A NOVEL MONITORING PROCEDURE FOR ASSESS THE CORRECT ROAD PAVEMENT RESTORATION AFTER THE ONE-DAY-DIG MINI-TRENCHING INSTALLATION

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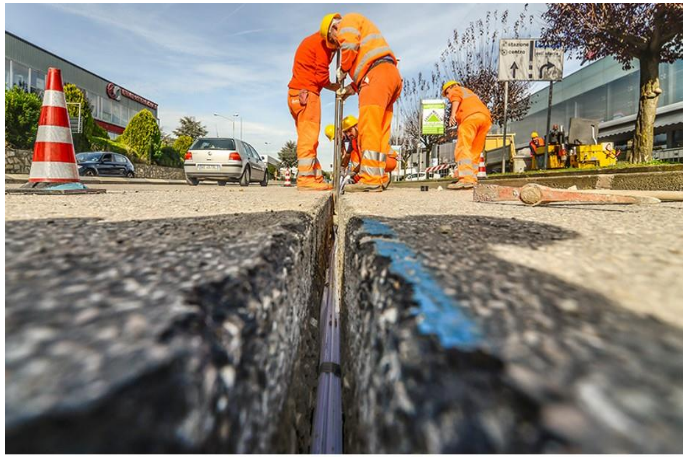
Installation of infrastructures on road pavements →

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



Quality of the restoration process?

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

Materials used as backfill :

- **Suitable**

(quick setting, fluid consistency, stable, properly bond with the existing structure, etc.)

- **Properly installed**

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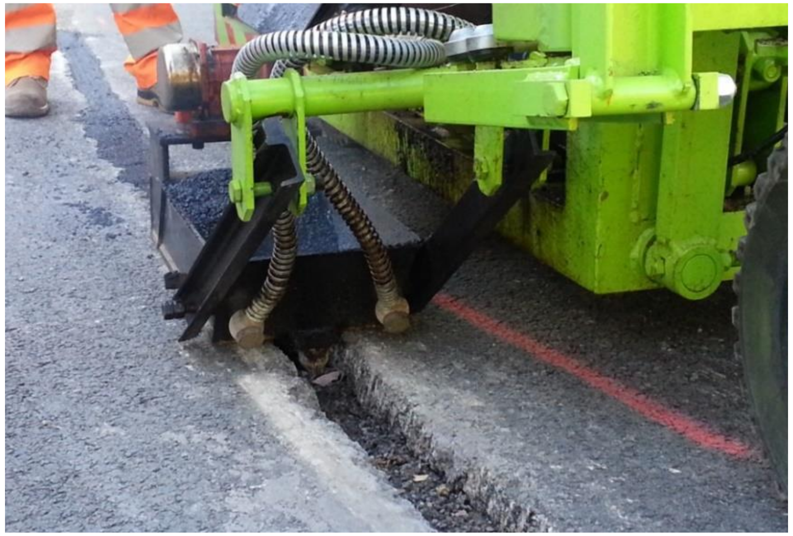

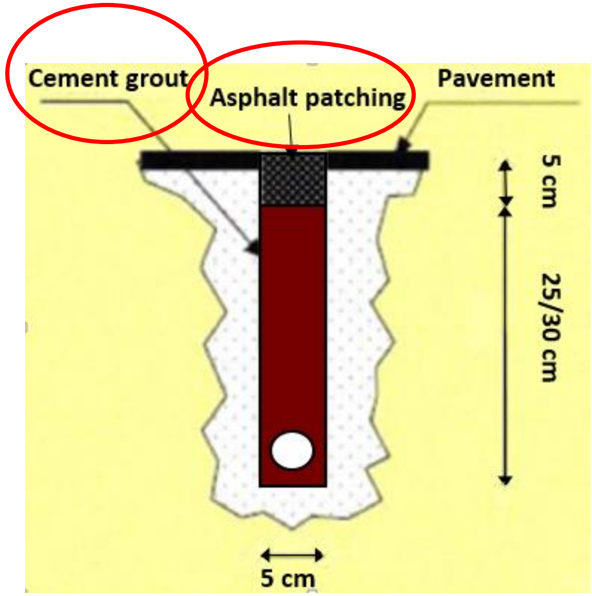

Experimental testing campaign:

- Cta samples → high permanent deformation
- Poor adhesion at the interface
- Different sites → Heterogeneity in mechanical (fatigue) performance

Do those issues affect the quality of the pavement restoration?

