EMPIRICAL PREDICTION OF MECHANICAL PROPERTIES OF FLEXIBLE PAVEMENT THROUGH GPR

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AIMS & OBJECTIVES

This work presents a GPR-based empirical model for the prediction of the bearing capacity of a road pavement, expressed as Stiffness Modulus.

METHODOLOGY

The modelling has involved the following steps:

1. on-field experimental activity
2. parameters calibration
3. model application on the database

The exprimental activity can be summarized as follows

- Multi-frequency GPR surveys using Horn Antennas $[1000MHz - 2000MHz]$
- Light Falling Weight Deflectometer (LFWD) as ground-truth stiffness data
- Real scale highway investigated $(1500m)$ nearby Rieti, Italy.
- Georeferencing of the data from NDTs by GPS

LFWD measurements resulted in an "equipollent elastic modulus", so defined:

$$E = \frac{\kappa(1-\nu^2)\sigma R}{\delta_c} \quad (2)$$

- $\kappa = 2$ in the case of flexible pavements
- δ_c being the deflection at the center of the plate $[\mu m]$
- σ being the load stress $[MPa]$ and R being the plate radius $[mm]$

GPR data were used for extracting:

- the thickness of the bound courses τ_b
- an attenuation coefficient γ

MODELLING

The following Empirical Model for predicting the Stiffness E_x at the position x is herein proposed:

$$E_x = \alpha(E_x)\beta\gamma_x\tau_{b,x} \quad (1)$$

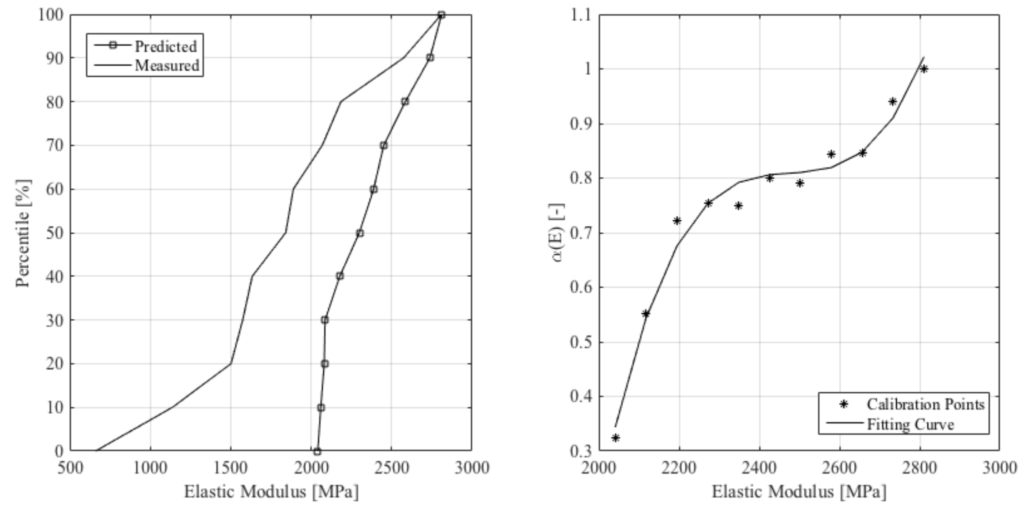
with $\alpha(E_x)$ being a fitting function and β $[MPa \times m^{-1}]$ being a scale factor to be calibrated.

CALIBRATION

A $100m$-long section, has been **randomly** selected for calibration purposes. This distance represents less than 10% of the full distance of $1500m$ covered in the survey.

$$\beta = \frac{E_{LFWD,MAX}}{\tau_{b,MAX}} \quad (3)$$

where $E_{LFWD,MAX}$ and $\tau_{b,MAX}$ are the maximum values of stiffness and thickness recorded amongst the calibration section from LFWD and GPR surveys, respectively.
$\alpha(E)$ was defined as the ratio of the modelled to the measured stiffness percentiles and represents a reductive factor for compensating the overestimation due to the definition of β.



