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Pervious concrete as environmentally friendly materials-an overview

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Abstract

Pervious concrete contains a mixture of water, cement, coarse aggregates and little or no fine aggregates. Pervious concrete is increasingly known as an environmentally friendly material due to its usefulness in improving water quality by removing all suspended solid particles in the flood, reducing the flow of flood water, reducing the heat island effect and other environmental benefits. In this article, the results of valid research on the physical (slump, density, porosity, water permeability) and mechanical (compressive strength, flexural strength, splitting tensile strength) properties of Pervious concrete have been briefed and reported. (DOI:https//**doi.org/10.52547/JCER.4.2.34**)

Keywords: Pervious concrete, porosity, permeability, environmentally friendly, mechanical properties

1. Introduction

Concrete pavement is known as a pavement with a long life. The use of conventional concrete as a paving material has caused some problems such as drainage for the flow of water caused by floods, as well as high noise compared to other types of pavements. Considering the negative effects of conventional concrete paving, the idea of using Pervious concrete (also called porous concrete or

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concrete with improved pores) in paving streets and sidewalks has been proposed for about 150 years [1,2]. Pervious concrete includes a mixture of water, cement, coarse aggregates and little or no fine aggregates [3,4]. Because Pervious concrete has a lot of empty space, its density, compressive strength and thermal conductivity are lower than normal concrete [5]. Pervious concrete is increasingly used due to its usefulness in improving water quality by removing all suspended solid particles in the flood, reducing the flow of flood water (Fig.1) and improving the sliding resistance of the pavement by rapid water drainage during storm events, reducing Sound leveling on the site, improving the visibility of the pavement surface, reducing the heat island effect, are used [1,6,7]. Therefore, Pervious concrete can be used as an environmentally friendly material in pavements with low traffic volumes, roads, alleys, urban streets, crossings and sidewalks, open parking areas, tennis courts, and as a base for conventional concrete pavements. , patio (private yard), artificial rocks, slope consolidation, tree network on sidewalks, hydraulic structures, drainage edge of pavements, sound insulation, load-bearing walls [6]. In this article, the results of valid research on the physical and mechanical properties of Pervious concrete have been briefed and reported.

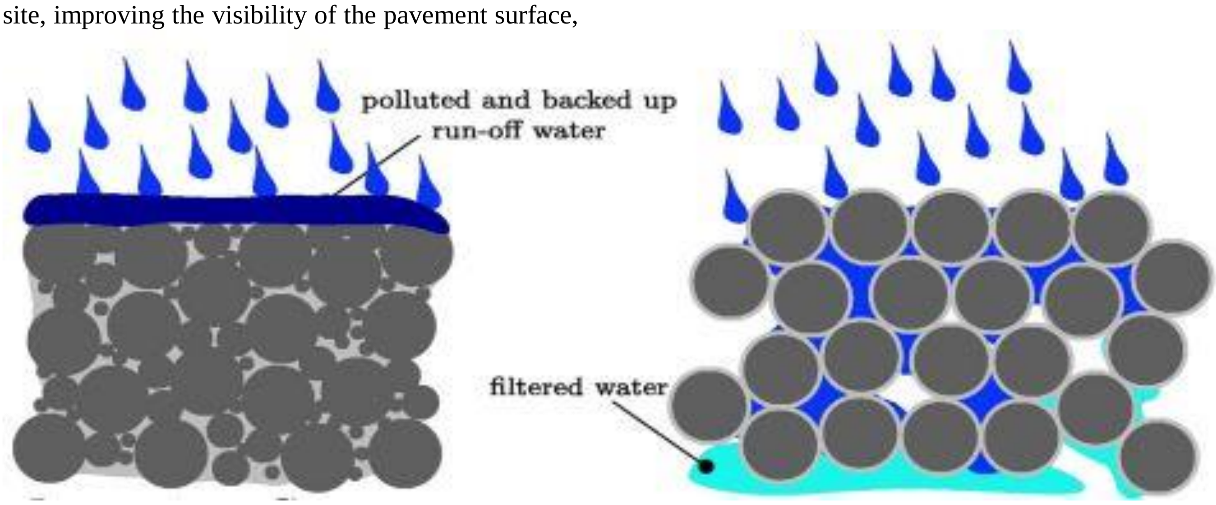

Fig . 1. Comparison of impervious concrete and pervious concrete [8].

2. Physical properties

2.1. Slump

Fresh Pervious concrete is very hard due to its water-to-cement ratio and low volume of cement paste, so it has low or even zero slump [9]. In the research of El-Hassan et al. [10], for the ratio of W / C = 0.4, the slump is in the range of 35-81 mm, while in the research of Nguyen et al. [9], for the ratio of W / C = 0.3, the slump is zero (Fig. 2) has been reported.

