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Review

Research and application of pervious concrete as a sustainable pavement material: A state-of-the-art and state-of-the-practice review

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HIGHLIGHTS

- State-of-the-art regarding pervious concrete materials is reviewed.
- State-of-the-practice of pervious concrete for paving is presented.
- Pore system characterization methods for pervious concrete are documented.
- Pervious concrete was found to be promising for paving applications.
- Challenges and future works are discussed.

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ABSTRACT

Pervious concrete (PC) has gained renewed interest in the past decade due to its positive environmental impacts. Extensive research employing a variety of strategies has been conducted to improve the overall performance of PC. Numerous literatures have been published. With the advances in high performance pervious concrete (HPPC), widespread application of this material has been made possible. This paper reviews the state-of-the-art and state-of-the-practice research and application of PC. Emphasis has been laid on the pore system characterization (PSC) and its influence on the mechanical, hydraulic and acoustical properties of PC. Among the various applications of PC, this review focuses on its application as a sustainable pavement construction material.

Contents

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1. Introduction

Pervious concrete (PC), also known as porous or permeable concrete, is a class of concrete characterized by a relative high volume of connected pores, typically in the range of 15% to 30% with pore sizes ranging from 2 to 8 mm [1], and a water permeability of about 2–6 mm/s [2,3]. This is achieved by intentionally incorporating continuous voids through gap grading the coarse aggregate and eliminating or minimizing the usage of fine aggregate. Typical designs of PC are presented in Table 1. The American Concrete Institute (ACI) defines PC as "concrete containing little, if any, fine aggregate that results in sufficient voids to allow air and water to pass easily from the surface to underlying layers" [4].

Although PC has been used for over 30 years, the material is attracting renewed interests recently. It is attributable to the Federal Water Pollution Control Act [12] and the Environmental Protection Agency (EPA) storm water regulations [13] that require control of both the quantity and quality of storm water runoff. The ability to allow water penetrating through its open pore structure makes PC a very effective tool to control storm water runoff. Additionally, the rapid expansion of impermeable surfaces and associated issues such as heat island effect, tire-pavement interaction noise, ground water depletion and traffic safety is another factor contributing to the increasing popularity of this material, as PC demonstrates potential to resolve these issues [14,15]. Therefore, it is promoted as a construction material for parking lots and road surfaces. Fig. 1 schematically illustrates the advantages and disadvantages of PC in comparison to conventional impervious concrete (CIC).

Fig. 2 shows the number of publications related to PC over the last decade. A survey of the literature indicates that this development spreads over the major continents, and is particularly intense in Europe, US and Japan. It indicates that we have entered an intense phase of research on the development of high performance pervious concrete (HPPC) and the pace of research will likely continue to accelerate. There has been a number of review articles on PC [16–18]. The purpose of this article is not to repeat these reviews, but rather to promote the concept of sustainable pervious concrete pavement (SPCP). Therefore, the literatures referenced are not meant to be exhaustive of what has been published. Specifically, this paper is aimed at highlighting the advantages and limitations of PC, to stimulate additional research to overcome current obstacles, and to generally accelerate convergence of PC technology developments that support the realization of SPCP. In light of that both structural and functional properties of PC pavement are dependent on the pore system characteristics (PSC) of PC [19–21], the review has been focused on the quantification of PSC and their influence on the mechanical, hydraulic and acoustic performance of PC. As for the structural application of PC, emphasis was laid on pavement.

Table 1
Typical compositions of PC.

Water to binder ratio (*w*/B)	Aggregate to binder ratio (A/B)	Fine sand (%)	Authors
0.26 ~ 0.33	3.2 ~ 3.7	0 ~ 15	Kevern et al. [5]
0.32 ~ 0.33	1.7 ~ 6.0	–	Deo at al. [6]
0.22 ~ 0.55	2.5 ~ 3.5	–	Zhong and Wille [7]
0.25 ~ 0.35	3.2 ~ 3.9	–	Yang [8]
0.37 ~ 0.42	2.9 ~ 4.2	–	Ghaffori and Dutta [9]
0.27 ~ 0.35	3.4 ~ 4.5	0 ~ 6.5	Huang et al. [10]
0.27 ~ 0.51	4.0 ~ 4.7	0 ~ 20	Meininger [11]

2. Pervious concrete

2.1. Pore system characterization

2.1.1. Porosity

Porosity is one of the most important PSC. However, there is still confusion as to the definition of porosity and which type of

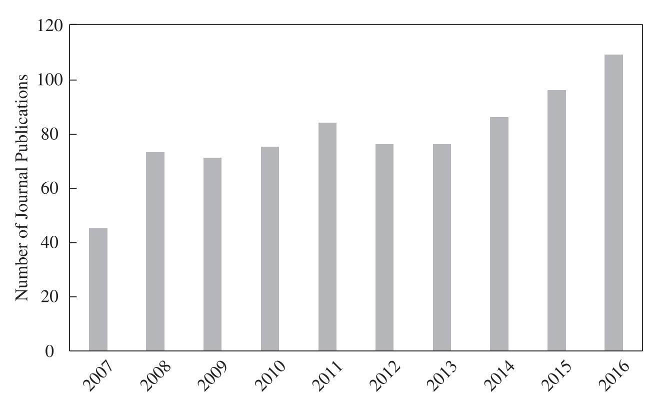

Fig. 2. Archived journal publications on PC over the last decade (2007–2016) (Source: Google Scholar online).

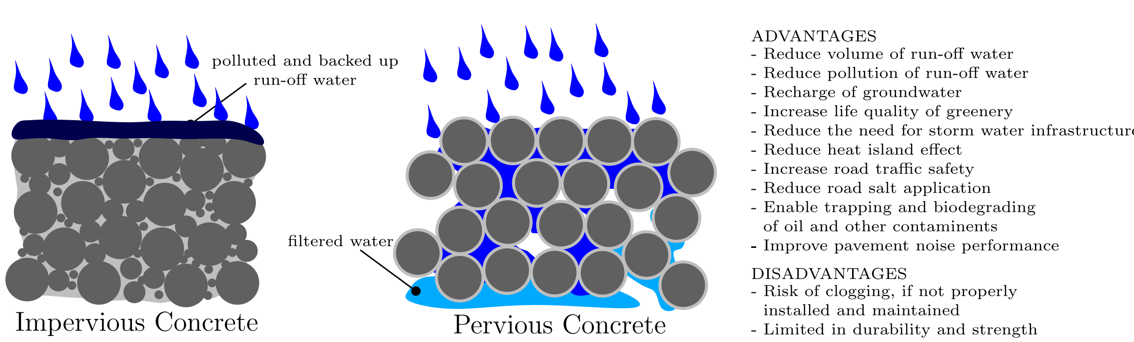

Fig. 1. Comparison of PC to CIC.