$$\alpha(E) = \sum_{i=0}^{3} a_i E \quad (4)$$

Coefficient	a_0	a_1	a_2	a_3
	-22.62	0.027	-1.24×10^{-6}	-1.74×10^{-9}

RESULTS

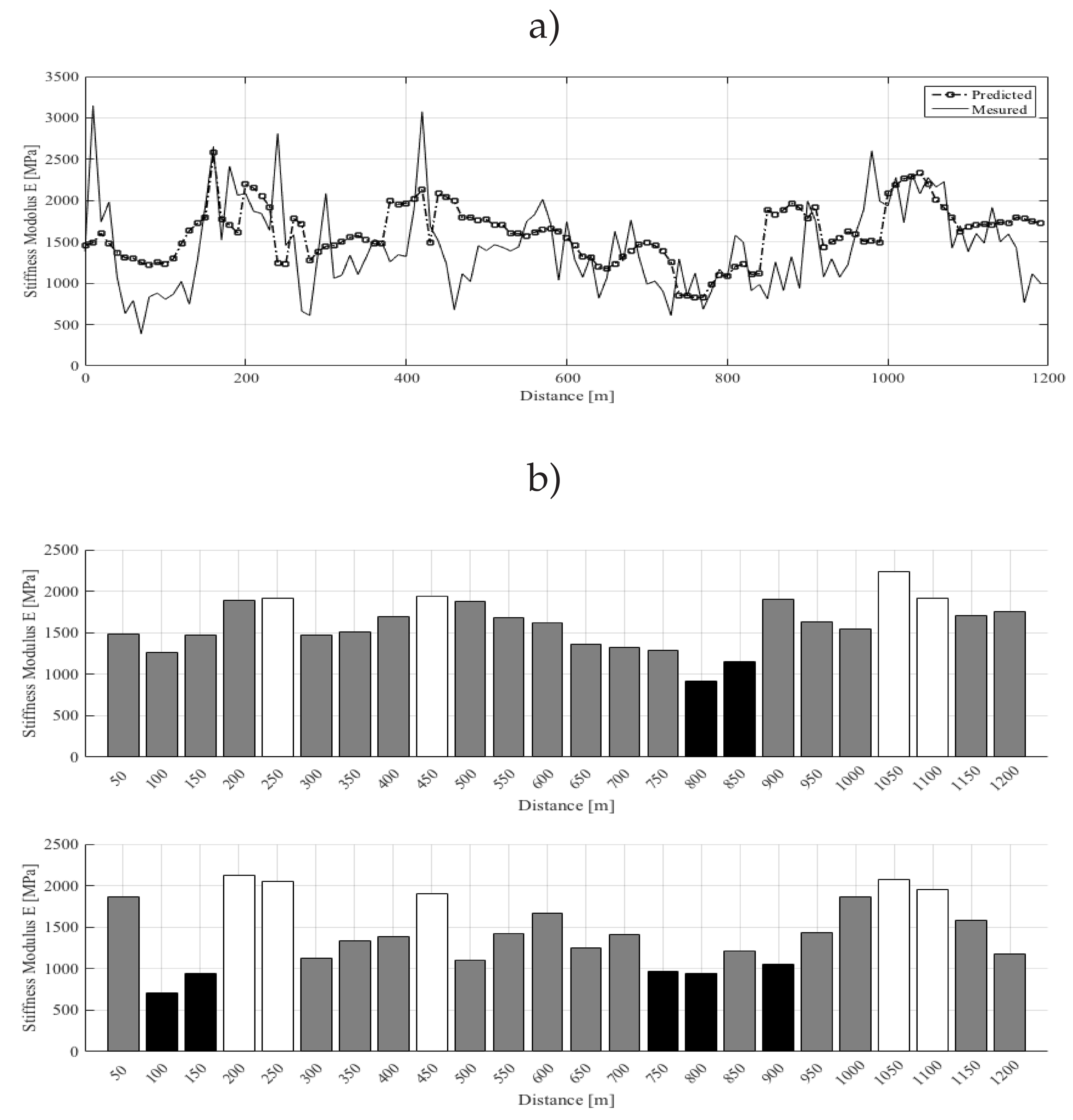
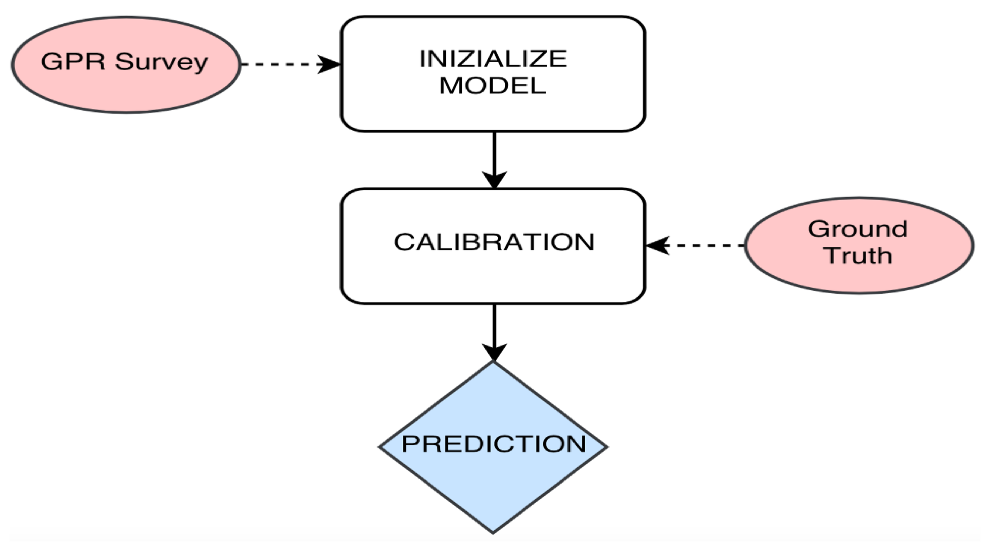


Figure 1: First plot (a) shows the result from a random extractions of the calibration length, while (b) plots shows a quantitative results for the predicted (above) and measured(below) modulil. Stiffness were divided into 3 classes: < 800 MPa, $800 - 1400$ MPa, > 1400 MPa

CONCLUSIONS



This study proposes a GPR-based model for the prediction of the stiffness in flexible pavements with substantial outcomes. Major novelties introduced are:

- Comprehensive input parameters (geometrical and physical)
- Efficient calibration (10% ground-truth data)
- Quantitative & qualitative data output

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FUTURE RESEARCH

- Calibration of model parameters for different flexible pavement configurations
- Use of different and more comprehensive NDTs for ground-truth measurements (FWD, e.g.)
- Use of temperature-based coefficients

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