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MACHINE LEARNING FOR NATURAL FIBRE-REINFORCED COMPRESSED EARTH BLOCKS

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ABSTRACT
For centuries, natural fibres have found wide application in traditional natural building materials, such as earth. However, the great variety of fibres in nature and the extreme variability between them make the design of modern blends difficult. The aim of this study is tocontinuetoinvestigatethepossibilityofusingartificialneuralnetworkstodeveloppredictive modelsthatsupportthedesignofcompressedearthblocksreinforced-withrandomlydistributed naturalfibres.Realandsyntheticdatafromliteratureminingformthedatabaseused-totrainthe network. The overall results show a very high prediction accuracy. For example, a correlation coefficient (R-value) of 0.97 was found for the prediction of the compressive strength value.

INTRODUCTION
Natural materials are gaining increasing interest due to the sustainability issues in the construction sector. Exploring new material design spaces is indispensable to promote innovation in this research field, but the great variability of natural elements makes the task hard to execute. Compressed earth blocks are a modern application of earth as a construction material. It is well known that earth suffers from certain problems such as durability, dimensional instability, brittleness, low mechanical strength, etc. (Turco et al., 2021b). For thesereasons,inadditiontovariouschemicalstabilisers(lime,cement),theadditionofnatural or synthetic fibres in the mixture design is being increasingly experimented. However, the literature underlines the effort that the experimental determination of the physical-mechanical characteristics of this construction material requires (Fabbri et al., 2022). In order to obtain reliable and statistically relevant knowledge of the information sought for the development of each product, extensive experimental campaigns employing large amounts of resources (materials, energy, instruments) are required. Artificial intelligence is a valuable tool in supportingmaterialscienceproblems.Themainadvantage initsapplicationisthatknowledge ofthephysicsgoverningthebehaviourofthematerialtobedeveloped,improvedoroptimised isnotrequired formachine training.Infact, machine learning models are trainedon databases andtherelationshipbetweentheinputvariablesandtheoutputissought.Basedontheprevious work (Turco et al., 2021a), the enhanced Artificial Neural Networks (ANN) model for the prediction of natural fibre-reinforced compressed earth blocks' mechanical properties is proposed in this paper.

RESULTS AND DISCUSSION
Data from literature mining and synthetic data are used to train the model. Features include mix design proportion (soil, binder, natural fibers and water content), curing time, fibers' properties (aspect ratio, tensile strength). Due to the lack of comprehensive data available in the literature, predictions are limited to blocks' mechanical characteristics. The available database was randomly divided as follows: 70% is used for training the network,

15% is used for validating the model and the remaining 15% is finally used for testing the model.
The graph in Figure 1 (left side) shows the result of the regression model obtained from the neural networks. The dotted line represents the ideal scenario in which the predicted compressive strength value coincides with the objective, or actual, value. The overall results show very high prediction accuracy. For example, a correlation coefficient (R-value) of 0.97 was found for the prediction of the compressive strength.randomly divided as follows:70% is used for training thenetwork, 15% is used for validating the model and the remaining 15% is finally used for testing the model.
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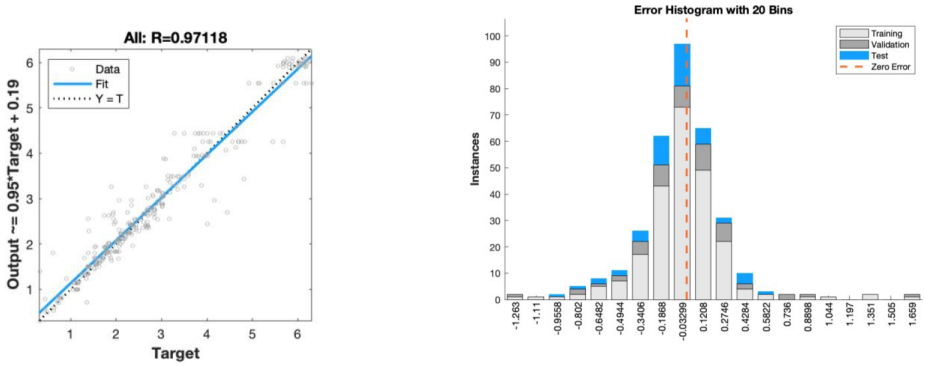

Fig.1 Accuracy of the regression model (left) and error distribution (right).

The developed computational tool allows to:
• Switch from systematic or random (trial-and-error) exploration approach to a more performing targeted mixture design approach.
• Perform several computer simulations and improve the knowledge of the problem, transforming some variables in design priority.
This study represents one of the first attempts to apply machine learning in the field of an all-natural building material (earth + natural fibers) for modern applications. The authors are aware of the small size of the database compared to other fields of application; however, it also represents an attempt to raise awareness of sharing experimental data and information relevant to the development of a robust model.

ACKNOWLEDGMENTS

This work was funded by the FCT, under grant agreement UIBD/150874/2021 attributed to the first author. Thiswork wasalso partly financed by Fundação “La Caixa”, under the reference PV20-00072, and FCT/MCTES through national funds (PIDDAC) under the R&D Unit ISISE, under reference UIDB/04029/2020.

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