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EXPERIMENTAL CHARACTERIZATION OF MINI-TRENCHES ON ROAD PAVEMENTS

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EXPERIMENTAL CHARACTERIZATION OF MINI-TRENCHES ON ROAD PAVEMENTS

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EXPERIMENTAL CHARACTERIZATION OF MINI-TRENCHES ON ROAD PAVEMENTS

→ Nervous system of any modern nation

Infrastructure

Services

→ Raw material of the future, for the entire economic and social environment

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EXPERIMENTAL CHARACTERIZATION OF MINI-TRENCHES ON ROAD PAVEMENTS

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Installation of infrastructures on road pavements → Design solution: **Cutting existing pavements** →

Time
Environmental impact
Social impact

Miniaturization of primary elements: **FENDER**

Sirti since 1921

Same potentiality of fiber

Smaller diameter

Realization of **new trenching techniques** with the goal of **space optimization**

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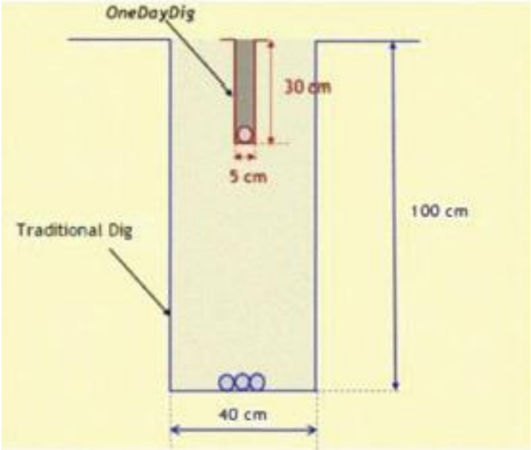
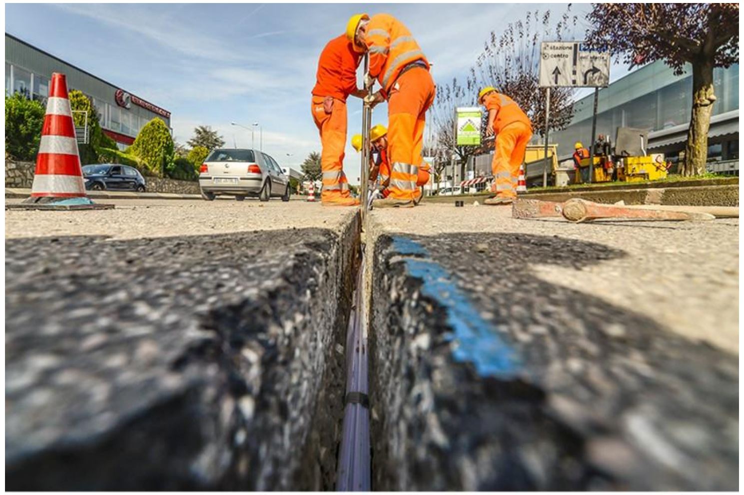
1DD
One Day Dig

→

Low impact trenching technique for FTTx fiber network to the end-users (ITU-T Recommendation, 2016)

→





Quick digging - Reduced dimension machinery - No residual material - Fast hardening – Quick pavement restoration

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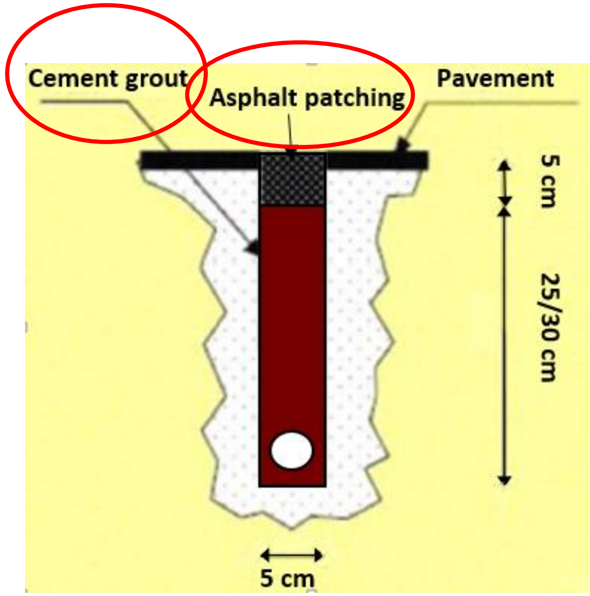
EXPERIMENTAL CHARACTERIZATION OF MINI-TRENCHES ON ROAD PAVEMENTS

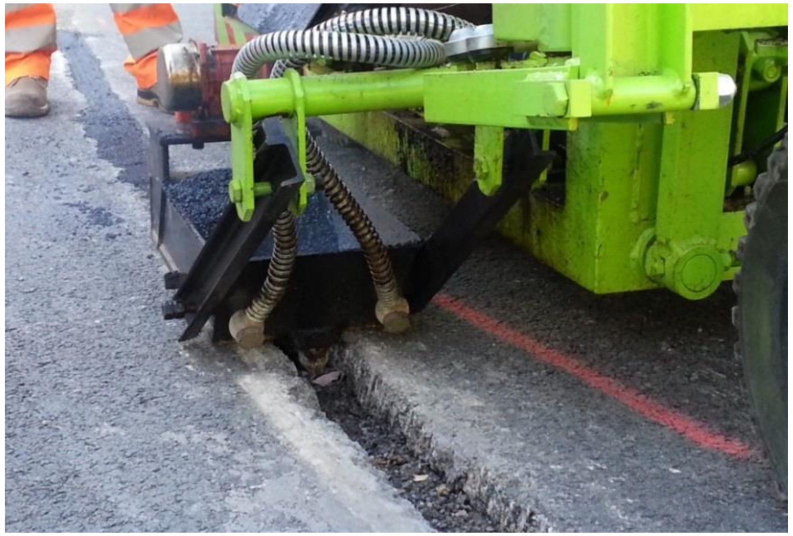
Backfilling materials that are → **Not suitable** / **Not properly installed** ⇒ **PREMATURE PAVEMENT FAILURE** (significantly reduce the pavement life)