Research Objective

Assess the correct road pavement restoration after the One-Day-Dig mini-trenching installation

→ A new monitoring procedure is here presented

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Experimental procedure main stages:

- The first phase focused on the **detection of the road network** (Perugia) interested by 1DD mini-trenching using a 3D laser scanner
- The second phase interested the **elaboration of the point clouds** collected during the detection phase through the open source software CloudCompare.

- A new procedure was developed to **assess the vertical deviations** of the mini-trench surface from a reference plan representative of the road pavement.
- In order to confirm the reliability of the method, **post-processing controls** were executed

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- Road network of Perugia where 1DD mini-trenching was constructed

→ <u>Total length: 28 km</u>

Road network partition:

- ✓ Ring AA
- ✓ Ring BB
- ✓ Ring CC
- ✓ Ring DD
- ✓ District of San Sisto
- ✓ District of Ponte Felcino

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- **1DD MINI – TRENCHING DETECTION THROUGH 3D LASER SCANNER** → LS.Rilievi

Z+F IMAGER 5010: phase-shift laser scanner:

- ✓ compact and easy handling apparatus
- ✓ high measurement speed (maximum rate: more than one million pixels/sec)
- ✓ high angular and distance accuracy
- ✓ range up to 187 meters
- ✓ extended field of view 320°x360°

The laser scanner was installed on the roof of a car through a multi-axis leveling platform (LEVEL-PLANE EVO 16, Scan&Go) and it was integrated by two GPSs, which allowed georeferencing each scanning

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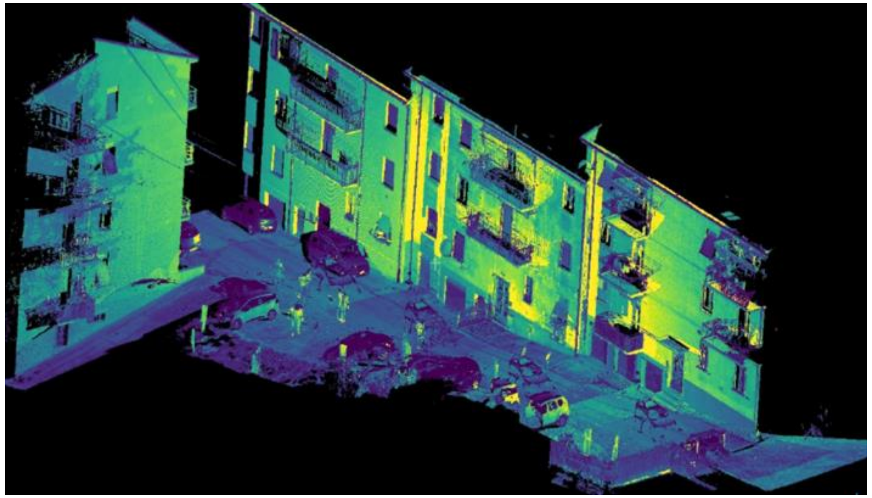
The 3D survey provided a series of point clouds

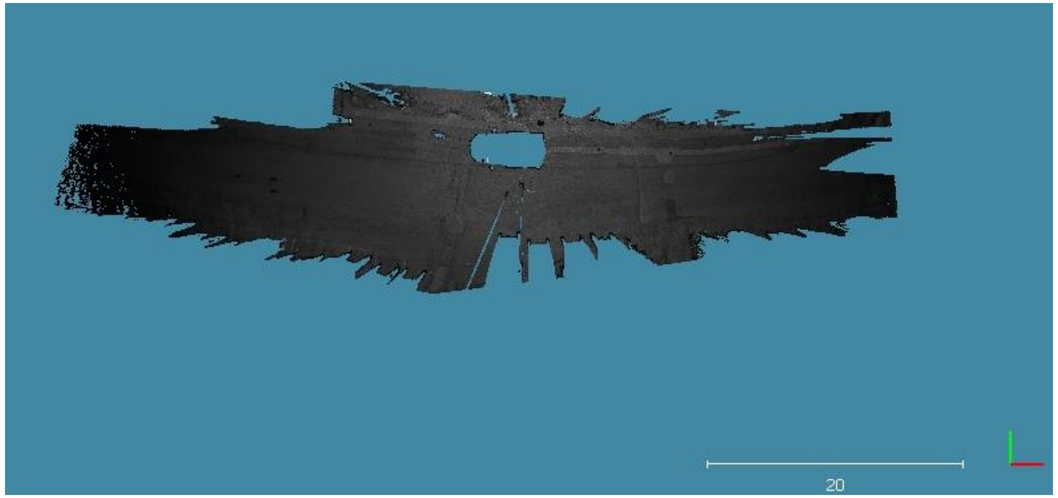
↓

Tridimensional model of the scan area

All the coordinates of each measured point are known.



