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INNOVATIVE SOLUTION FOR MINI-MICRO-TRENCHING SYSTEMS

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dal 1980 l'edilizia in buone mani

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OUTLINE

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- Fiber to the Home
- No Dig technologies

EXPERIMENTAL PROGRAM

- Objectives
- Material
- Testing methods
- Sample preparation

EXPERIMENTAL RESULTS

- Preliminary tests
- Micro and Macrotexture tests
- ITS tests

CONCLUSIONS

• INTRODUCTION

➢ Telecommunication networks

Nervous system of any modern nation

➢ High-speed internet

- Infrastructure
- Services

Raw materials of the future, for the entire economic and social environment

• INTRODUCTION

FTTH (Fiber To The Home)

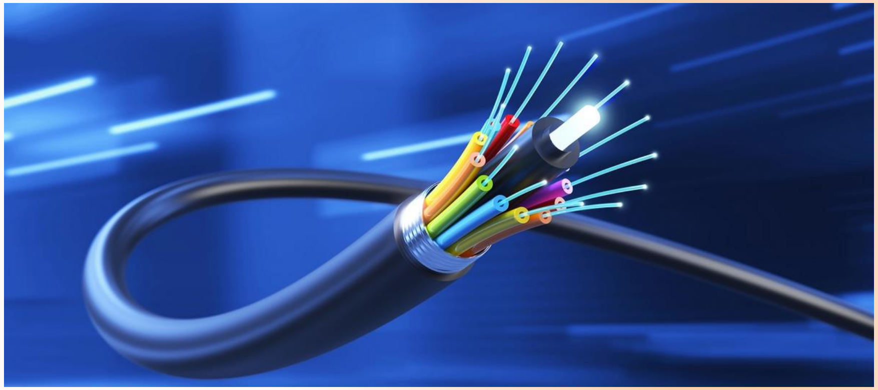
- High speed for add-on services (Video on demand, Online Gaming, HDTV)
- Future-proof solution.

Over the last decade, the technological development concerning such networks has led to optical fiber cables with greater efficiency and smaller sizes.

Miniaturization of primary elements

↕

Improved digging technologies

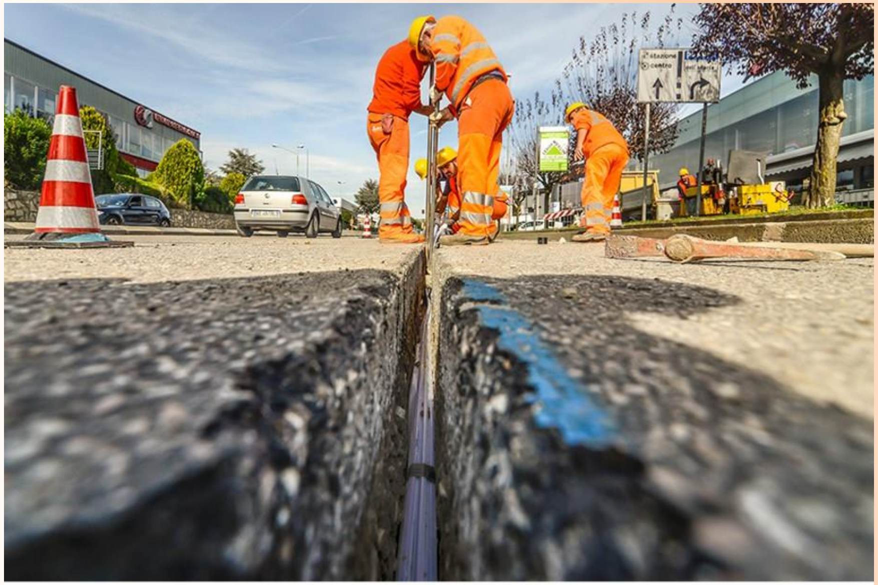


• INTRODUCTION

No-dig technologies are a set of techniques ideal for reline, repair and renew the underground utilities network minimizing the impact on road pavements.

Unlike the traditional trench, those techniques (**MINI and MICRO-TRENCHES**):

- faster execution → lower production of waste material;
- reduced excavation section → minor damage on existing pavement;
- lower recovery times and costs.



• INTRODUCTION

The quality of backfilling plays an important role in the performance of the trench.

Material used:

- Granular mixtures
- Cement grout
- Cement concrete
- Bituminous mixtures

Backfilling materials → **Not suitable**
Backfilling materials → **Not properly installed**

PREMATURE PAVEMENT FAILURE

• EXPERIMENTAL PROGRAM - Objective

OBJECTIVE → Investigation on the suitability of a new technology for mini-micro-trenching applications which based on the use of a **CEMENTITIOUS BITOMINOUS GROUT** as backfilling material.

Preliminary tests:

- Characterization of the grout (fresh and hardened).

Application on road pavements as backfilling material:

- Evaluation of **MICRO** and **MACROTEXTURE** on laboratory manufactured slabs;
- Investigation on mini and micro-trenching systems in terms of **ADHESION AT THE INTERFACE** → crucial aspect to ensure longer lasting systems.

- EXPERIMENTAL PROGRAM - Material

Cementitious-bituminous grout → **Flowmix Fast**, patented by CVR S.p.A.

Main components:

Highly reactive hydraulic binders, bituminous binder, fine aggregate, micro silicates with pozzolanic behaviour, expansive agents, specific no segregating and superplasticizers additives.