Fig. 2. Consistency of fresh Pervious concrete [9].

2.2. Density

Sata et al. [5], in a research, used natural limestone (NA), recycled concrete (RC) and recycled clay brick (RB) in the form of coarse aggregate in the size of 4.5-9.75 mm to make Pervious geopolymer concrete (PGC) (Fig. 3). The density of Pervious concrete with NA , RC and RB were reported in the range of 1710-1730 and 1420-1520 kg/m3, respectively. Cosic et al.[3], in a research of dolomite aggregate in sizes 0-4,4-8,8-16 mm, 10% sand in size 0-2 mm and steel slag in sizes 16-8,8-4 mm , used 10% sand in the size of 0-2 mm to make Pervious concrete. The results of their research showed the density of Pervious concrete in the range of 2076.6 - 2442.4 kg/m3.

(a) NA

(b) RC

.

(c) RB

Fig. 3. Comparison of coarse aggregate [5].

2.3. porosity

Total porosity is the sum of open and closed porosity in Pervious concrete and depends on aggregate porosity and binder amount. Open porosity (Fig. 4) is the effective porosity for water flow to pass through hardened Pervious concrete. In the research of Tennis et al. [6], the of open porosity for the passage of water flow through Pervious concrete was reported as 15-25%. In the researches of Huang et al. [1], Chindaprasir et al. [2], Cosic et al. [3], Zhang et al. [4], Sata et al. [5], the of total porosity is 20%-30%, 15%-25%, respectively. , 6.3%-22.2%, 15.1%-16.5%, 21.7%-27.4% have been found. The recommended value for the of total porosity according to ACI 522 [11] is 18%-35%.

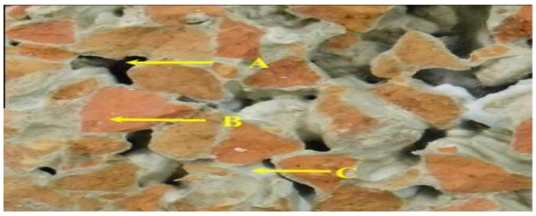

Fig. 4. Fracture surface of PGC containing RB ; (A) open prosity ; (B) fractured RB ; (C) geopolymer paste [5]

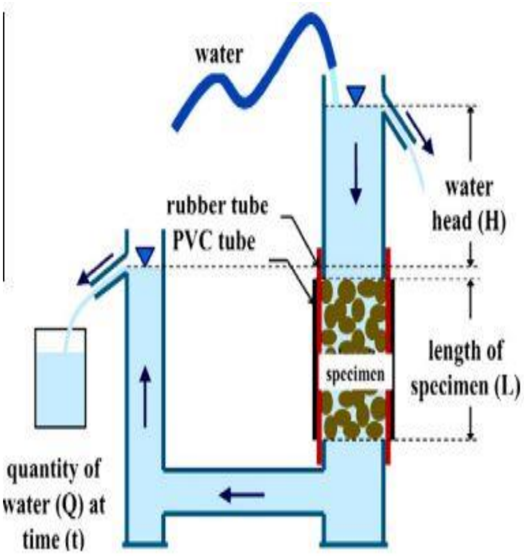

Fig. 5a.The device for measuring water permeability coefficient by constant head method [5].

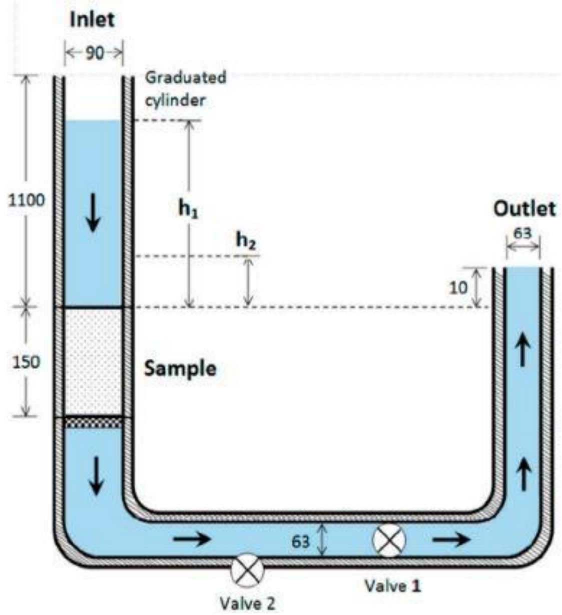

Fig. 5b. The device for measuring water permeability coefficient by falling head method [12].