- **RESEARCH OBJECTIVE**

In this experimental study, a **laboratory investigation** on the materials used for the realization of the 1DD mini-trenching system in **Perugia** was carried out

The backfill placements, realized in different days and by different team of workers, have been monitored to determine the **in-situ mechanical behavior** of materials and **any possible heterogeneity**





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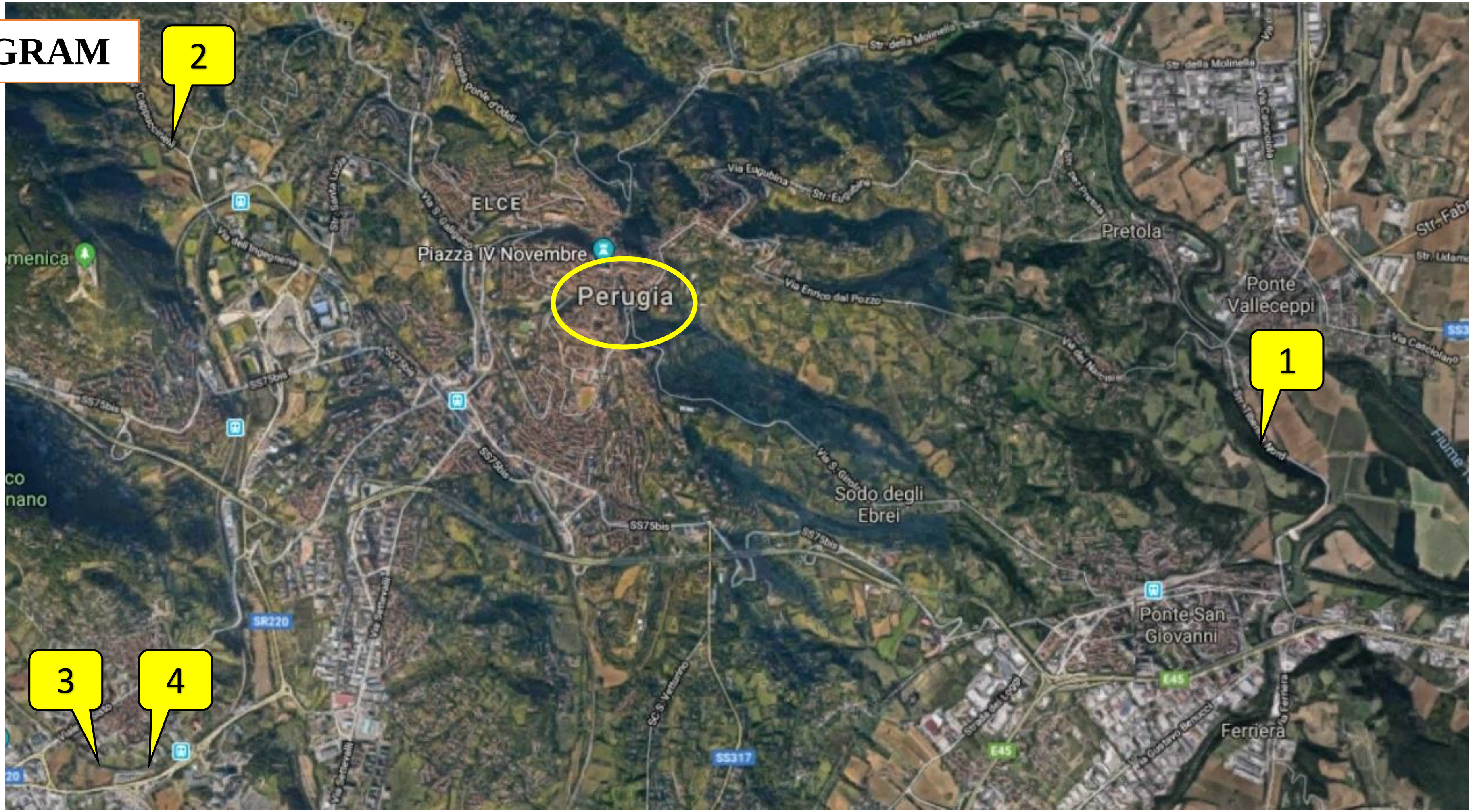
- **EXPERIMENTAL PROGRAM**