- Siliceous and carbonate aggregates with a controlled 0/4 mm gradation;
- The main hydraulic binder is an ordinary Portland cement CEM IIA LL 42.5R;
- Cationic slow setting bituminous emulsion:

Test	Value	Reference Standard
Bitumen content (%)	60	UNI EN 1428
Penetration (dmm)	<100	UNI EN 1426
Softening point (°C)	43	UNI EN 1427
Adhesiveness (%)	>80	UNI EN 13614
Density (Kg/m^3)	1000±50	-

- EXPERIMENTAL PROGRAM - Material

Cementitious-bituminous grout → **Flowmix Fast** → One-time backfillig






- EXPERIMENTAL PROGRAM – Methods

PRELIMINARY TESTS

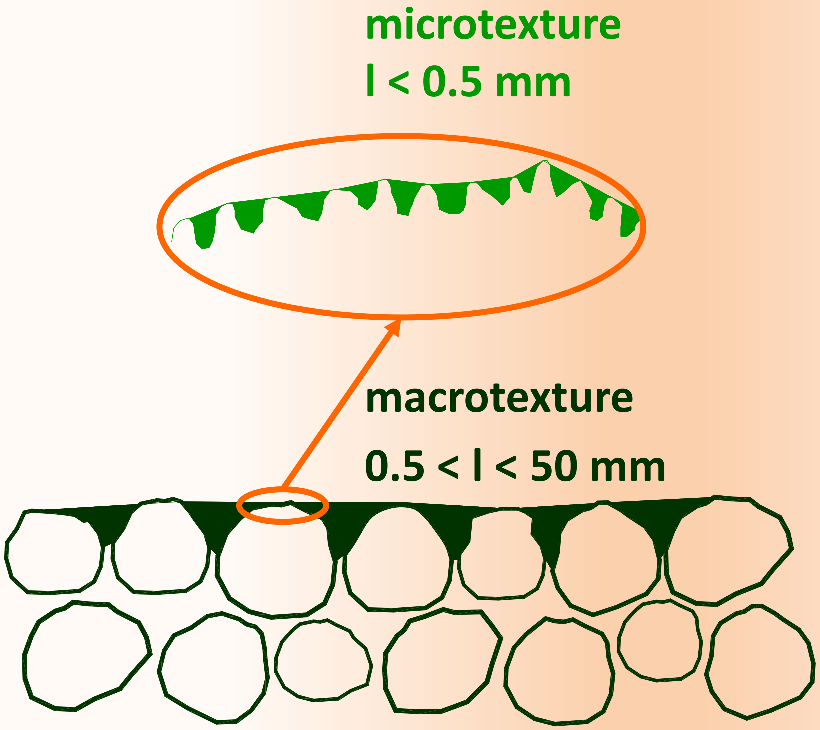
Test	Reference Standard
FRESH GROUT	
Air	UNI EN 1015-7
Spreading	UNI EN 1015-3
Setting start time	UNI EN 196-3
End of grip time	UNI EN 196-3
Fresh grout density	UNI EN 1015-6
HARDENED GROUT	
Hardened grout density	UNI EN 1015-10
Average flexural strength at 2 hours	UNI EN 1015-11
Average compressive strength at 2 hours	
Average flexural strength at 28 days	
Average compressive strength at 28 days	
Average resistance to adhesion after 28 days on concrete “f_u”	UNI EN 1015-12
Characteristic value of the initial shear strength "f_{v0k}"	Tab.11.10.VIII NTC DM 17/1/2018
Water absorption by capillarity coefficient “C_m”	UNI EN 1015-18
Modulus of elasticity in compression “E”	UNI EN 13412
Shrinkage at 28 days	UNI 8147 – B method

- EXPERIMENTAL PROGRAM – Methods

MICROTEXTURE and MACROTEXTURE

Aggregate physical properties affect road pavement surface characteristics which are in turn related to pavement functionality. Such characteristics are related to the geometrical profile of the pavement on the vertical level.

- The **micro-texture** has a wavelength up to approximately 0.5 mm;
- The **macro-texture**, from 0.5 to 50 mm;



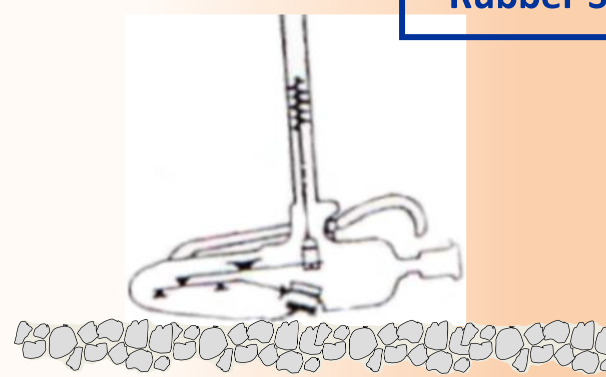
- EXPERIMENTAL PROGRAM – Methods

MICROTEXTURE → UNI EN 13036-4

An apparatus for stationary measurements of **slip/skid resistance** of a surface is the **SKID TESTER (BRITISH PENDULUM)**

The device consists of a pendulum arm that has a spring-loaded standard rubber slider to its end. On release of the pendulum from a horizontal position, the loss of energy as the slider assembly passes over the test surface is measured by the <u>reduction in length of the upswing</u> using a calibrated scale → **PTV value**

The arm is released from its horizontal position to swing over a contact path length of 126 ± 1 mm.