From each acquisition, point clouds referred to the road pavement were selected only.



Performing more acquisitions in sequence, all the road pavements interested by the construction of the 1DD mini-trenches were surveyed.

All scans related to the road in object were than imported in **CloudCompare**.

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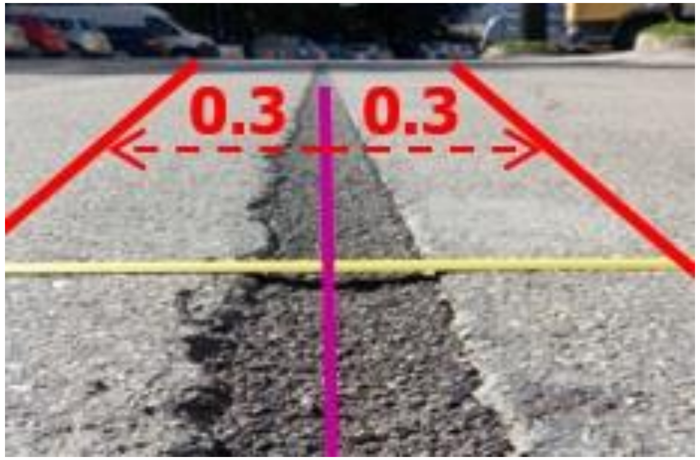
- **METHODOLOGY OF ANALYSIS**

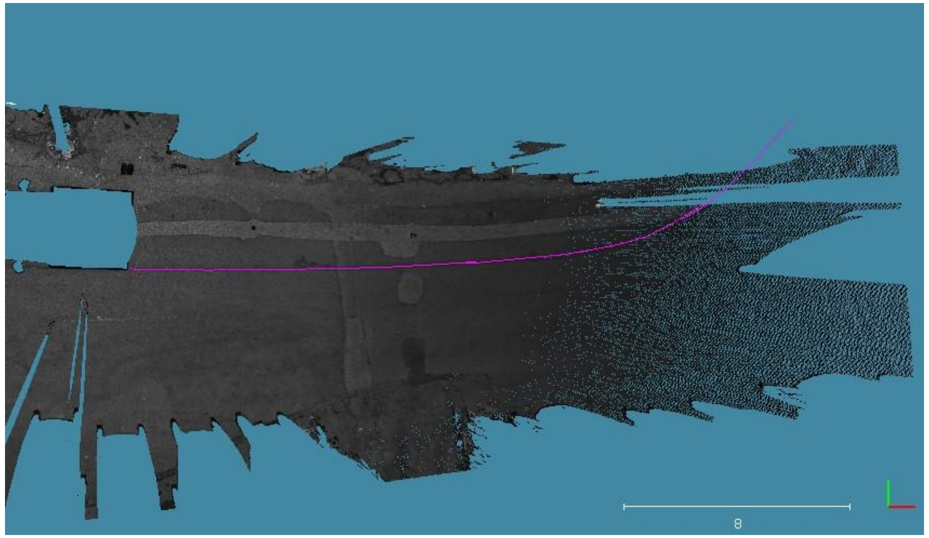
On each scanning → polylines were drown following the axis of the mini-trench and the whole path was covered.

