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Investigation of impact of aggregate shape on pervious concrete using machine learning classification methods

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ABSTRACT

Optimizing compaction energy reduces uncertainty in mass production of pervious concrete, but depends on aggregate-shape. This study analyses impact of aggregate size and shape on porosity and compressive strength. Aggregate-to-cement-ratio (AC) (3–5), compaction (Comp) (0–60 blows), aggregate-size (5–25 mm) and aggregate-shape (0, 200 and 1000 revolutions in Los Angeles Abrasion Value) were used to cast 486 samples. Porosity was computed from constituent-ratios (T.Poro) and apparent-weight (M.Poro) and Compressive-strength (Com.S) using Universal Testing Machine. M.Poro and T.Poro had significantly different impact from size and shape of aggregates. Feature selection models, Minimum-Redundancy-Maimum-Relevance (MRMR) and Kruskal-Wallis had significantly different ranking of features, owing to the different concepts. MRMR indicated dominance of M.Poro while a tenth of which was observed for Com.S and less than a twentieth for T.Poro. MRMR indicated significant impact of aggregate size (second highest score, half of M.Poro), indicating the impact aggregate shape had on performance was not uniform across different size of aggregates. Three performance parameters (M.Poro, T.Poro and Com.S) classified observations for aggregate shape (degree of milling) with an accuracy of 92.2% and 93% on Support-Vector-Machine (SVM) and K-Nearest-Neighbours (KNN) algorithms. Inclusion of aggregate size as feature improved accuracy to more than 96% while further inclusion of AC Comp improved the accuracy further to 99.6%. Classification of aggregate size was less accurate (70–80% with performance parameters alone and 92–93% with three design parameters included), indicating less impact on pervious concrete performance compared to shape of aggregates.

1. Introduction

Unlike traditional concrete, pervious concrete has a unique porous structure with interconnected voids that allow water to pass through easily (Chandrappa and Biligir, 2016; Zong et al., 2018). This type of concrete comprises of coarse aggregates, cement (binder), water, and interconnected pores, with the pores occupying approximately one-third of its volume. Due to absence of fine aggregates, pervious concrete has porous structure (Hui et al., 2023; Singh et al., 2023). Pervious concrete has become a popular choice for permeable pavements in various settings including residential, commercial and industrial zones due to its environmental advantages (Xie et al., 2019). It helps decrease rainwater runoff, improve stormwater infiltration, enhance pavement surface grip, maintain underground water quality, and reduces issues like hydroplaning, heat retention, and traffic noise. Additionally, it aids in capturing suspended solids, biochemicals, and chemical oxygen demand, while keeping ammonia levels in check within the pavement infrastructure (Diets, 2007; Scholz and Piotr, 2007; Xie et al., 2019). Furthermore, its structure acts as a natural aerobic bioreactor, which reduces hydrocarbon pollution and mineral oil buildup on pavement surfaces (Lian and Zhuge, 2010b; Pieralisi et al., 2015; Sathiparan et al., 2024b).

Contemporary studies on pervious concrete, mostly found since late 2010's, have harnessed exponentially increased attention, owing to its potential as a sustainable material for urban development. Studies are mostly based on laboratory scale experiments with few studies testing

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