



1st International Workshop on Asphalt Recycling Technologies
9-10 September, 2024 – RWTH Aachen, Germany

The Italian Experience on Cold Recycling: from Research to Construction Specifications for Motorways

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- Introduction
- Background
- New Specifications





Highway Pavement Evolutive Research

Guidance and Coordination Unit:



Academic Research Unit:



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Operational Support Units:



Autostrade per l'Italia (ASPI) Motorway Network



- ASPI manages about 3000 km of Italian toll motorways
- High heavy-traffic volumes
 - A1 (3-4 lanes), ≈ 16.5 Mil 100 kN ESALs/year
 - A14 (3 lanes), ≈ 9.0 Mil 100 kN ESALs/year
- Constant maintenance and rehabilitation
- Excess of huge amount of RA
- Application of cold (and hot/warm) recycling



4 cm, Open-Graded Friction Course (OGFC)
except in mountain areas

10 cm, asphalt concrete (AC) binder course

15 cm, AC **base** course

all asphalt mixtures are produced with PMB

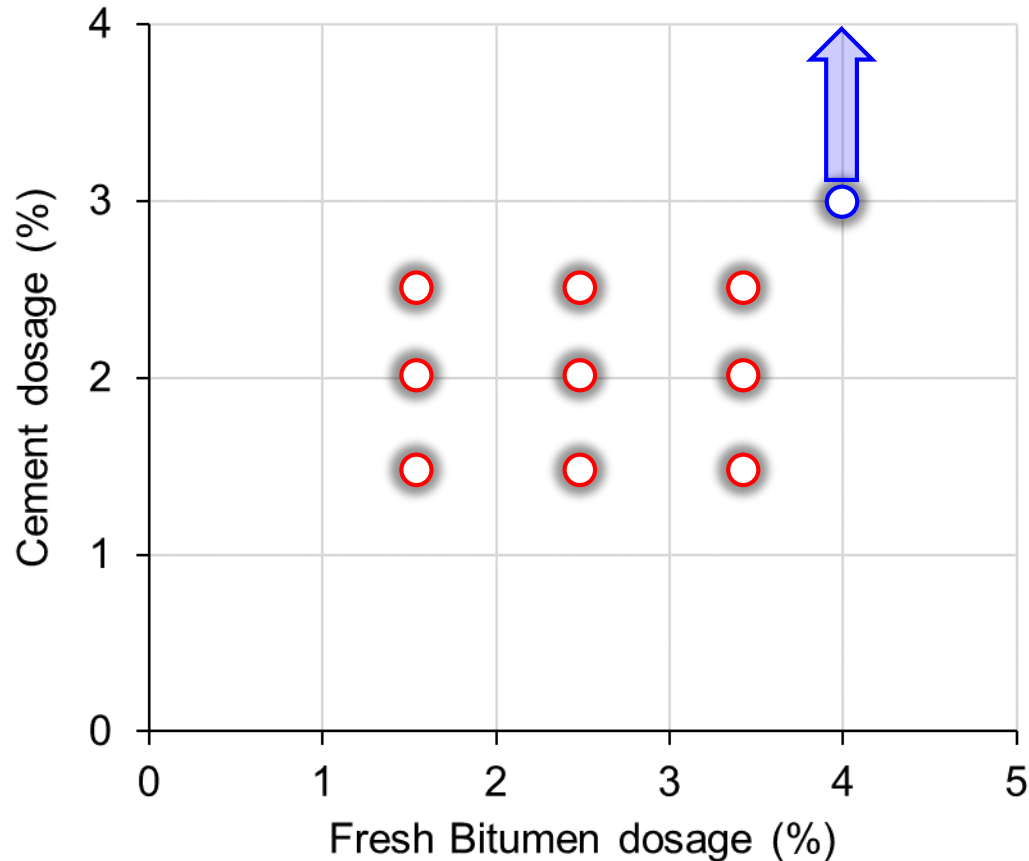
25 cm, cement-treated material (CTM) **subbase** course

Granular **foundation** course
(variable thickness above the subgrade)

Cold recycling techniques are applied in **base, subbase and foundation**

- **1.050 km, cold-recycled subbase (foam), total volume 483.000 m³**
Thickness → from 20 to 25 (35) cm
Aggregate → D = 31.5 mm, RA and virgin
Foamed bitumen → 70/100 pen
Portland Cement → CEM I, III, IV; 32.5
- **912 km, cold-recycled base (emulsion), total volume 401.000 m³**
Thickness → from 10 to 20 cm,
Aggregate → D = 20 mm, RA and virgin
Modified Emulsion → C60BP5/C60BP10, elastic recovery of residual binder ≥ 50%
Portland Cement → CEM I, III, IV; 32.5