Fig. 5. The device for measuring water permeability coefficient

In the researches of Tennis et al. [6], Huang et al. [1], Zhang et al. [4], Sata et al. [5] and Lee et al. [12], the water permeability coefficient is 2-5.4 mm/s, 10-20 mm/s, 3.1-3.8 mm/s, 7.1-17.1 mm/s and 1.2-18.4 mm/s have been reported respectively. The recommended value for the water permeability coefficient according to ACI 522 [11] should be more than 1mm/s. The results of Huang et al.'s research [1] showed that three types of single size coarse aggregates (4.75, 9.5, 12.5mm)did not have a great impact on porosity and permeability coefficient. Also adding latex and sand reduced a small amount of porosity and permeability coefficient, but the simultaneous combination of latex, sand and fibers did not reduce porosity and permeability coefficient.

3. Mecanical properties

3.1. Compressive strength

In their research, Sata et al [5] investigated the 7-day compressive strength of cylindrical samples with a diameter of 100 mm and a height of 200 mm. The compressive strength for NA, RC and RB mixtures was reported in the range of 11.9-13.6 Mpa, 7-11.3 Mpa and 2.9-6.6 Mpa, respectively. In their research, they found that like conventional concrete with increasing density, the compressive strength as shown in Figure 6 Given, it improves. In their research, Cosic et al. [3] investigated the 28-day compressive strength of 150 mm cubic samples. They reported compressive strength in the range of 20.2-69.5 Mpa. In the study of Chindaprasir et al [2], the compressive strength of cylindrical samples with a diameter of 100 mm and a height of 200 mm for total porosities of 15%, 20% and 25% were found in the range of 38-44 Mpa, 29-35 Mpa and 15-22 Mpa, respectively. Huang et al. [1] reported the 7-day compressive strength of cylindrical specimens with a diameter of 152 mm and a height of 305 mm in the range of 15-5 Mpa. In their research, they found that replacing natural coarse aggregate with 7% sand and replacing 10% cement with latex improves the compressive strength compared to the control sample. Adding fibers in samples without sand and latex also improves the compressive strength. Mixtures with sand, fibers and latex did not improve the compressive strength further. Zhang et al. [4] reported the 28-day compressive strength of rectangular cube samples with dimensions of 150*150*300 mm in the range of 15.5-24.2 Mpa. In their research, they found that with the increase of the crushing index, the compressive strength decreased. Lee et al. [12] reported the 28-day compressive strength of cylindrical samples with a diameter of 100 mm and a height of 200 mm in the range of 12.6-52.76 Mpa. They found that the 90-day and 28-day compressive strength values are close to each other, and the addition of glass and steel fibers increases the compressive strength.

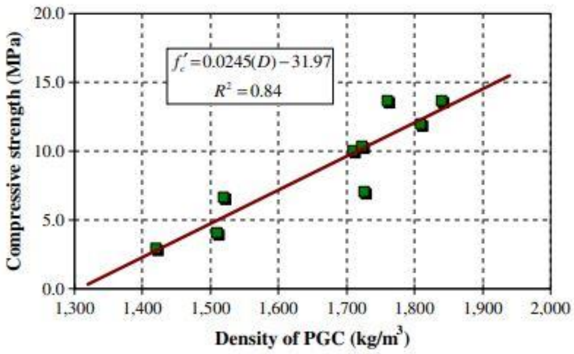

Fig. 6. Relationship between compressive strength at the age of 7 dayes and density of PGC [5].

3.2. flexural strength

In their research, Cosic et al [3] investigated the 28-day flexural strength of rectangular cube samples with dimensions of 100*100*400 mm. They reported flexural strength in the range of 4-9.7 Mpa. Zhang et al. [4] reported the 28-day flexural strength of rectangular cube samples with dimensions of 150*150*600 mm in the range of 2.55-3.56 Mpa. In their research, they found that with the increase of the crushing index, the flexural strength decreased. Lee et al. [12] reported the 28-day flexural strength of 100*100*350mm rectangular cube samples in the range of 3.02-8.48 Mpa. They found that the addition of glass and steel fibers resulted in increased flexural strength. El-Hassan et al [10] in their research used rectangular cube samples with dimensions of 150*150*450 mm to test the flexural strength. The results of their research showed the flexural strength at the age of 28 days in the range of 0.93-3.15 Mpa.