- EXPERIMENTAL PROGRAM – Methods

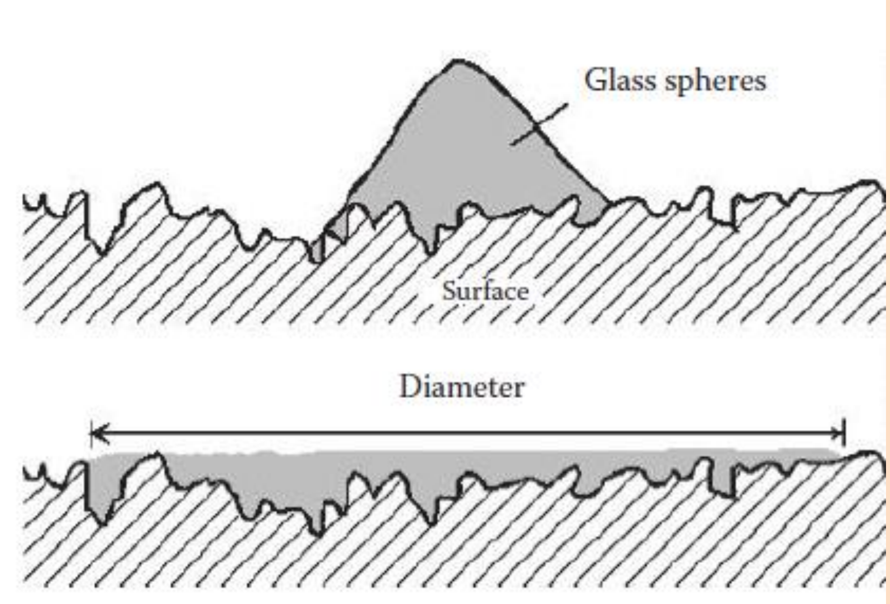
MACROTEXTURE → UNI EN 13036-1

Measurement of texture depth by volumetric technique (sand patch method).

A known volume (>25 ml) of graded glass spheres is poured on the dry and clean pavement surface. These are spread on the surface through a spreading tool, filling the surface voids. A circular patch is determined so as the spreading tool touches the surface particle tips.

The mean texture depth (mm) MTD is

→ $\boxed{\mathbf{MTD = 4 \times \mathit{V}/(\pi \times \mathit{D}^2)}}$



- *V* is the volume of spheres (mm3),
- *D* is the average diameter (at least 4 values) of the area covered by the material (mm).

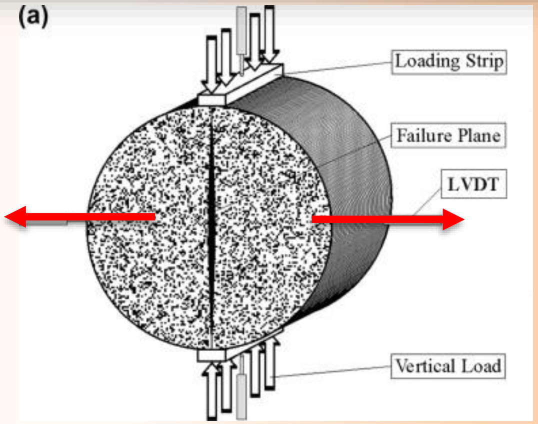
- EXPERIMENTAL PROGRAM – Methods

INDIRECT TENSILE STRENGTH (ITS) TEST
→ UNI EN 12697-23

A cylindrical specimen is brought to the specified test temperature placed in the compression testing machine between the loading strips, and loaded diametrically along the direction of the cylinder axis with a constant speed of displacement (50 mm/min) until it breaks.

Temperature = 25 °C

VERTICAL DIAMETER ≅ INTERFACE



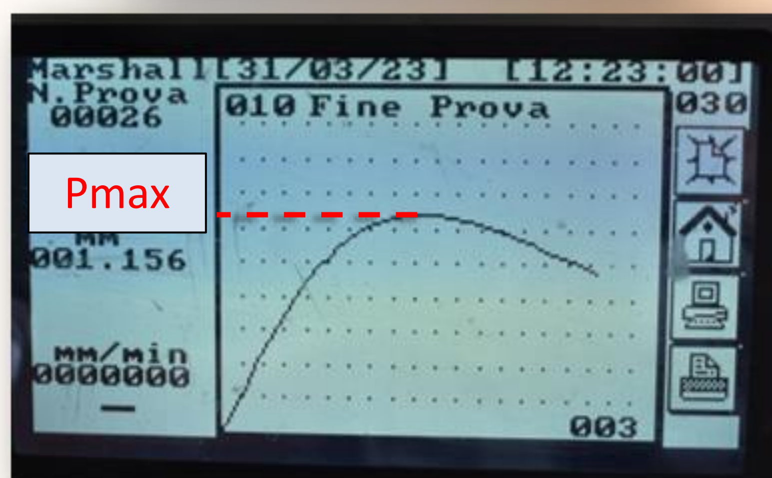
- EXPERIMENTAL PROGRAM – Methods

INDIRECT TENSILE STRENGTH (ITS) TEST
→ UNI EN 12697-23

The indirect tensile strength is the maximum tensile stress calculated based on:

- the peak load applied at break Pmax
- the dimensions of the specimen (h, D).

$$ITS = \frac{2\textcolor{red}{Pmax}}{\pi h D}$$



- EXPERIMENTAL PROGRAM – Sample preparation

MICROTEXTURE and MACROTEXTURE tests

- Slab: length x width x heigth → 36cmx36cmx1cm
- 2 replicates

- **EXPERIMENTAL PROGRAM – Sample preparation**

INDIRECT TENSILE STRENGTH test

→ *Adhesion at the interface*

3 types of samples: **CMT, MMT, CP**

Trial site – Gubbio (Pg, Italy)

- CMT → Cored from mini or microtrenches

- EXPERIMENTAL PROGRAM – Sample preparation

INDIRECT TENSILE STRENGTH test

→ *Adhesion at the interface*

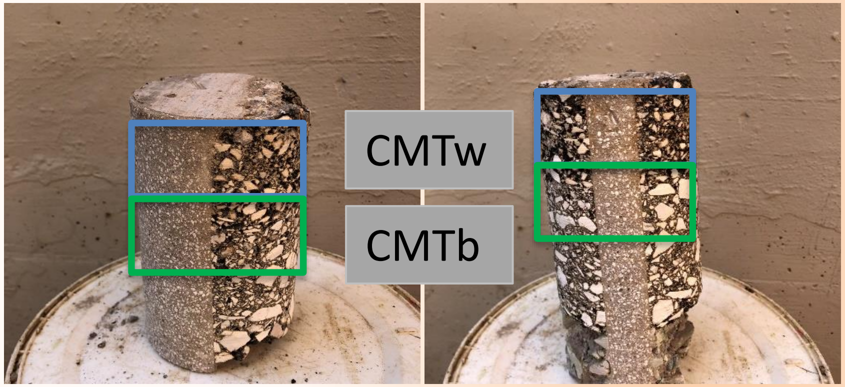
3 types of samples: **CMT, MMT, CP**

Trial site – Gubbio (Pg, Italy)