Specifications for maintenance works (until 2023)



In-place cold-recycled subbase (foam)

- Dosages of bitumen and cement are fixed
- cement dosage can be increased "to compensate for high aggregate moisture"
- "optimal" water content of "about 6%"
- $ITS@25\text{ °C} \geq 0.30\text{ MPa}$ (3d@40 °C),
- $ITSM@20\text{ °C} \geq 3000\text{ MPa}$ (3d@ 20 °C)

Cold-recycled base (emulsion)

- In-plant or In-place production
- $C = 1.5, 2.0, 2.5\%$, dosages of bitumen and water can be adjusted
- $ITS@25\text{ °C} \geq 0.30\text{ MPa}$ (3d@40 °C),
- $ITSM@20\text{ °C} \geq 1500\text{ MPa}$ (3d@ 20 °C)

Cold Recycling Example 1 (2007-2008)



A14 motorway

40 + 40 km between Ancona and Civitanova Marche

30 cm cold recycled subbase (replacing the 20 cm CTM)

In-place technique (photos), 50% RA + 50% rec. agg.

3.0% Emulsion, 2.0% Cem II





A1 Motorway

16 km between Fiano Romano and Settebagni

30 cm cold recycled base (replacing the 20 cm AC)

In-plant technique (photos), 85% RA, 15% virgin sand
4.0% Modified Emulsion, 2.0% Cem II



Areas of Improvement:

- Classification and selection of aggregates (RA, reclaimed aggregate)
- Mixture design
 - Dosage of water
 - Dosage of Portland cement (and mixture stiffness)
- Description of field trial (in-place construction)
- Quality assurance procedures

Cold recycling techniques are implemented within the following 6 items:

Depending on structural design

3.2 Cement-treated foundation or subbase course (*in-plant* production)

3.3 Cold *in-place* recycled foundation or subbase course with cement

RA < 50%

3.4 Cold *in-place* recycled foundation or subbase course with bitumen and cement

3.5 Cold *in-plant* recycled foundation or subbase course with bitumen and cement

Emulsion
or Foam

3.6 Cold *in-plant* recycled subbase or base course with modified bitumen emulsion and cement

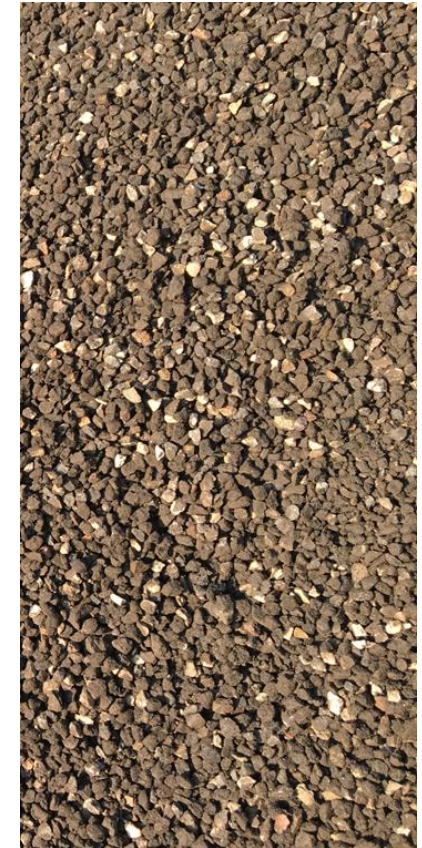
3.7 Cold *in-place* improvement of unbound foundation courses using foamed bitumen and cement

Items 3.4, 3.5 and 3.6:

1. General description of the works
2. Material properties (aggregates and binders)
3. Mix design procedure (either in-plant or in-place)
4. Construction (laydown and compaction)
5. Acceptance testing (on the as-built course)

Reclaimed Asphalt (RA)

- Must be classified according to EN 13242 “Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction” ⇒ **RA is considered as a “black rock”**
 - This is also a *mandatory requirement of the Italian law* that regulates recycling in construction works
 - The Italian law also prescribes the name “*granulato di conglomerato bituminoso*” that can be translated as “RA granulate” or “RA aggregate”
- All items require that the RA aggregate **must not be heated above 50 °C** when tested (e.g. to measure its water content)



In-plant production ⇒ **laboratory**

In-place production ⇒ **field trial + laboratory**

1. selection of **aggregate blend**

grading limits are specified "by volume"

