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Predicting the Bearing Capacity of Road Flexible Pavements using GPR

Chiara Ferrante[(1)], Luca Bianchini Ciampoli[(1)], Fabio Tosti[(2)], Amir M. Alani[(2)] and Andrea Benedetto[(1)]

[(1)] Department of Engineering, Roma Tre University, Rome (IT) – luca.bianchiniciampoli@uniroma3.it [(2)] School of Computing and Engineering, University of West London, London (UK)– Fabio.Tosti@ac.uwl.uk

BACKGROUND

Most of the damage in road-flexible pavements occur where stiffness of the asphalt and loadbearing layers is low. To this extent, an effective assessment of the strength and deformation properties of these layers can help to identify the most critical sections [1].

Bearing capacity of subgrades can be evaluated by on-site, and laboratory tests.

Pro:
- Reliability of the results
- Wide-spread and acknowledged methods

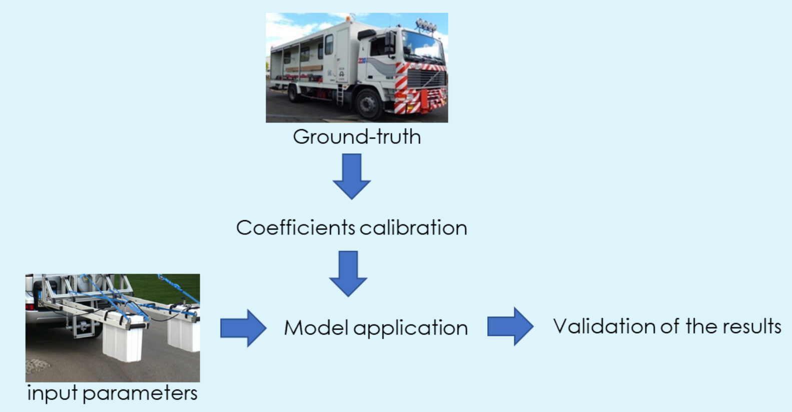
Cons:
- Time-consuming and costly
- Partian information achieved
- Closure of road or lane for surveys

Within this context, applications of non-destructive testing (NDT) methods for the assessment of the mechanical properties of pavements have increased over the last decades. **This paper aims at providing a faster and robust GPR-based model for the estimation of the mechanical properties of road flexible pavements.**

METHODOLOGY

The methodology used in this paper for the development of the prediction algorithm follows a multi-stage framework, consisting of the following steps:

- Analysis of expected ground-truth data from Curviameter
- Choice model input parameters from GPR tests
- Modelling
- Data collection
- Calibration of the model
- Model application
- Effectiveness evaluation



Pavement thickness indicator

$$T_z = \sqrt{\frac{R_c}{D_{max}}}$$

where Tz is the bearing capacity, and Rc and Dmax are the **radius of curvature** and the **maximum deflection of the deflection bowl** measured by Curviameter, respectively.

Input parameter from GPR

τ, α

The **overall thickness of the bitumen-bond layers** (i.e., surface, binder and base layers) as well as an **attenuation factor** accounting for relevant reflections at the interface between the above-considered layers were taken into account as model input parameters from the GPR acquisitions.

Data Collection

The above methodology was applied to a real-life rural road network located in the districts of Madrid and Guadalajara, Spain

Tab. 2. GPR acquisition parameters.

Freq. (MHz)	Time window (ns)	Spatial res. (m)	Samples
2000	15	0.0208	512

Tab. 3. Curviameter acquisition parameters.

Load (kN)	Speed (km/h)	Spatial res. (m)	Depth
130	18	5	1

Three road stretches were surveyed using GPR and the Curviameter equipment. The overall surveyed distance was approximatively 45 km long.

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RESULTS & DISCUSSIONS

Discussed results refer to the application of the method described in Section III to the structural data for the Road Stretch 2.