1. **Strada Tiberina Nord**
Ponte San Giovanni

2. **Strada dei Cappuccinelli**
Loc. Santa Lucia

3. **Via Pergolesi**
Loc. San Sisto

4. **Via Albinoni**
Loc. San Sisto



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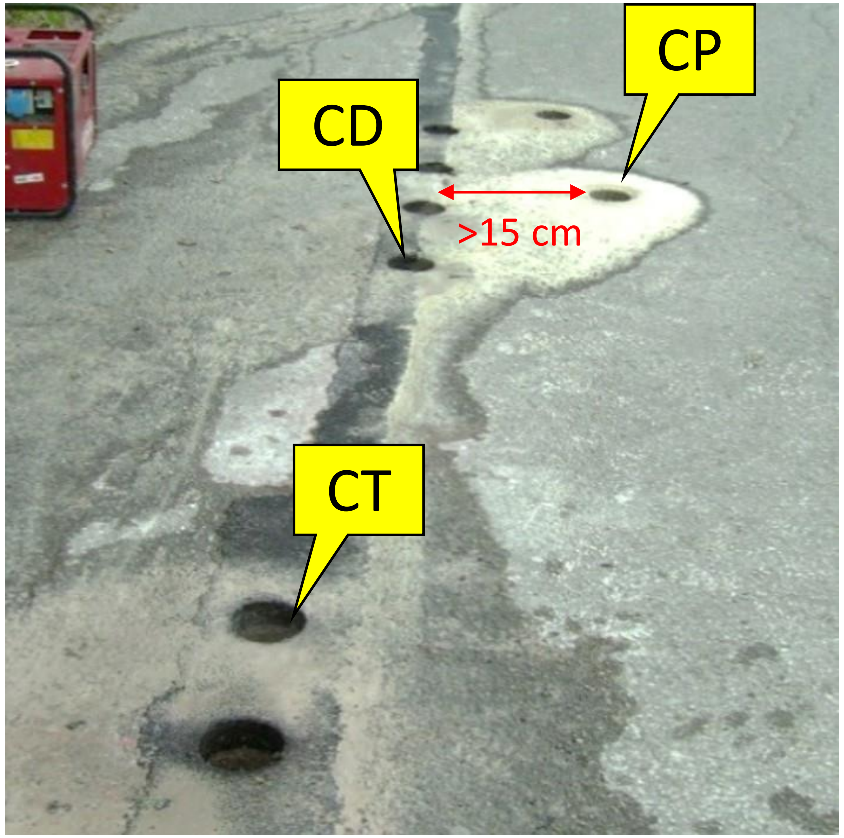
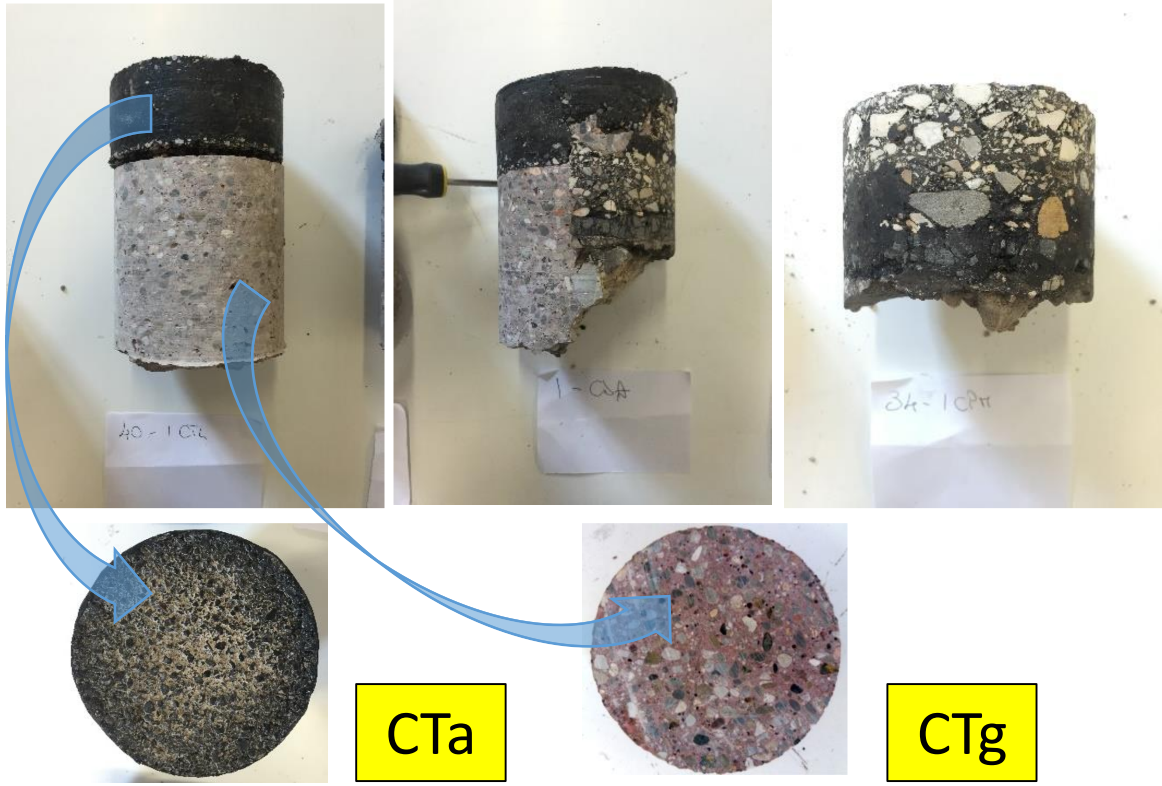
For each set of samples, **four replicates** were tested at the testing temperature → 20° C

- **EXPERIMENTAL PROGRAM**



- 75 Cylindrical samples were cored



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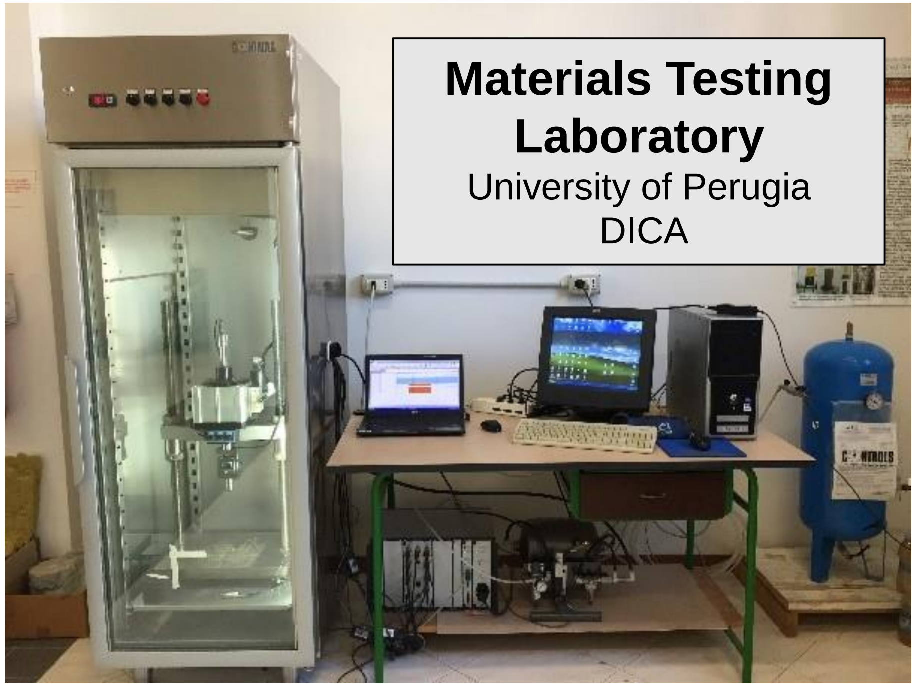
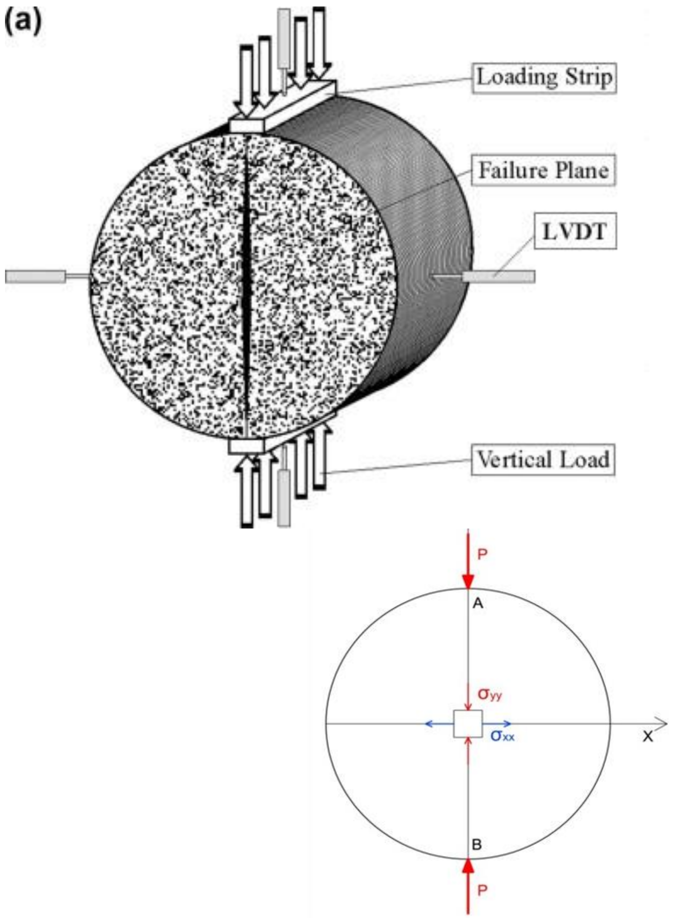
- **EXPERIMENTAL PROGRAM**