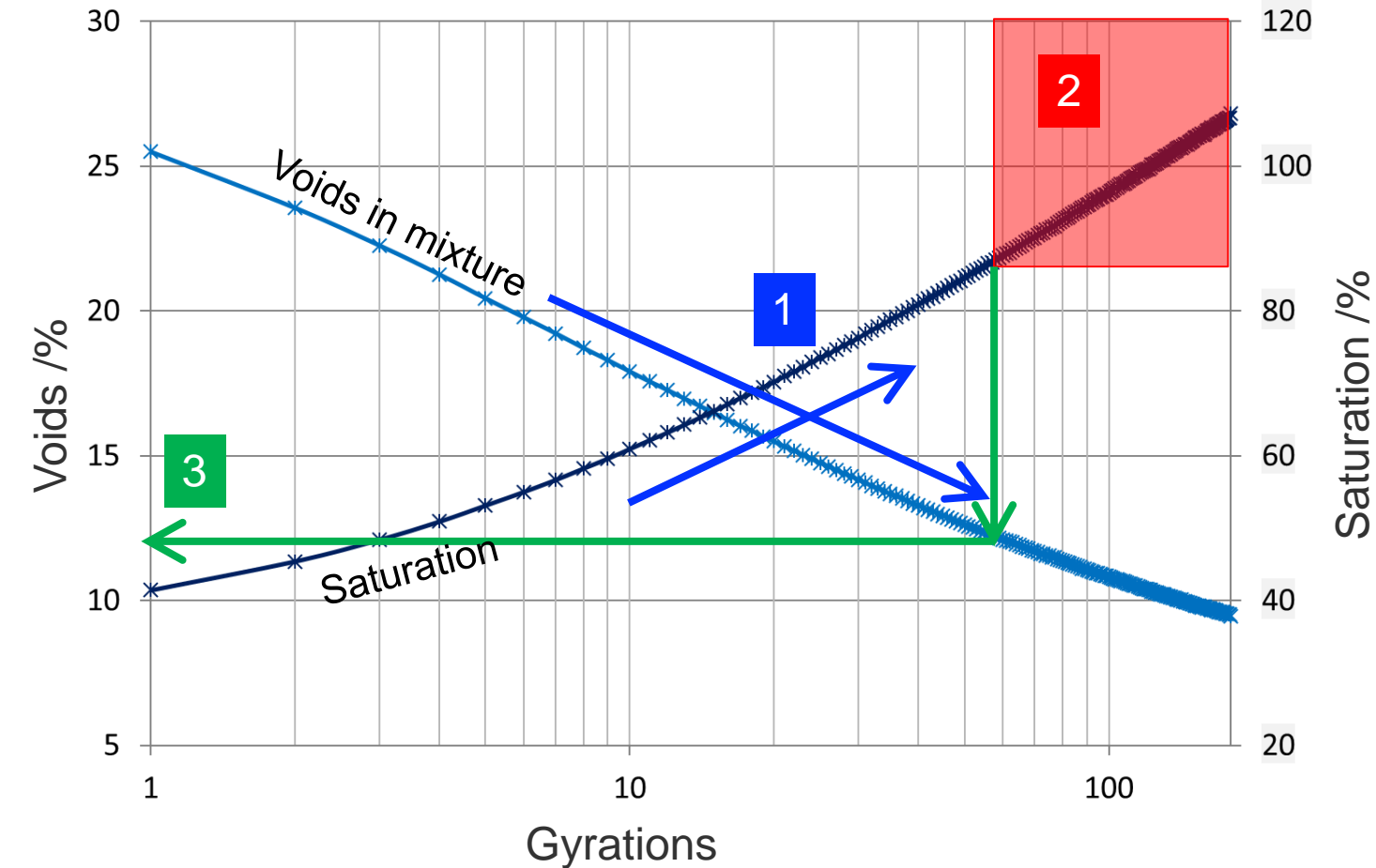
2. selection of the **design water dosage**

the maximum value that allows compacting with 100 gyrations and obtaining, at the end of compaction, a mass loss of less than 0.5% (practical saturation)