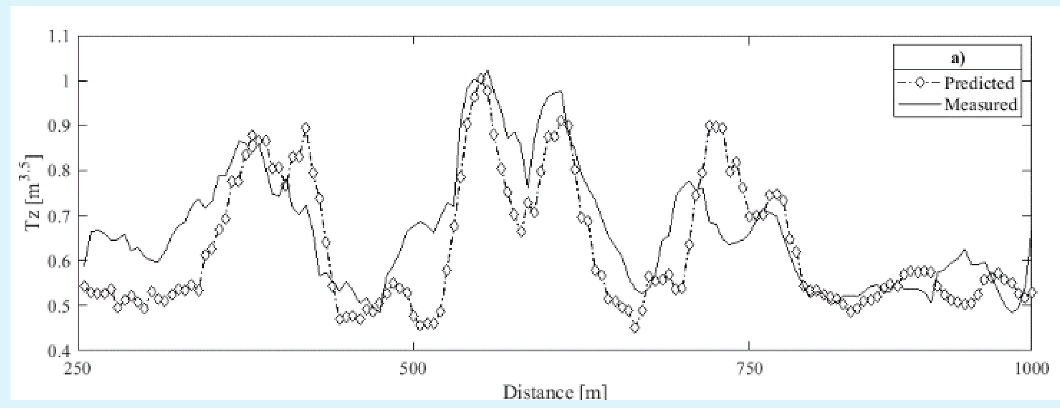
Tab. 1. Information on the pavement structures extracted from cores.

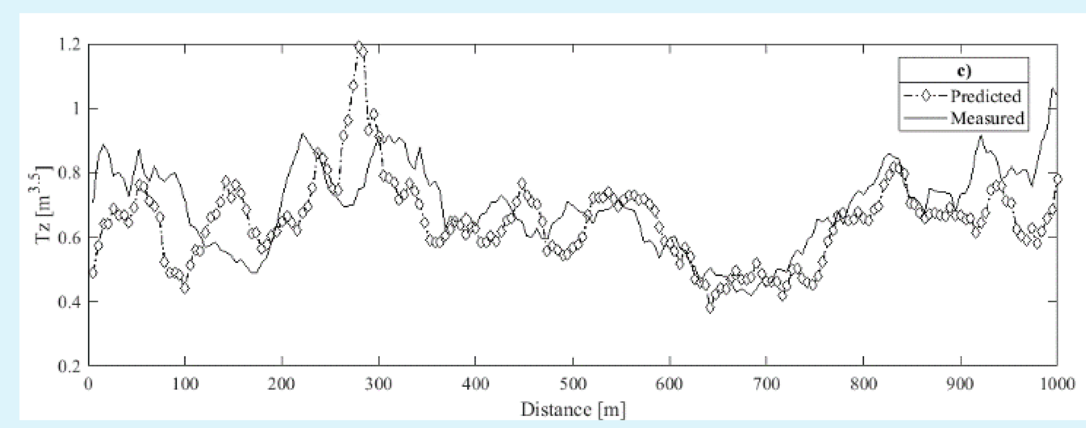
Stretch	Wearing (cm)	BB Base (cm)	Gran. Base (cm)
1	8	10	N.A.
2	6	8	18
3	10	15	N.A.

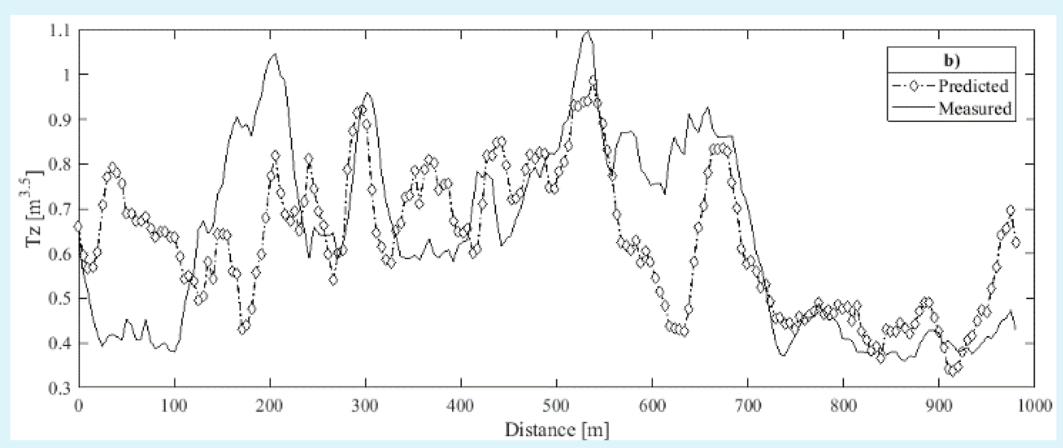
BB: bitumen-bond; Gran.: granular; N.A.: not available.