Dynamic servo-pneumatic machine – UTM14 P

INDIRECT TENSILE TEST



- The loading frame consists of two loading strips
- Repeated compressive (vertical) loads with a haversine load signal are applied.
- This loading results in repeated tensile stress pulses perpendicular to the direction of the applied load

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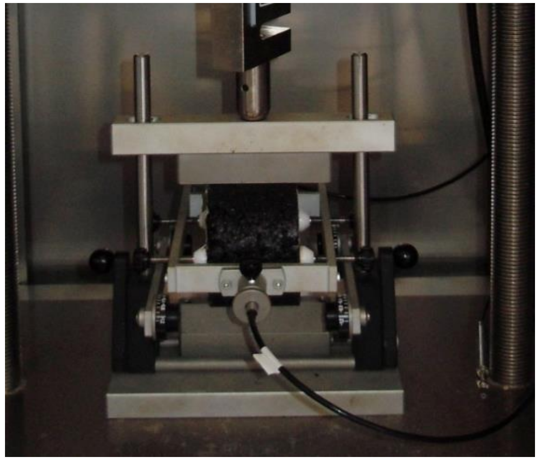
• EXPERIMENTAL PROGRAM

Stiffness Modulus Test → UNI EN 12997 -26

- 5 repeated compressive load pulses
- Horizontal (diametric) displacement of 5 μm (strain-controlled mode)
- Load amplitude ≅ 0.25 sec   Load period=3 sec

$$S_m = \frac{P \cdot (0.27 + \nu)}{z \cdot h}$$



Fatigue Test → UNI EN 12997 -24

- Compressive load pulses are applied until vertical cracking appear on the vertical axis
- 400 kPa tensile stress at the centre of the specimen is applied (stress-controlled mode)
- Load amplitude = 0.1 sec   Load period=0.5 sec

$$\sigma_t = \frac{2P}{\pi D h}$$

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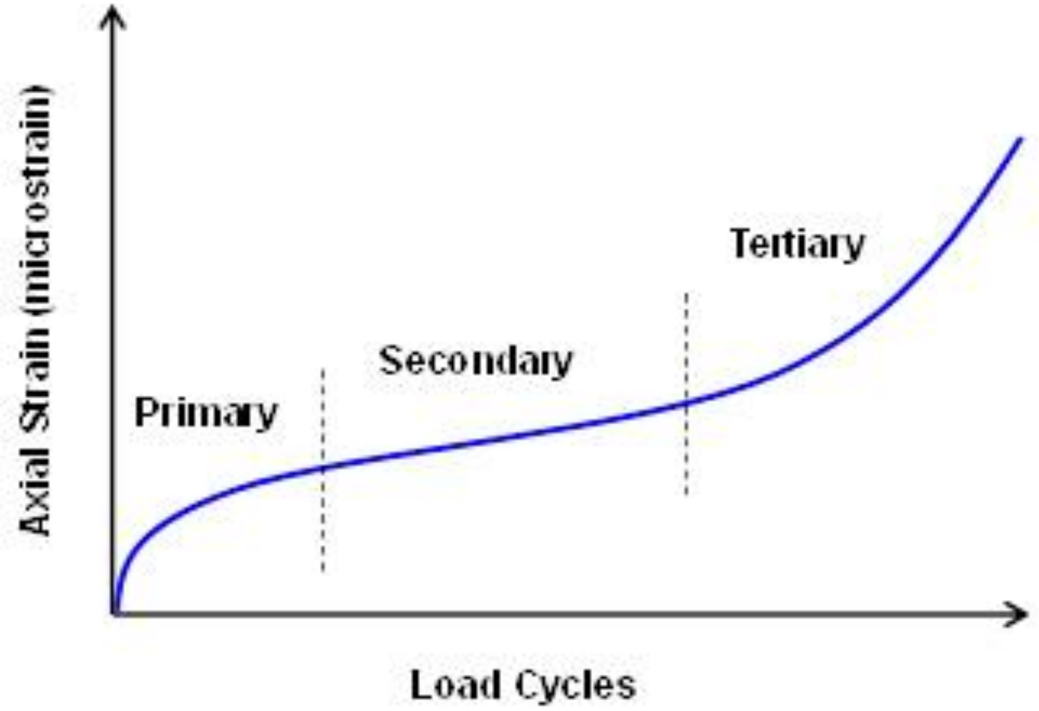
EXPERIMENTAL CHARACTERIZATION OF MINI-TRENCHES ON ROAD PAVEMENTS

- **Fatigue test**



- **Primary Phase**: it consists in an adaptation phase, characterized by a rapid growth of permanent deformation.
- **Secondary Phase**: This phase is a quasi-stationary period, where the accumulation rate of permanent deformation is approximately linear. Phase I and Phase II constitute the fatigue initiation phase up to the point where micro-cracks begin to coalesce.
- **Tertiary Phase**: this is the failure phase, Macro-cracks begin to develop and global failure is experienced by the material.

