Measurement 225 (2024) 114006

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Surface response regression and machine learning techniques to predict the characteristics of pervious concrete using non-destructive measurement: Ultrasonic pulse velocity and electrical resistivity

Navaratnarajah Sathiparan [a,*], Pratheeba Jeyananthan [b], Daniel Niruban Subramaniam [b]

[a] Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Sri Lanka
[b] Department of Computer Engineering, Faculty of Engineering, University of Jaffna, Sri Lanka

ARTICLE INFO

Keywords:
Pervious concrete
Ultrasonic pulse velocity
Electrical resistivity
Surface response regression
Machine learning

ABSTRACT

It is crucial to assess the characteristics of pervious concrete even post-construction. The quality monitoring of such a procedure is tricky in pervious concrete that it is typically avoided. As a potential means of enhancing the aforementioned quality control, the current study investigates the possibility of predicting characteristics of pervious concrete through response surface methodology and machine learning techniques using non-destructive test measurement (ultrasonic velocity and electrical resistivity). A total of 225 datasets from the experimental study were taken for this study. To recognize the best reliable model for predicting characteristics of pervious concrete, response surface methodology up to sixth order polynomial and five different machine learning techniques were used as statistical assessment tools. Using both ultrasonic pulse velocity and electrical resistivity as predictors for estimating porosity and compressive strength via response surface methodology, using a quadratic model for porosity prediction and a cubic model for compressive strength prediction are recommended. The machine learning models used in the research exhibited superior performance compared to the response surface methodology. Among the many machine learning models evaluated in this study, boosted decision tree regression model better predicted porosity (R^2 = 0.92) and compressive strength (R^2 = 0.92) of pervious concrete. Therefore, prediction models for the characteristics of pervious concrete are created using non-destructive measurement and machine learning techniques, which may ensure that the construction sector can utilize the offered models without any theoretical expertise.

1. Introduction

Pervious concrete has garnered significant interest in contemporary literature owing to its potential in many applications, including but not limited to parking lots, pedestrian pathways, residential streets, regions with minimal traffic, and greenhouses. The composition of the previous concrete mixture is characterized by a reduced or no proportion of fine aggregate, leading to a more porous structure. Additionally, the coarse aggregate exhibits a rather uniform size distribution. Two crucial elements for recommending pervious concrete in its use are porosity and compressive strength. Pores in pervious concrete are created by the presence of empty spaces between particles that are covered with cement paste. Pervious concrete is often characterized by a porosity of 15 % to 35 %, hence qualifying it as a pervious material [1–3]. The range of compressive strength is reported to exhibit variability between 3 and 30 MPa, as study [4] shows. The properties of pervious concrete are influenced by the quality and quantity of its component materials, including cement and aggregates. Additionally, many mixed design factors, such as the ratio of aggregates to cement, the ratio of water to cement, and the level of compaction effect, all play a role in determining the characteristics of pervious concrete [4]. Nevertheless, it is essential to note that despite the similarity in formulation design, compaction levels and the boundary effect may lead to considerable differences in the properties of individual components of pervious concrete when applied in an industrial setting, as opposed to the initial design expectations [5]. Therefore, evaluating the characteristics of pervious concrete, even after its construction, is essential.

Ensuring quality is most effectively achieved through laboratory testing; nevertheless, the issues of accessibility, cost, and time can pose considerable obstacles, particularly in remote regions. Hence, it is

* Corresponding author at: Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Ariviyal Nager, Kilinochchi, Sri Lanka.
E-mail address: sakthi@eng.jfn.ac.lk (N. Sathiparan).

https://doi.org/10.1016/j.measurement.2023.114006
Received 23 August 2023; Received in revised form 26 October 2023; Accepted 6 December 2023
Available online 10 December 2023
0263-2241/