- CMT → Cored from mini or microtrenches

CMTw

CMTb



- **EXPERIMENTAL PROGRAM – Sample preparation**

INDIRECT TENSILE STRENGTH test

→ *Adhesion at the interface*

3 types of samples: **CMT, MMT, CP**

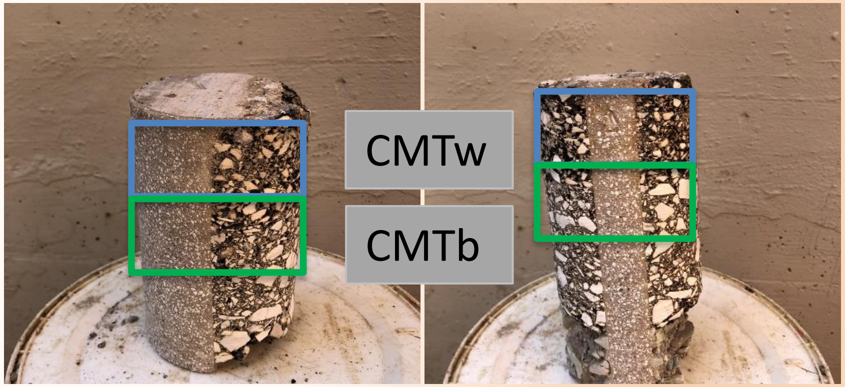
Trial site – Gubbio (Pg, Italy)

- CMT → Cored from mini or microtrenches

CMTw CMTb

- CP → Cored from the existing pavement

CPu CPb



- **EXPERIMENTAL PROGRAM – Sample preparation**

INDIRECT TENSILE STRENGTH test

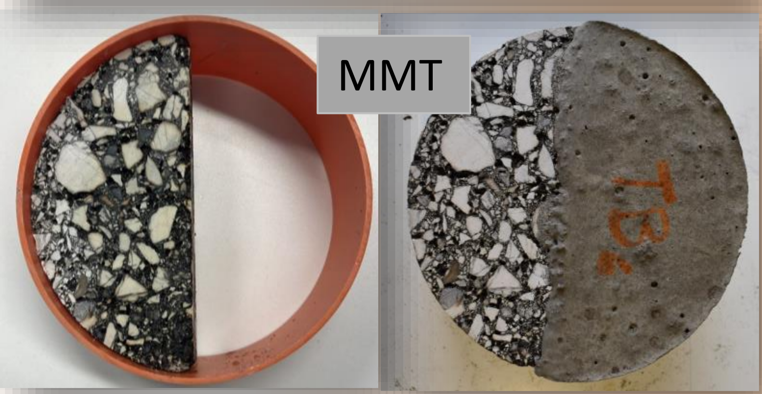
→ *Adhesion at the interface*

3 types of samples: **CMT, MMT, CP**

Trial site – Gubbio (Pg, Italy)

➢ MMT

- Coring on mini or microtrenches prior to backfilling → Half specimen
- Trimming → MMTw - MMTb
- Setting up specimen into a plastic tube over a plane surface
- Casting
- Curing (14 days)



- EXPERIMENTAL RESULTS – Preliminary tests

Test	Value
FRESH GROUT	
Air	≤10%
Spreading	165 mm
Setting start time	15 minutes
End of grip time	25 minutes
Fresh grout density	2050 kg/m^3
HARDENED GROUT	
Hardened grout density	1900 kg/m^3
Average flexural strength at 2 hours	≥ 1,0 N/mm^2
Average compressive strength at 2 hours	≥ 4,0 N/mm^2
Average flexural strength at 28 days	≥ 3,5 N/mm^2
Average compressive strength at 28 days	≥ 18,0 N/mm^2
Average resistance to adhesion after 28 days on concrete “f_u”	≥ 0,80 N/mm^2 - A
Characteristic value of the initial shear strength "f_{v0k}"	≥ 0,30 N/mm^2
Water absorption by capillarity coefficient “C_m”	≤ 0,20 $kg/(m^2\ min^{0,5})$
Modulus of elasticity in compression “E”	≥ 16 GPa
Shrinkage at 28 days	≤ 300 µm

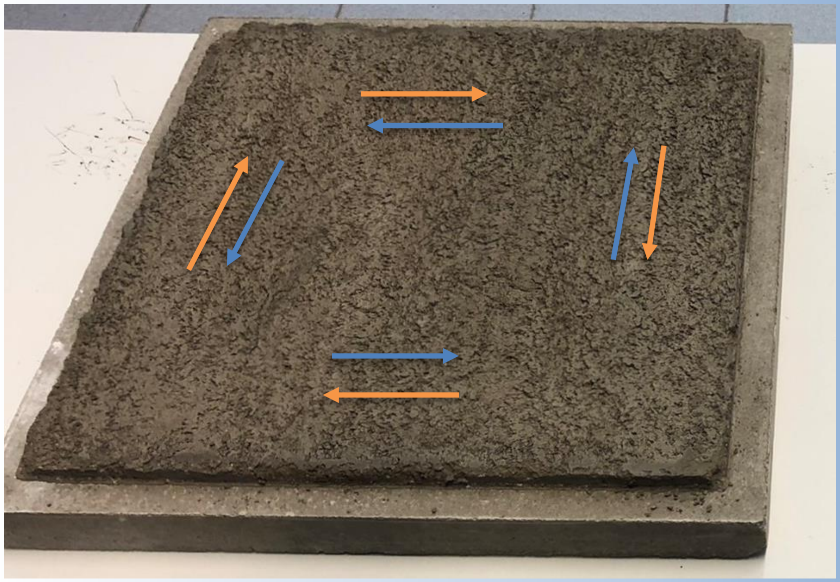
- EXPERIMENTAL RESULTS – Preliminary tests

- Fluid consistency → monolitic backfilling;
- Lack of bleeding phenomena → homogeneity;
- Walkability and trafficability in 40 minutes and 50 minutes, respectively;
- Expansive behaviour to ensure compensated shrink;
- Lack of lowering phenomena.