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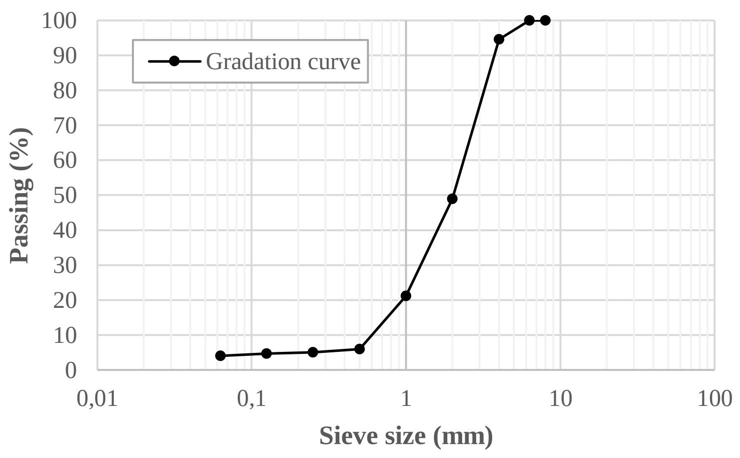
- **Materials used in the backfilling: main characteristics**

Asphalt concrete

- Bitumen content of about 15% by mix weight was used
- Riverbed aggergates type was used

Property	Unit	Bitumen	Performance
Penetration at 25°C	dmm	EN 1426	≥45
Softening point	°C	EN 1427	≥90
Dynamic viscosity at 180°C	Pa·s	EN 13302	0.7 - 1
Elastic recovery at 25°C	%	EN 13398	100
Fraass breaking point	°C	EN 12593	≤-18



Cement grout

- The cement grout is obtained by mixing water and a pre-blended powdered grout, (hydraulic binders, high strength cement, graded aggregates and special admixtures)
- As aggregate, a dried fine gravel 0.8/5 mm was used
- Fast-hardening properties
- High long-term mechanical performance, impermeability to water and high abrasion resistance.

Time interval	Compressive strength [MPa]
After 2h	10
After 4h	13
After 24h	16
After 7 days	27
After 28 days	30

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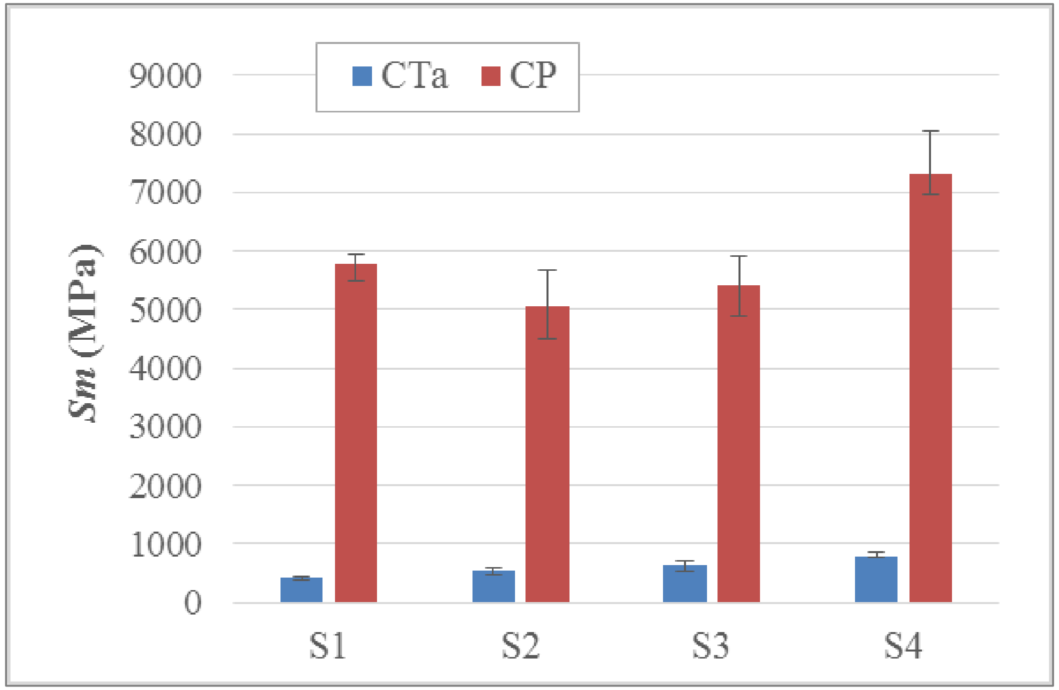
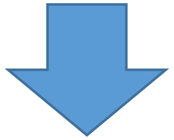
- **RESULTS: Stiffness Modulus Test**



- CP samples showed modulus values at least 8 times greater than CTa
- The dispersion of the data, shown by vertical black lines denoting maximum and minimum stiffness values, is significantly fewer than the performance gap



Acccording to flexible pavements design criteria, the asphalt concrete of CP samples can be assumed as the stiffer material of the existing pavements. Otherwise, the asphalt concrete used at the top of the backfilling should work as a sealant, without neglecting safety and driving comfort.