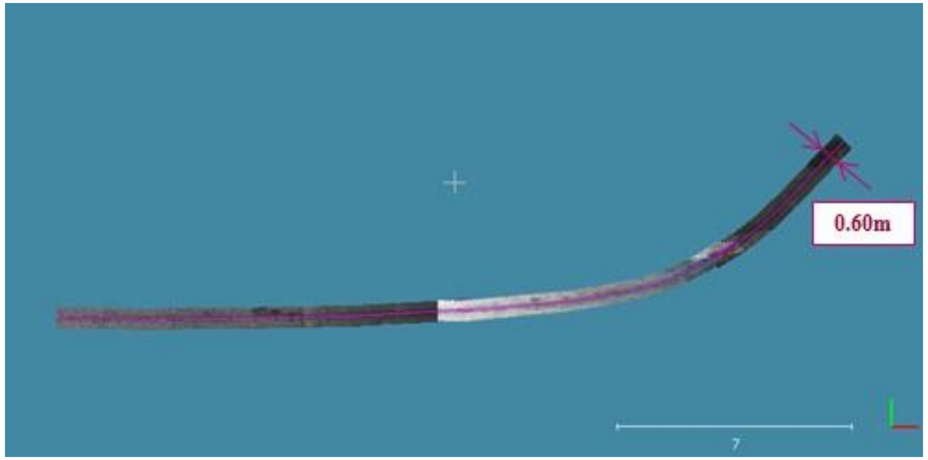
Among those polylines, **strips of 0.60 m wide**, which contain both the mini-trench and a small portion of the existing pavement, were cut out.

The strip width was chosen based on the compromise of having a strip large enough to define a representative surface of the existing road pavement, and, at the same time, small enough to avoid the presence of irregularities.

→ Such irregularities may misrepresent the reference surface.







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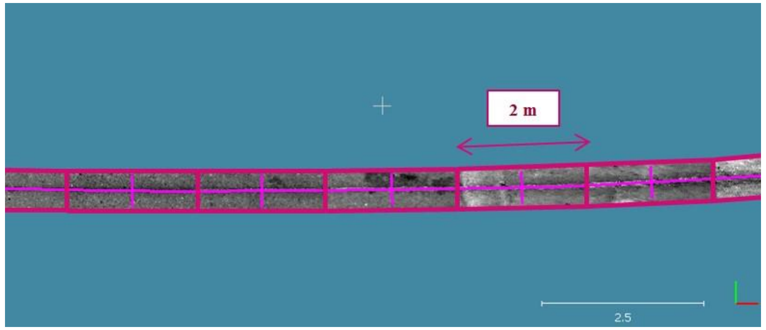
- **METHODOLOGY OF ANALYSIS**

Each strip was then divided into segments **2 metres long**

Each segment provided **separately** average data concerning both **positive and negative weighted deviations** from a **reference surface** (pre-existing condition).

Deviations are weighted **based on the number of** positive and negative points within each segment.



Smaller lengths

- May lead to excessive time of analysis
- May lead to results not useful for the management of real stretch restorations (operating on shorter segments would not make sense).

Longer lengths

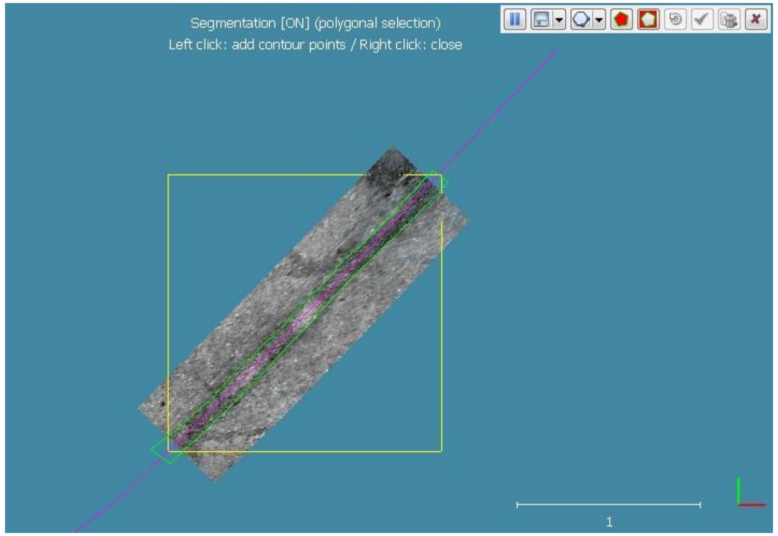
- May lead to identify incorrectly the reference road pavement.
- May lead to affect the results by inhomogeneous point density in the same cloud and, eventually, to wrong estimates in terms of average value of the deviation (which is useful for possible restorations).