3.3. Splitting tensile strength

In their research, Sata et al. [5] investigated the 7-day splitting tensile strength of cylindrical specimens with a diameter of 100 mm and a height of 200 mm. Splitting tensile strength for NA, RC and RB mixtures was reported in the range of 1.5-1.8 Mpa, 1.3-1.5 Mpa and 0.4-0.9 Mpa, respectively. Huang et al. [1] reported the 7-day splitting tensile strength of cylindrical specimens with a diameter of 152 mm and a height of 76 mm in the range of 0.55-1.9 Mpa. They found that mixing with aggregates with a smaller diameter resulted in Pervious concrete with higher splitting tensile strength, and the effect of replacing coarse aggregate with sand sometimes caused a decrease in tensile split strength. Replacing cement with latex and adding fibers increased the splitting tensile strength. Nguyen et al. [9] reported the splitting tensile strength for cubic specimens with dimensions of 150 * 150 *150 mm at the age of 28 days in the range of 1.78-2.56 Mpa (Figure 7a). They found that the splitting tensile strength (Rt) is proportional to the compressive strength (Rc) and their relationship is linear (Figure 7b). El-Hassan et al. [10] in their research used cylindrical samples with a diameter of 150 mm and a height of 300 mm to test the splitting tensile strength. The results of their research showed the splitting tensile strength at the age of 28 days in the range of 0.68-3.1 Mpa.

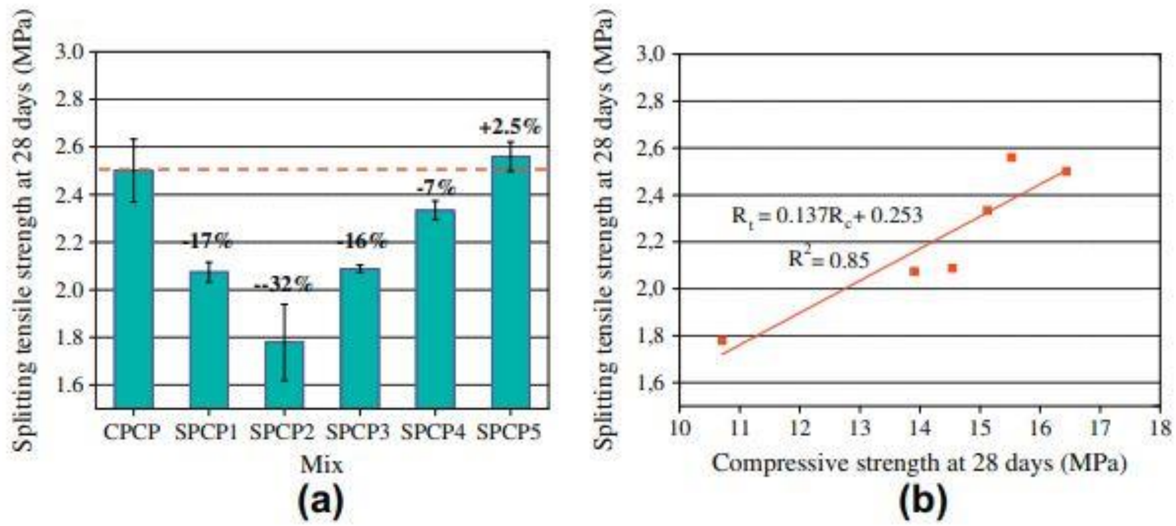

Fig. 7. splitting tensile strength test at 28 dayes (a) and relation between splitting tensile strength and compressive strength (b) [9].

4. Conclusion

In this article, the physical and mechanical properties of Pervious concrete in the researches conducted in the past are reported in summary form. The most important results of these studies are as follows:

1) Slump of Pervious concrete is less than conventional concrete and can even be zero. Slump of Pervious concrete is dependent on the ratio of water to cement and the amount of cement paste. The maximum slump of Pervious concrete has been reported 81mm with a ratio of W/C = 0.4.

2) The density of Pervious concrete is lower than the density of conventional concrete due to higher porosity, which depends on the density of aggregate and the amount of cement paste. The density value of Pervious concrete is reported in the range of 1420-2442.4 kg/m3.

3) Total and open porosity have been reported in the range of 6.3%-30% and 15%-25%, respectively, and the recommended value for total porosity according to ACI 522 [11] is 18%-35%.

4) The water permeability coefficient was reported in the range of 1.2-18.4 mm/s, which was higher than the minimum recommended value according to ACI 522 [11].

5) Pervious concretes had lower compressive strength due to higher porosity than conventional concretes. The compressive strength depended on the type and amount of binder and aggregate strength. The 28-day compressive strength of cylindrical samples with a diameter of 100 mm and a height of 200 mm has been reported in the range of 12.6-52.76 Mpa. Like conventional concrete, the compressive strength increased linearly with the increase of density in Pervious concrete.

6) The 28-day flexural strength of Pervious concrete is reported in the range of 0.93-9.7 Mpa, and the addition of glass and steel fibers increased the flexural strength.

7) 28-day splitting tensile strength of Pervious concrete, considering the type of sample, has been reported in the range of 0.68-3.1 Mpa, and replacing cement with latex and adding fibers in the mixture increased the splitting tensile strength.

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