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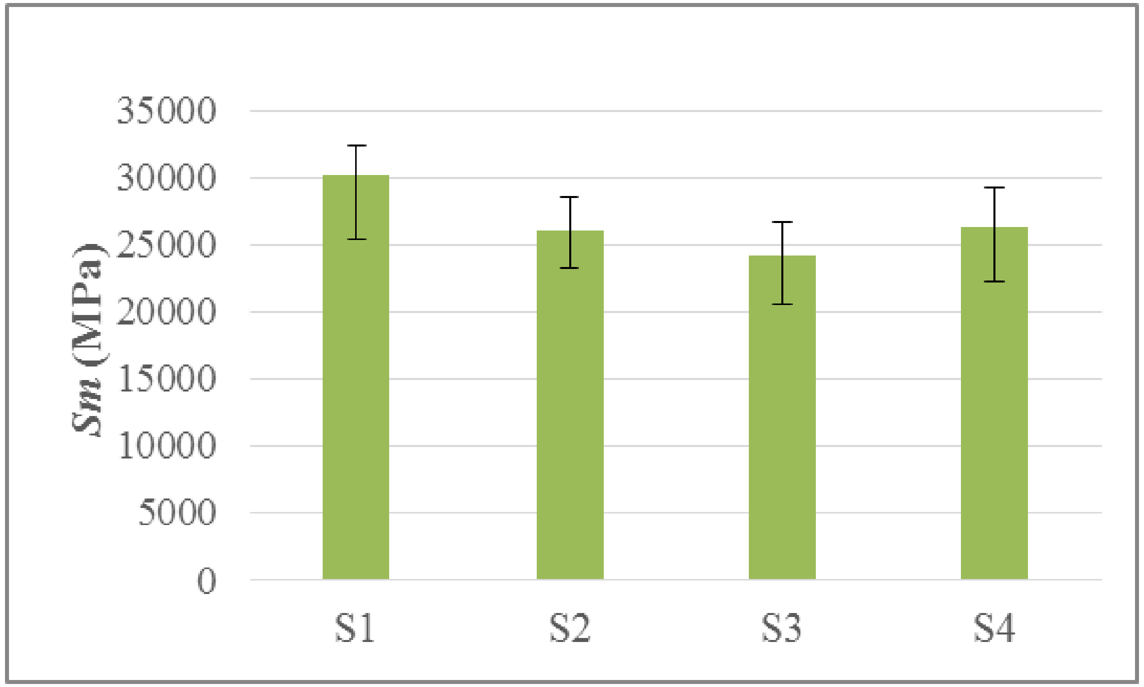
- **RESULTS: Stiffness Modulus Test**



- The cement grout, which is at least 25 cm deep, is required to guarantee adequate mechanical performance within the mini-trench.
- The stiffness values obtained were higher then those of the asphalt concrete mixtures, both CTa and CP.

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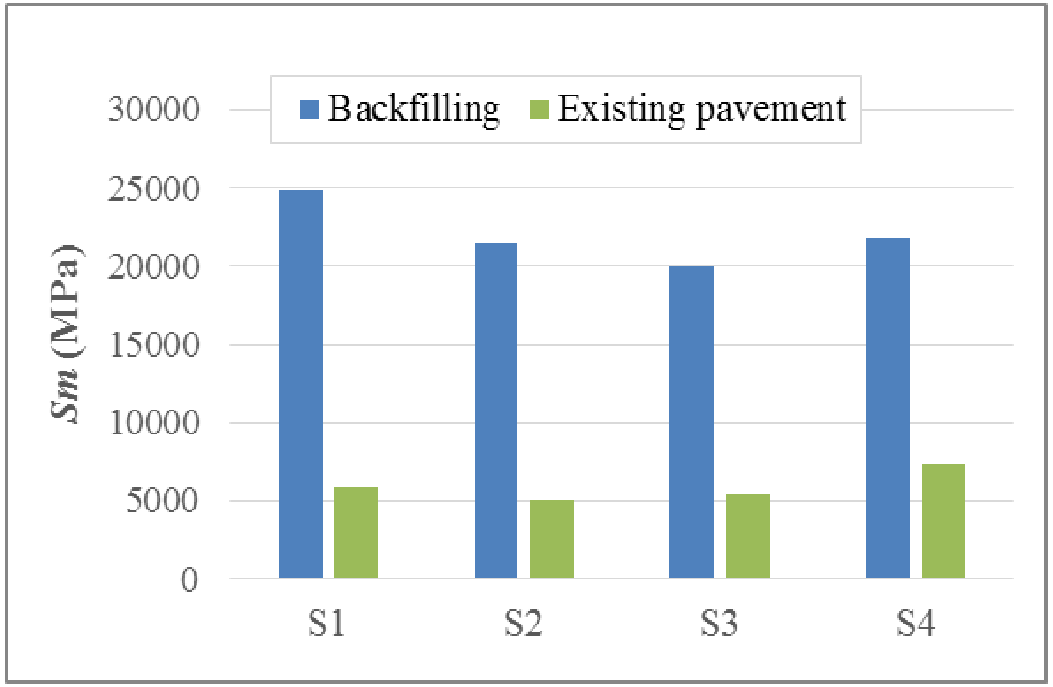
• RESULTS: Stiffness Modulus Test



- In order **to evaluate the performance of the entire mini-trenching** and to compare such properties with those of the existing pavements, the stiffness of the CTa and CTg samples were weighted based on material depths (5 cm and 25 respectively)

hyp. → The stiffness of the existing pavement is assumed to be constant going downwards.

- The overall stiffness of the mini-trench backfilling resulted to be significantly greater than that of the existing pavements.

<u>CD specimens were subjected only to ITFT because of the weakness of the interface noticed during sampling activity</u>