- **EXPERIMENTAL RESULTS** - Microtexture test

Skid resistance properties ⟷ PTV

- 2 slabs were tested
- 4 testing positions (from 1 to 4)
  - 5 cm far from each edge
  - half of its width
- 2 sliding directions
  - clockwise (A)
  - counter-clockwise (B)
- 5 measuremnts were carried out for each test position



- **EXPERIMENTAL RESULTS** - Microtexture test

SLAB "1"															
Edge	Sliding direction	Swing					PTV	Sliding direction	Swing					PTV
		1	2	3	4	5			1	2	3	4	5	
1	A	69	67	68	67	68	68	B	64	64	67	64	64	65
2	A	70	67	65	65	65	66	B	66	66	65	65	65	65
3	A	71	70	70	69	69	70	B	64	67	63	63	67	65
4	A	68	66	65	64	64	65	B	67	66	65	65	65	66
SLAB "2"														
Edge	Sliding direction	Swing					PTV	Sliding direction	Swing					PTV
		1	2	3	4	5			1	2	3	4	5	
1	A	72	71	71	70	70	71	B	73	73	70	70	70	71
2	A	66	66	65	65	64	65	B	66	65	64	64	64	65
3	A	71	71	70	70	70	70	B	74	71	70	70	70	71
4	A	70	69	68	68	68	69	B	72	71	69	69	69	70

- SLAB 1: DIRECTION A → PTV = 69 DIRECTION B → PTV = 67 PTV= 71
- SLAB 2: DIRECTION A → PTV = 71 DIRECTION B → PTV = 71 PTV= 71

PTV: New asphalt pavement: ≥ 60 [Centro Sperimentale Interuniversitario di Ricerca Stradale, 2001]

- **EXPERIMENTAL RESULTS** - Macrotexture test

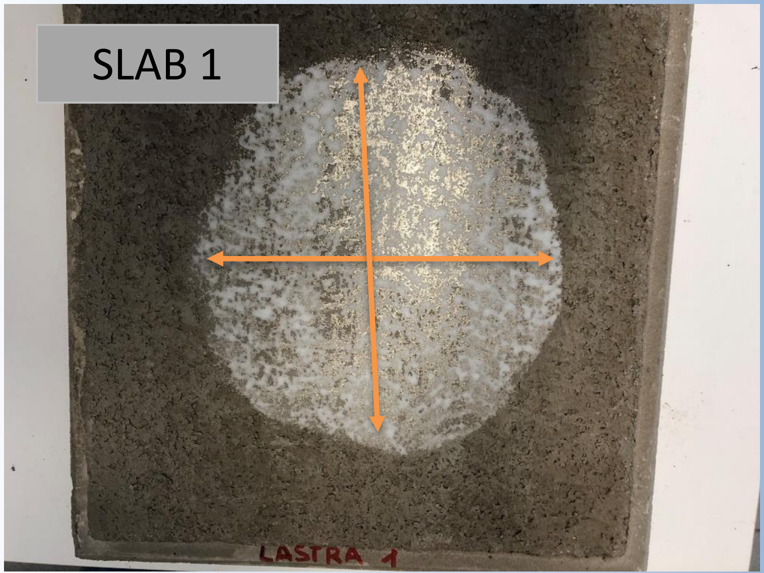
- 2 slabs were tested
- Tests carried out before (1st test) and after (2nd test) the pendulum test campaign → possible wearing effect due to swings

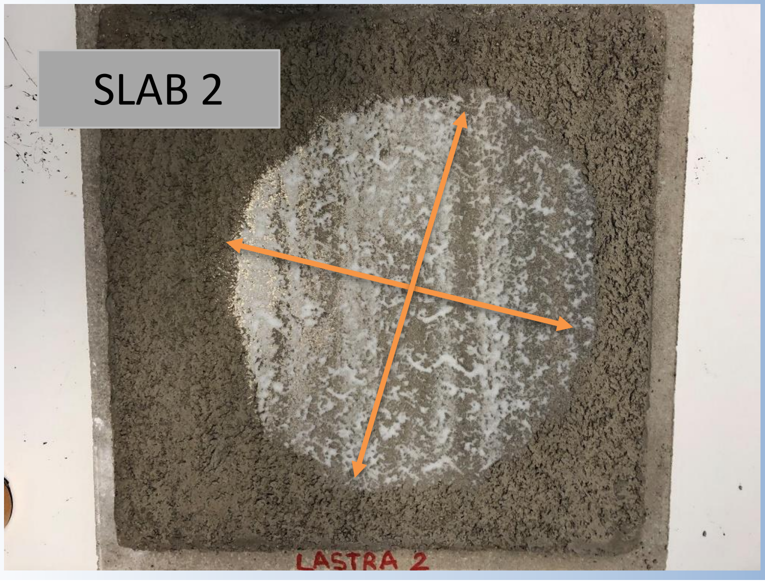
$$\mathbf{MTD = 4 \times \mathit{V}/(\pi \times \mathit{D}^2)}$$

Slab ID	MTD 1st test	MTD 2nd test	Decrease (%)	MTD Mean value
1	0.57	0.50	12	0.54
2	0.51	0.50	2	0.51

*MTD: New asphalt pavement: **≥ 0.4***

[Centro Sperimentale Interuniversitario di Ricerca Stradale, 2001]