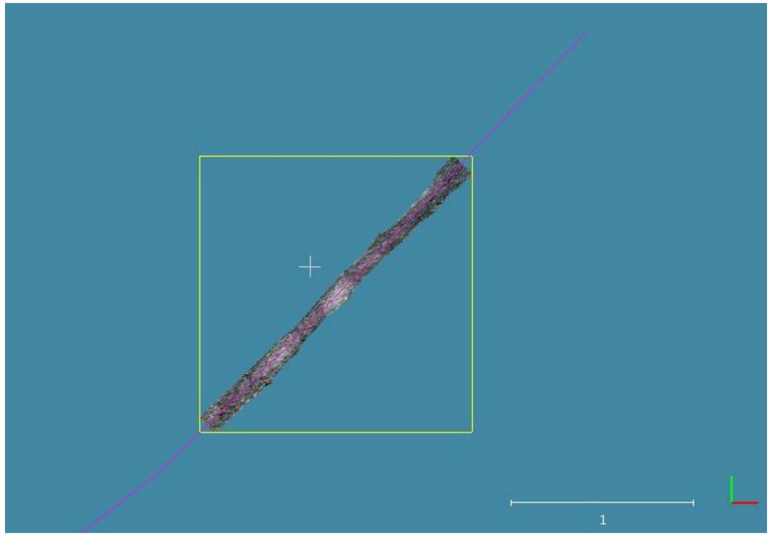
- **METHODOLOGY OF ANALYSIS**

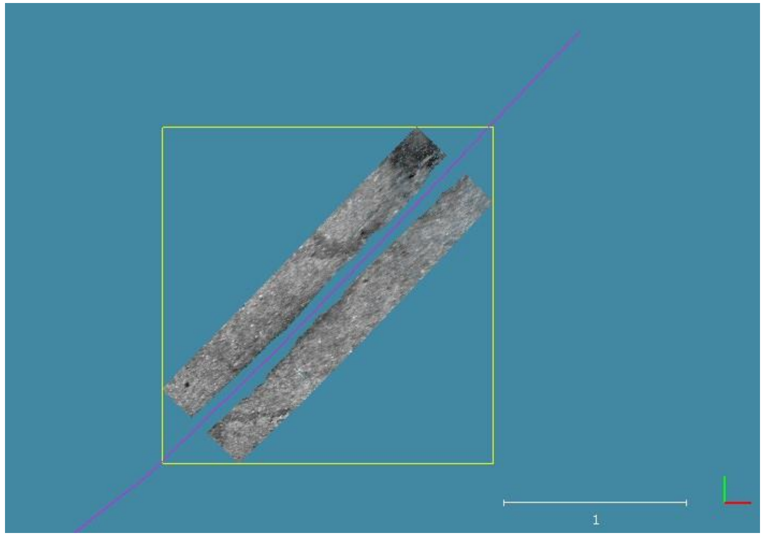
On each segment, the mini-trench was cut out trying to follow as accurately as possible the actual development (a).

New clouds are generated:

- Points within the mini-trench (b)
- Points of the existing pavement only (c)