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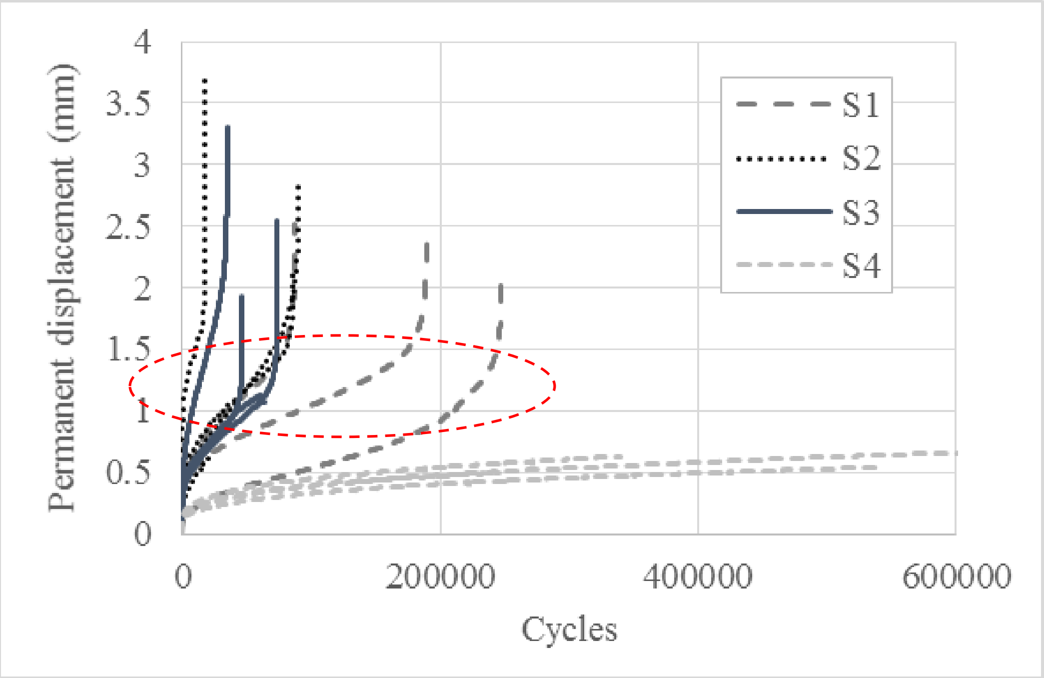
• RESULTS: Fatigue Test



<u>Stress level</u>: <u>400 kPa</u> (applied to both CTa and CP samples)

CP results

- Marked scattering → <u>**Expected!**</u>
- Average N_f values for S1, S2, S3 and S4 are 174938, 64641, 51901 and 629918 respectively.
- Vertical permanent displacement, evaluated at the final failure approaching, ranges from 1 to 1.5 mm at the most

N_f values → Total number of load applications before obvious cracking appeared on the vertical axis of the specimen

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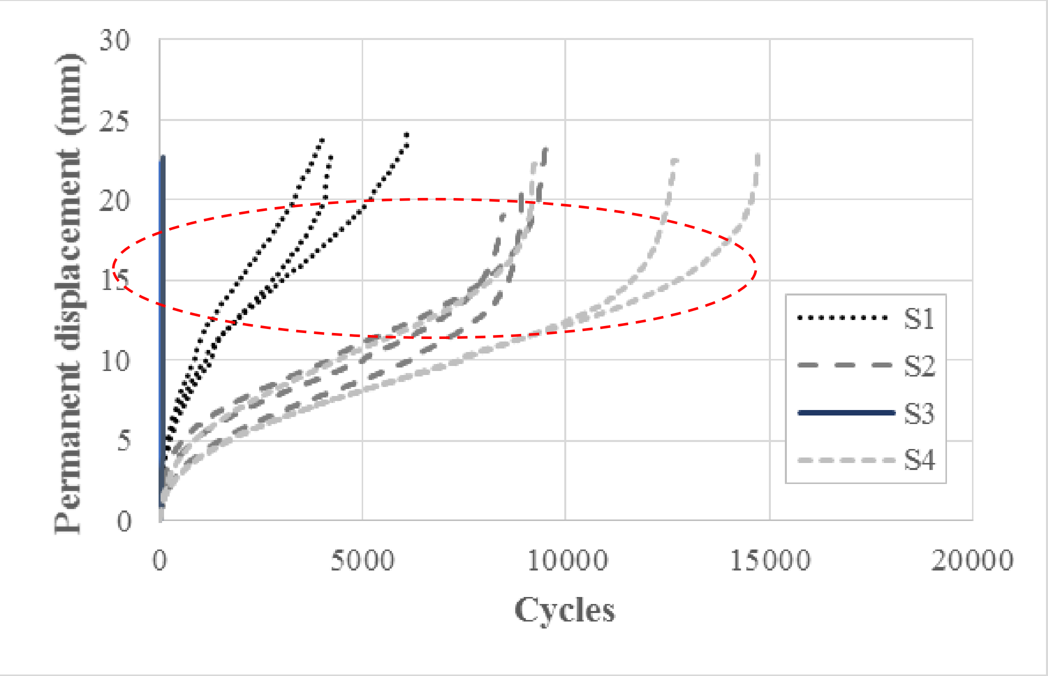
- **RESULTS: Fatigue Test**



CTa results

- Scattering → **Not Expected!**
- S3: all the replicates showed few tens cycles to failure

  → Either environmental condition or machinery malfunctioning during construction might have affected material fatigue performance.
- Average Nf values for S1, S2, S3 and S4 are 834, 4161, 51 and 5238 respectively.
- Vertical permanent displacement, evaluated at the final failure approaching, ranges from 10 to 18 mm (high values).

N_f values → Total number of load applications required to reach 9 mm as vertical permanent displacement

Results suggested that the asphalt concrete employed in the upper part of the trench worked as a sealing cap and therefore it was likely designed so as to keep a good fluidity and to adhere the sides of the cut.