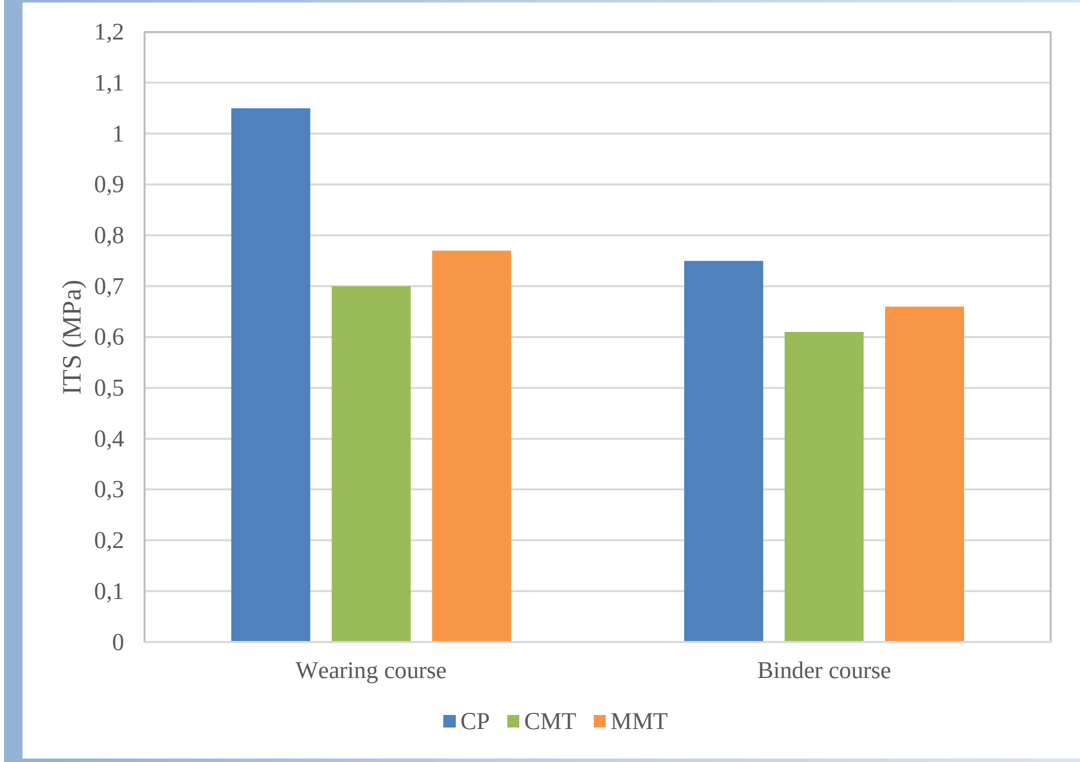
- EXPERIMENTAL RESULTS – Preliminary tests

ID	t (mm)	d (mm)	ITS (MPa)	ID	t (mm)	d (mm)	ITS (MPa)
CPu-1	45.54	123.30	**1.00**	CPb-1	42.98	123.30	**0.69**
CPu-2	45.31	123.30	**0.98**	CPb-2	45.78	123.30	**0.75**
CPu-3	42.91	123.30	**0.94**	CPb-3	45.73	123.30	**0.78**
CPu-4	43.74	123.30	**1.12**	CPb-4	44.78	123.30	**0.72**
CPu-5	45.62	123.30	**1.10**	CPb-5	42.03	123.30	**0.64**
CPu-6	44.25	94.70	**1.00**	CPb-6	46.70	94.70	**0.76**
CPu-7	48.19	94.70	**1.14**	CPb-7	41.33	94.70	**0.85**
CPu-8	44.92	94.70	**1.15**	CPb-8	44.80	94.70	**0.83**

ID	t (mm)	d (mm)	ITS (MPa)	ID	t (mm)	d (mm)	ITS (MPa)
CMTu-1	47.27	94.70	**0.47**	CMTb-1	46.41	94.70	**0.7**
CMTu-2	44.99	94.70	**0.45**	CMTb-2	47.54	94.70	**0.57**
CMTu-3	44.82	94.70	**0.75**	CMTb-3	46.99	94.70	**0.56**
CMTu-4	45.34	94.70	**0.69**	CMTb-4	47.55	94.70	**0.62**
CMTu-5	47.63	94.70	**1.12**	-	-	-	-

ID	t (mm)	d (mm)	ITS (MPa)	ID	t (mm)	d (mm)	ITS (Mpa)
MMTu-1	45.51	123.30	**0.77**	MMTb-1	46.93	123.30	**0.98**
MMTu-2	48.44	123.30	**0.85**	MMTb-2	45.89	123.30	**0.91**
MMTu-3	46.04	123.30	**0.66**	MMTb-3	46.72	123.30	**0.35**
MMTu-4	47.59	123.30	**0.85**	MMTb-4	48.90	123.30	**0.63**
MMTu-5	46.15	123.30	**0.78**	MMTb-5	49.11	123.30	**0.67**
MMTu-6	42.50	123.30	**0.73**	MMTb-6	47.23	123.30	**0.41**

