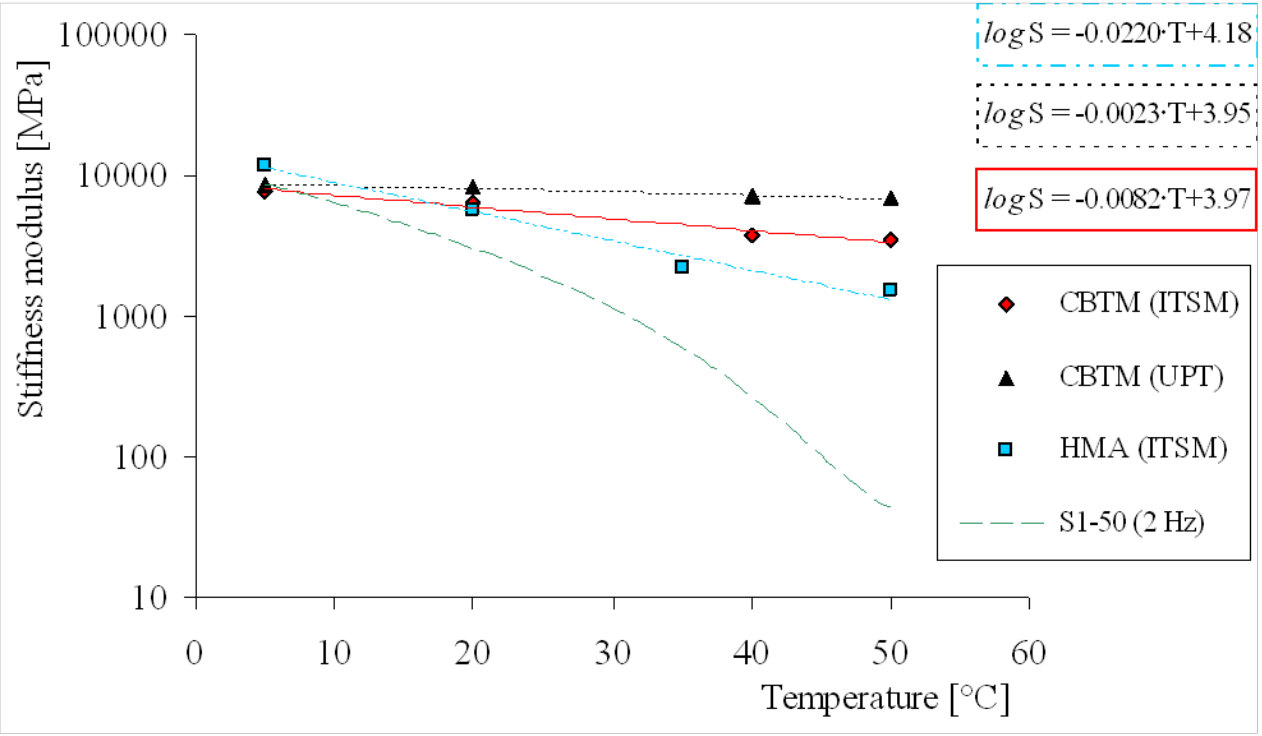
Characteristics of the extracted bitumen	C 60 P (over stabilized)
Polymer	non-modified
Penetration (EN 1426)	70 dmm
Softening point (EN 1427)	50°C
Fraass breaking point (EN 12593)	-10°C
Elastic recovery @ 25°C (EN 13398)	-

Temperature influence on curing



1. ITSM increases with the increase in curing time and reaches a maximum value of about 6,500 MPa for series 1 and 2, and about 4,500 MPa for series 3
2. higher curing temperatures resulted in higher rates of ITSM increase and higher maximum values
3. ITSM increase started again rising the curing temperature from 5 to 40°C
4. ITSM reached a value similar to that obtained for series 1 and 2