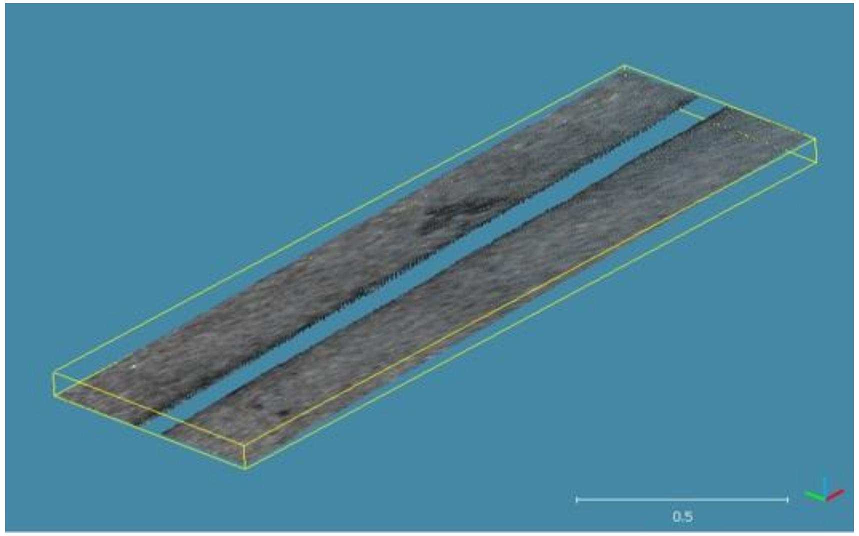


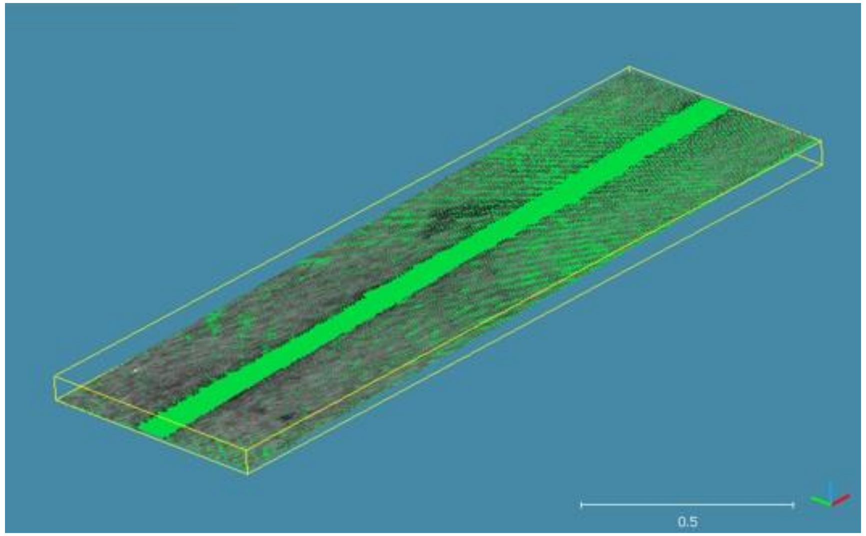


- **METHODOLOGY OF ANALYSIS**

Best fit of the existing pavement point cloud → **Quadric surface**

It is representative of the road pavement before the execution of the dig





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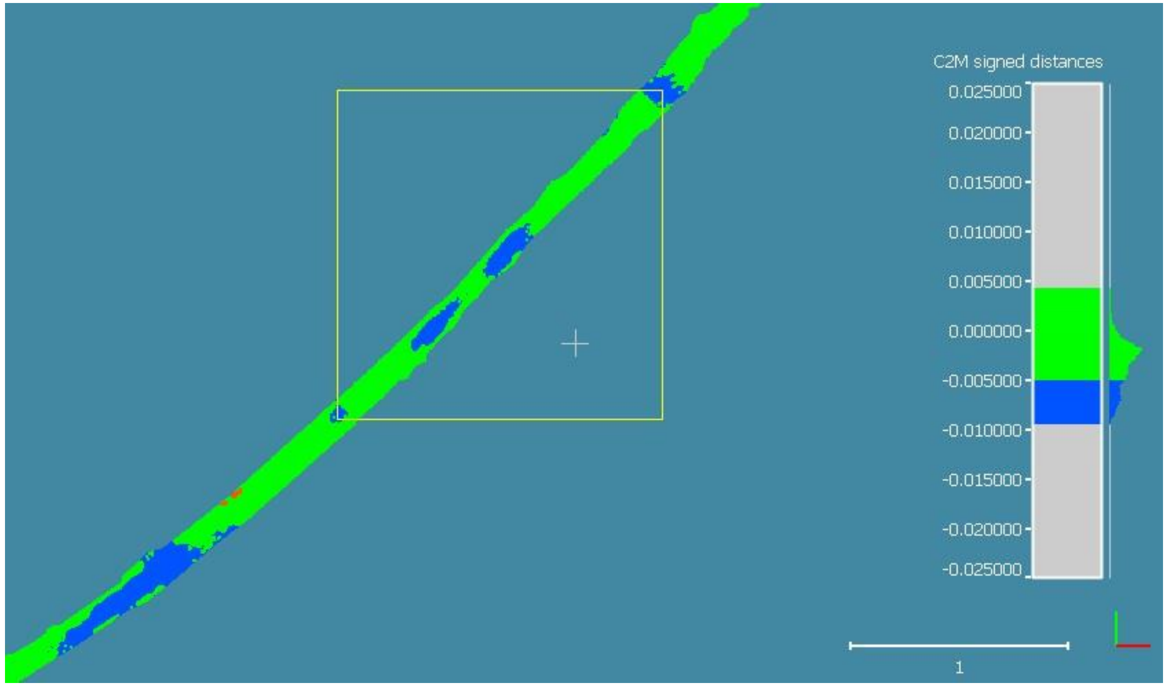
- **METHODOLOGY OF ANALYSIS**

The reference surface was compared to the points collected within the mini-trench. →

This operation generated a **scalar field** linked to the mini-trench that showed in every point the **distance to the reference surface.**



Results obtained can be exported for further elaborations.