- EXPERIMENTAL RESULTS – Preliminary tests



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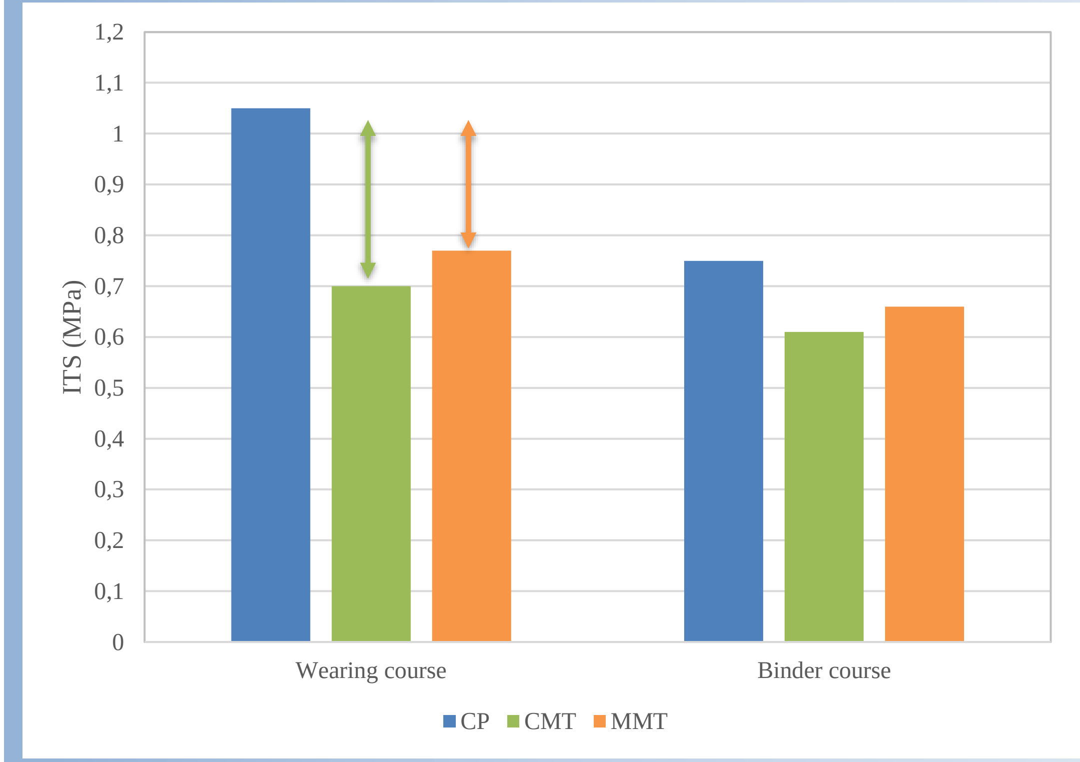
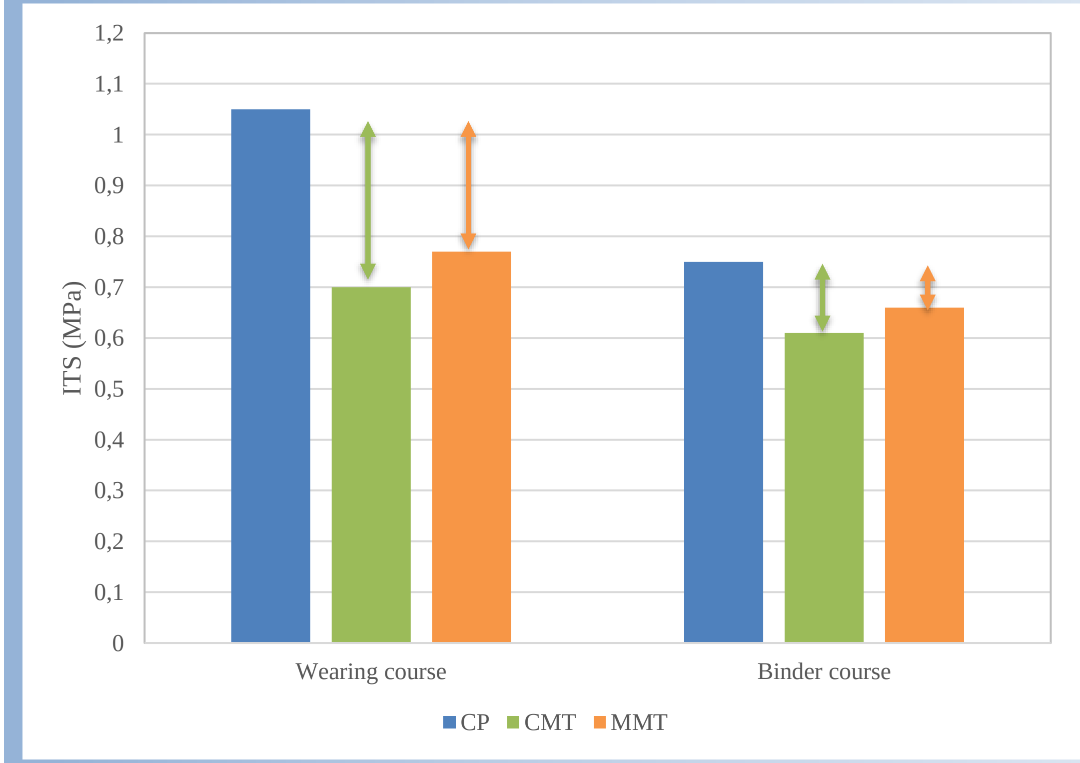