Temperature influence on stiffness



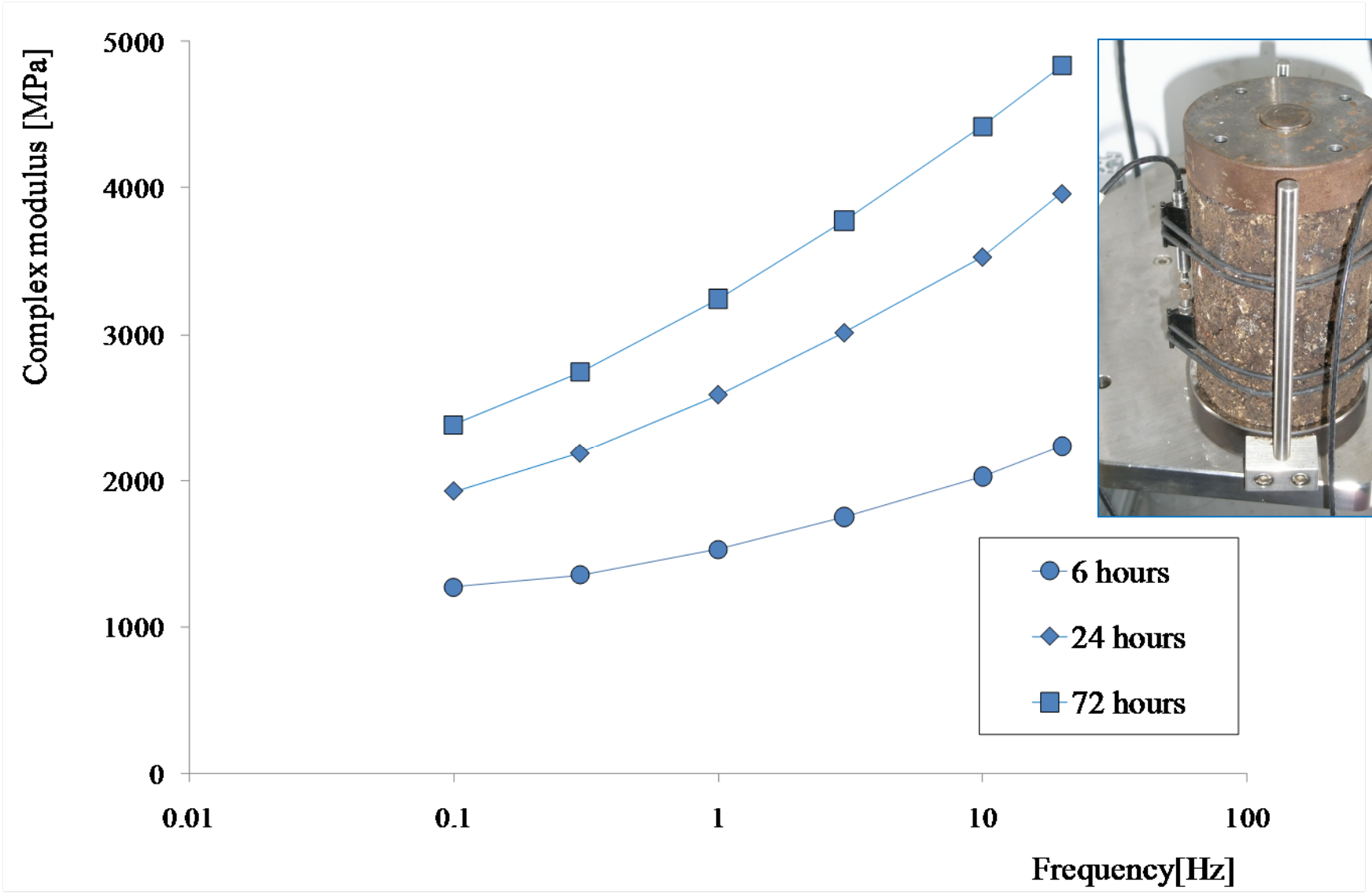
$$\log S = -\alpha \cdot T + b$$

- S is the stiffness modulus at temperature T
- a and b are experimental parameters

1. Results confirmed the thermo-dependence of CBTM, showing a decrease in modulus with the increase in temperature
2. the apparent lower temperature sensitivity evaluated by the ultrasonic pulses can be related to their higher loading frequency (39 kHz)
3. CBTM showed a considerable lower thermal-sensitivity than HMA

Bocci, Grilli, Cardone, Graziani
"A study on the mechanical behaviour of cement-bitumen stabilised materials"
Submitted to the International Journal of Construction and Building Materials, 2010

Further studies



Conclusions <1>

- use of **bituminous emulsion as an alternative to foamed bitumen** allowed good performance
- the construction technique for the A14 allowed the obtaining of **relevant environmental benefits** in terms of saved natural resources and the avoiding of pollutant emissions and energy consumption
- design and construction of CBTM courses should consider all the relevant **factors that influence their mechanical behaviour**

Conclusions <2>

- **temperature has a critical influence on the stiffness development** of CBTMs in the curing phase
- **higher temperatures resulted in higher rates of modulus increase** and higher maximum values
- **at low temperatures the curing process is slower, but the potential performance of the mixture is not penalized**
- CBTM shows **thermo-dependent behaviour**
- UPT can be considered an useful tool for a rapid evaluation of CBTMs

Thank you for your attention

…and welcome to Italy!!!

The cathedral, Parma

The ducal park, Parma

The gastronomy

Mezzavalle, Ancona