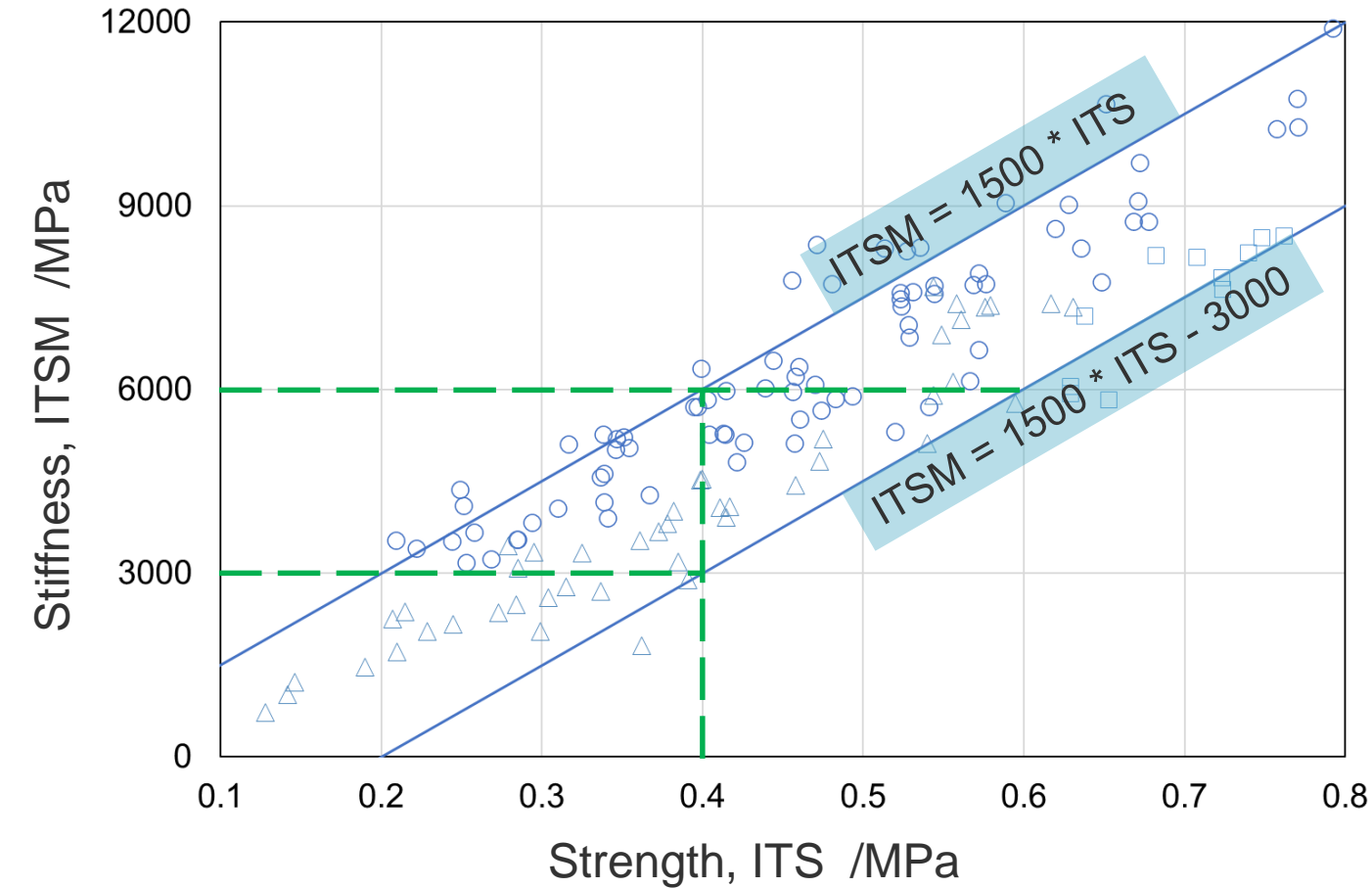
3. selection of the **design bitumen and cement dosage**

	Dosage (*) of binders			Mechanical requirements (**)	
	Cement /%	Bitumen /%	B/C	ITS /MPa	E /MPa
foundation or subbase	1.5 - 2.5	1.5 - 3.0	≥ 1	0.40	3000 - 6000
subbase or base	1.5 - 2.5	1.5 - 3.0	≥ 1	0.45	3000 - 6000

(*) with respect to dry aggregate mass; (**) measured at 25 °C, maximum horizontal deformation of 5 mm



1. With compaction porosity (i.e. voids) reduces and saturation increases
2. **Practical Saturation** is obtained when water flows out from the mould (may include fines, cement and bitumen)
3. We can determine the **minimum porosity** of the mixture (with given compaction effort) by limiting mass loss to 0.5%



- Experimental results including a wide range of mix compositions (within the specification ranges)
- Different curing times (1 to 90 d) and temperature (25 and 40 ° C)
- Lower limit on stiffness (3000 MPa) "duplicates" lower limit on strength
- Upper limit on stiffness (6000 MPa) prevents fragile mixes (excess cement)

- ASPI uses cold recycling techniques on its motorway network since 2001
- The recent improvement of the construction specifications involved:
 - Classification and selection of aggregates (RA, reclaimed aggregate)
 - Mixture design (dosage of water and Portland cement)
 - Detailed specifications for field trial (in-place construction)
 - Quality assurance procedures
- The new specifications are in use (included in bid documents) since ...now!



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Thank you!

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autostrade // per l'italia



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Francesco Canestrari: *The Italian Experience on Warm-Recycled Asphalt Mixes: from Research to Motorway Construction Specifications*