Wearing course

CMT – CP → -34%

MMT – CP → -26%

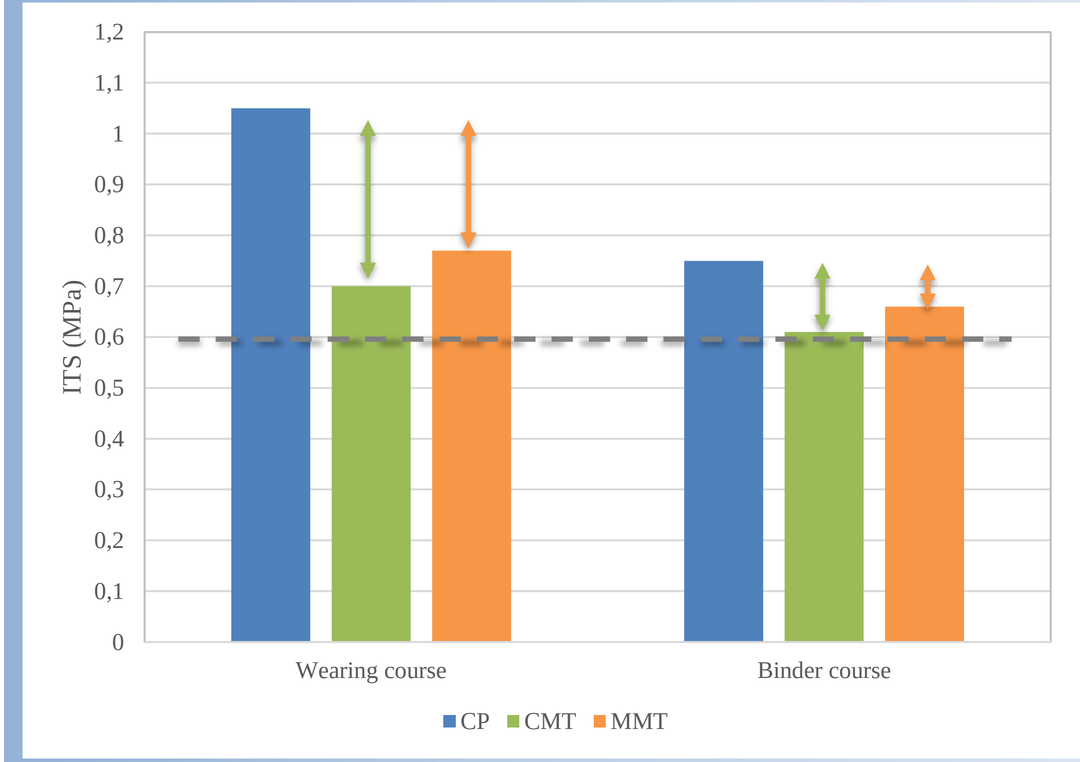
- EXPERIMENTAL RESULTS – Preliminary tests



Wearing course
CMT – CP →-34%
MMT – CP → -26%

Binder course
CMT – CP →-19%
MMT – CP → -13%

- EXPERIMENTAL RESULTS – Preliminary tests



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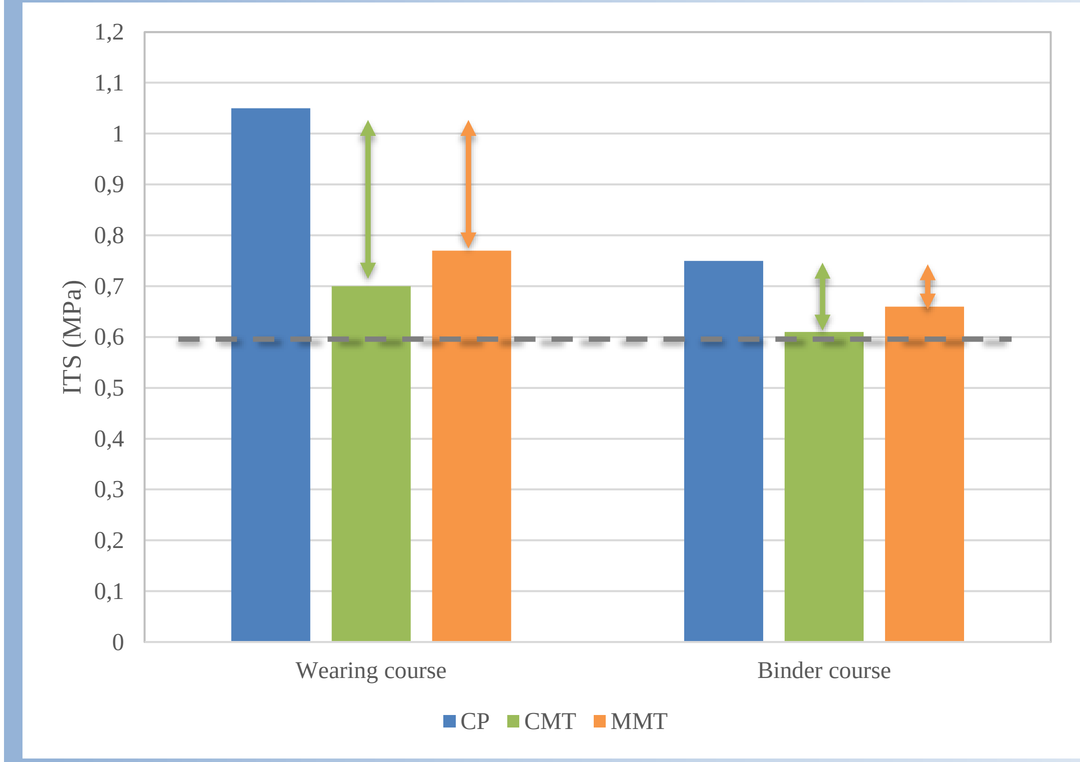
New asphalt pavement: ITS ≥ ***0.6***

[Centro Sperimentale Interuniversitario di Ricerca Stradale, 2001]

- EXPERIMENTAL RESULTS – Preliminary tests



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*New asphalt pavement: ITS ≥ **0.6***

[Centro Sperimentale Interuniversitario di Ricerca Stradale, 2001]

ITS (CMT) < ITS (MMT) → Results might be affected by coring activity

• CONCLUSIONS

- The bituminous-cementitious grout shows a fluid consistency → promising for use as monolithic backfilling in mini and micro-trenching systems.
- By quickly setting and hardening, the product might assure fast repairs on road pavements. Such behaviour is confirmed by noticeably mechanical performance after two hours from casting, both in terms of compressive and flexural strengths.
- Surface performance of the material results valuable both in terms of microtexture and macrotexture.
- The adhesion properties at the interface of the existing pavement – mini and microtrenching systems were evaluated in terms of ITS on both CMT and MMT samples → ITS values gathered testing CMTu and MMTu samples comply with minimum requirements of Italian technical Standard for asphalt concrete pavements.

In conclusion, from this study on Flowmix Fast as backfilling material for mini-micro-trenching applications, promising surface and interface adhesion properties were observed. Future development of the research will focus on the adhesion properties of the grout, testing the interface under repeated dynamic loads

Thank you for your attention