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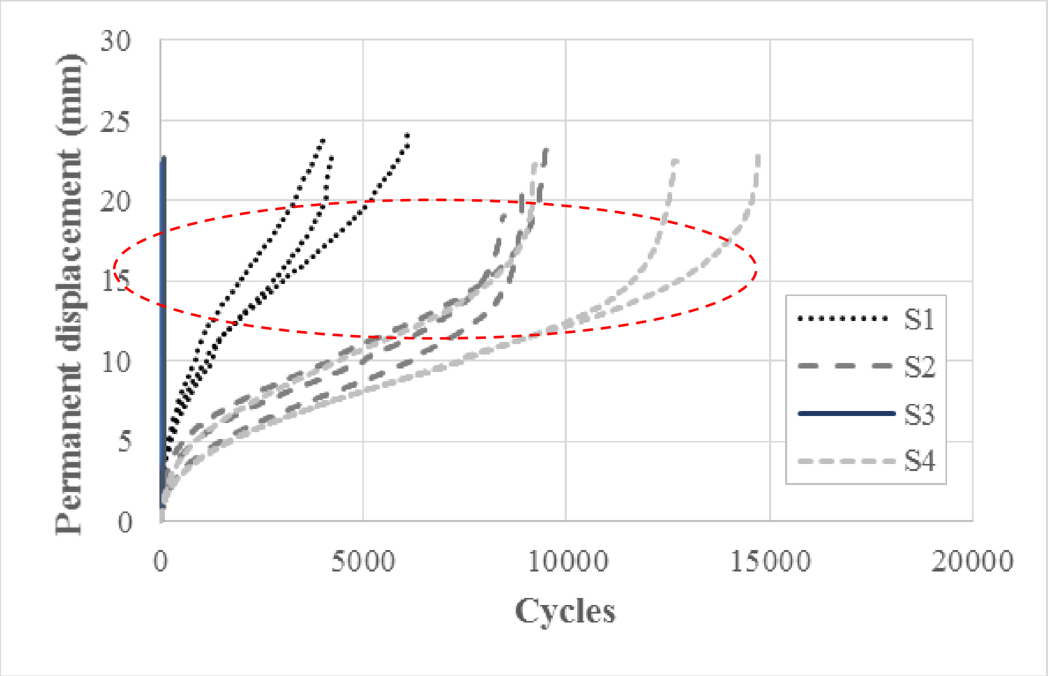
- **RESULTS: Fatigue Test**



CTa results

- Otherwise, a great tendency to accumulate permanent deformation was observed.
- The compaction phase at the end of the construction process could represents a crucial phase to avoid densification under traffic loading over time.

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- **RESULTS: Fatigue Test**

CTg results

- Concerning CTg samples, the same stress value of 400 kPa was imposed without showing significant accumulation of permanent deformation during testing.
- The stiffness modulus reduction, recognized as a reference parameter for failure detection widespread was monitored as well, but the decreasing during testing was negligible.
- A second attempt was performed increasing the stress level to 1000 kPa but a slight stiffness reduction continued to be observed

→ The cement grout, as expected, was considered much more resistant to fatigue loads than the other asphalt concrete blends.

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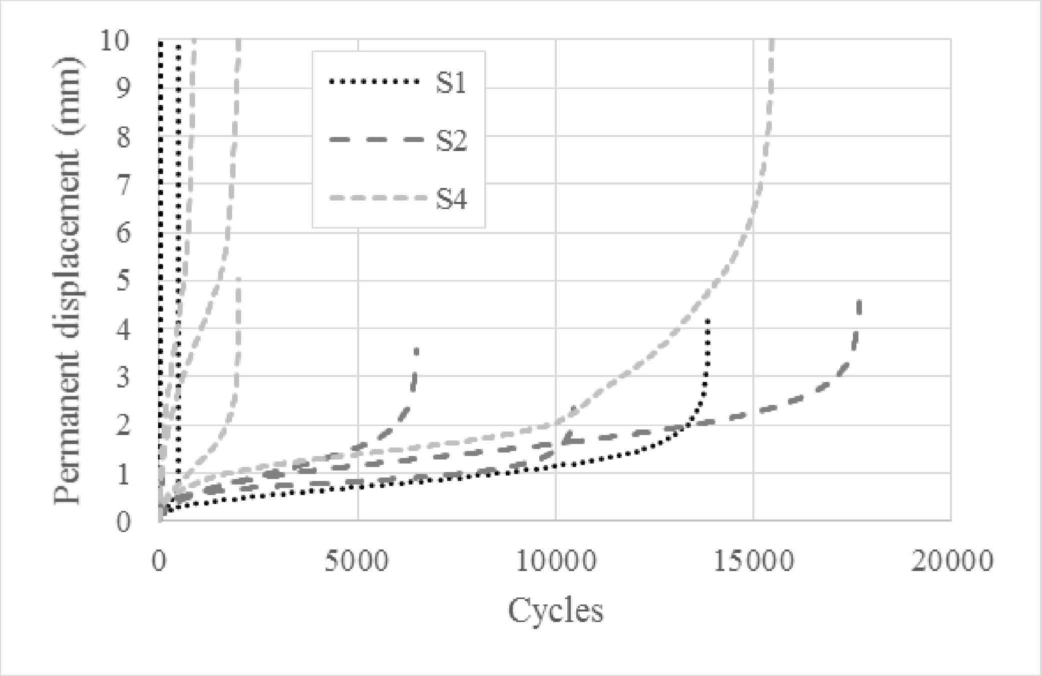
- **RESULTS: Fatigue Test**



CD results

- Drilling activities revealed that in some circumstances (as in S3) the adhesion was totally absent after sampling operations
- Marked scattering
- In S1, S2 and S4 some specimens showed a great adhesion at the interface
- Performance might be increased by improving construction operations such as cleaning the excavation walls in order to obtain a stronger bond between the existing pavement and the new material.

N_f values → Total number of load applications before the specimen splits into two halves along the interface

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• CONCLUSIONS

Thanks to the laboratory experimentation carried out, materials used as mini-trench backfilling were characterzed in terms of steffness and fatigue properties, which are primary parameters to be used within sevral mechanistic-empirical pavement design methods.

Indirect tensile stiffness modulus tests revealed :

- A clear difference in terms of stiffness modulus values between CTa and CP specimens, with greater values for the existing pavements.
- The asphalt concrete used at the top of the backfilling should work as a sealant, without neglecting safety and driving comfort.
- The cement grout is required to stand and distribute vehicle loads.
- The overall stiffness of the mini-trench backfilling can be assumed to be significantly greater than that of the existing pavement.

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• CONCLUSIONS

Indirect tensile fatigue tests revealed :

- CT specimens showed scattering results: **either environmental conditions or machinery malfunctioning during construction might have affected material performance**.
- Results on CP and Cta suggested that the asphalt concrete employed in the upper part of the trench (low fatigue lives) **works as a sealing cap** and therefore it was likely designed so as to keep a good fluidity and to adhere the sides of the tranch. **Due to the tendency to accumulate permanent deformation**, **the compaction phase at the end of the construction process could represents a crucial phase to avoid densification under traffic loading over time**.
- Concerning the CTg specimens those resulted much more resistant to fatigue than the asphalt concrete blends.
- The **adhesion at the interface might be increased by improving construction operations** such as cleaning the excavation walls.

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