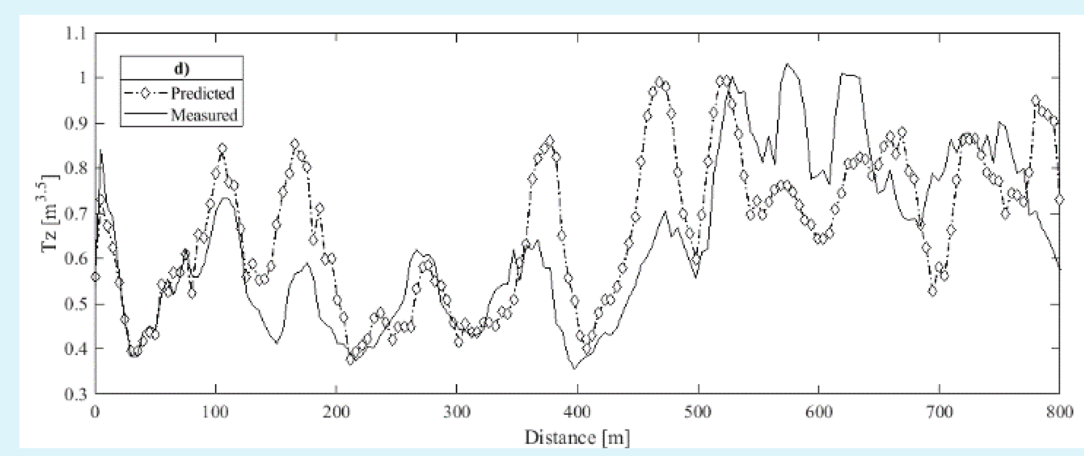
According to the information gathered from cores and after a preliminary analysis of the GPR data, the road stretch was divided into two sub-sections, homogenous in terms of pavement structure and main configuration.

Calibration of the model parameters for these two sub-sections was performed on a randomly-selected percentage of 5% of the overall data.



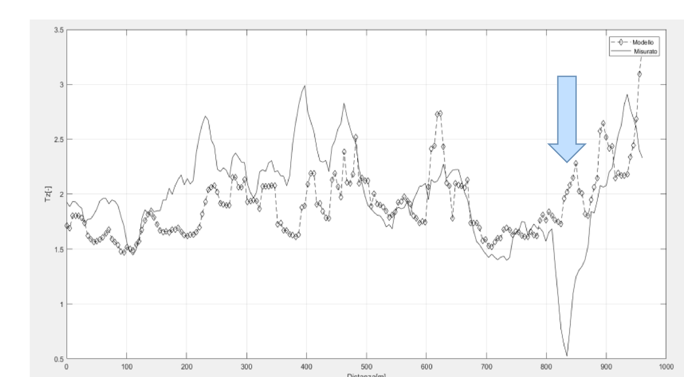






The final optimised modelled value of bearing capacity Tz' was eventually compared with the measured value of bearing obtained from the Curviameter measurements.
Comparison shows a very limited mismatching between predicted and measured bearing capacity values. To support this evidence, **an average NMRSD value of 7% was observed, with a corresponding standard deviation of 3.7%.**

Peak values of both the EM signal and deflections from the Curviameter were considered as outliers and excluded from the analyses.



It was observed that these values were mainly due to the presence of small bridges and water drainage systems along the scanning direction.

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