For each analyzed segment, an ASCII file can be saved, which showed the coordinates X, Y, Z of each point and the value of the related scalar field, namely the value of the deviation of the point itself as compared to the reference surface

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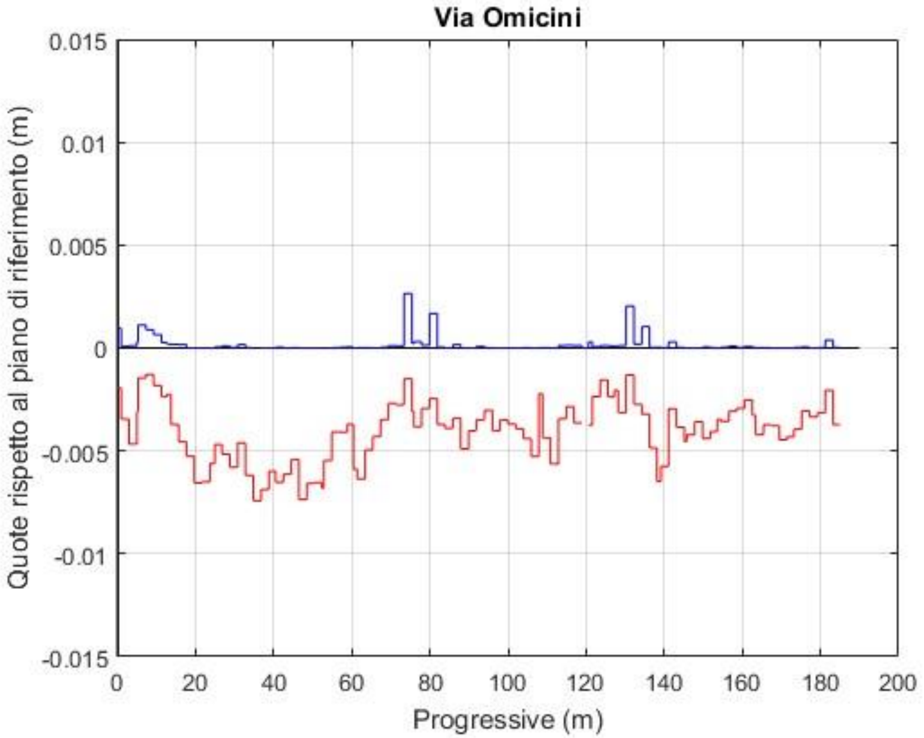
- **ELABORATIONS OF THE RESULTS**

Using a Matlab routine, average deviations suffered by each segment were calculated.

- Arithmetic means of negative and positive deviations
- Weighted means in relation to the number of points of negative and positive deviations

The weighted means, displayed in a graph as a function of the progressive lengths, provided an immediate vision of the status of the analyzed mini-trench



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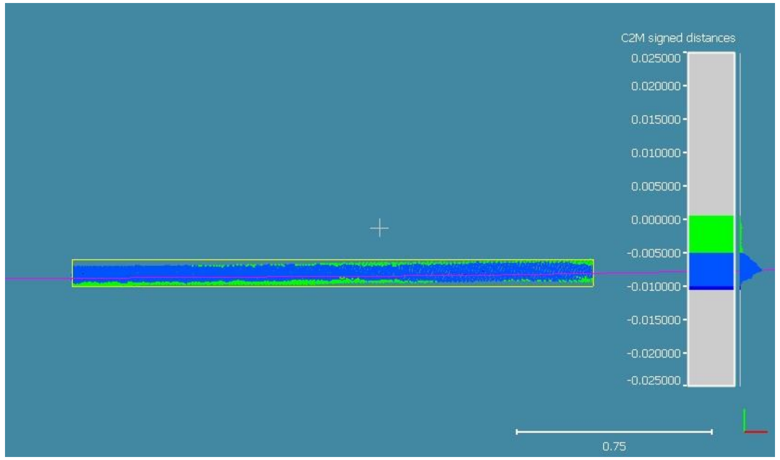
- **DATA CHECK**

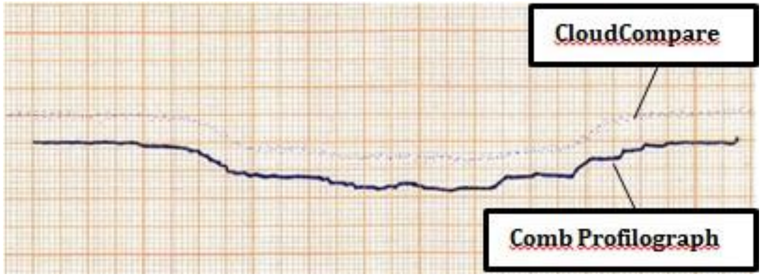
The reliability of the method was evaluated

- Visual inspection
- «Comb profilograph»

The final data check proved an excellent fit of the results obtained through the elaboration in CloudCompare to the actual situation.





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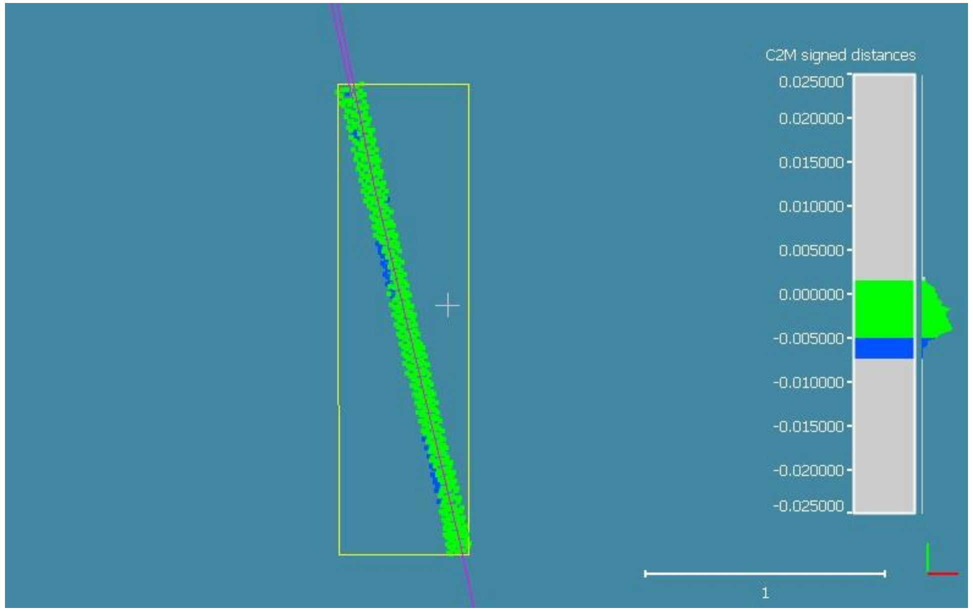

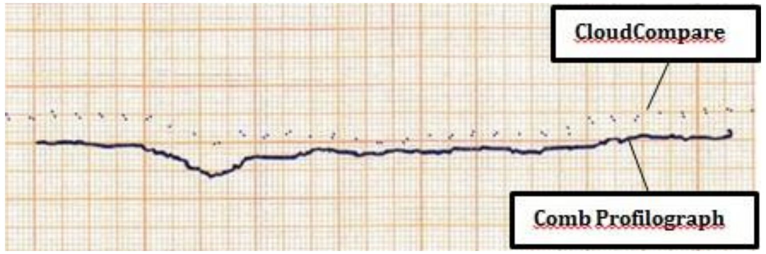

- **CONCLUSIONS**

➢ Experimental results highlighted that the procedure proposed by the authors provides a reliable representation of the road surface evenness where pavement restoration are required due to 1DD mini-trenching installation.

➢ Thanks to the methodology chosen for the detection and the interpretation of the measures, it has been possible to determine with a high level of accuracy the punctual deviations, negative and positive, suffered by the mini-trench as compared to the existing road pavement.

➢ The method provided punctual data, which, duly elaborated, allow concise indicators of the quality of the works done with the 1DD technology to be obtained.

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Fortezza da Basso • FLORENCE (Italy)

30th September • 2nd October 2019

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