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Review:

A Shed the light on the properties of pervious concrete

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Abstract:

Pervious concrete is considered one of the important elements in establishing sustainable cities because it is characterized by its open voids structure, which allows it to have specific applications such as residential roads, pervious pavements, sidewalks, alleys, parking lots, patios, and so on. It is of great benefit because it allows water to penetrate through it due to little its cement content and the available voids, and thus it maintains this water cycle and on the other hand it works as a water purifier from pollutants. Although its resistance is relatively little compared to normal concrete, it has some important characteristics that made it one of the most important types of concrete used in paving paths and roads of little and medium traffic volume. For these reasons, we focus on the various properties of previous concrete in this article.

Key words: fresh properties; durability properties; hardened properties; pervious concrete.

I. Introduction

Many variations happened on the environmental because of people when they build roads and constructions. One of these variations is related with build of new impervious areas instead of places that were primarily permeable. Impervious areas such as roadways, garages and homes were preventing the water from infiltrating soil underneath.

Since, there is an inverse relationship between the environment and the increase in the impervious areas. This truth leads to disturbance in natural water cycles. Thus, the flow of water during storms and snow melt will be very fast, because we prevented the water from infiltrating into the soil. Finally, that's lead to (1) decreased the level of underground water, (2) change in the natural flow figures of a drainage tub, and (3) Transfer of pollutants from impervious surfaces to future water bodies .[1]

One solution to this problem is to use pervious concrete, which is a special high porosity concrete mainly consisting of paste (cement and water) and aggregate with little or no sand [2, 3, and 4]. Also, previous concrete has many names such as porous concrete, permeable concrete, no-fines concrete, gap-graded concrete, and enhanced-porosity concrete [5].

In spite of the fact that, pervious concrete not a new building material since its found in 1852 [6] but, it is highly utilized in different infrastructures on account of environmental avails, it is used as pavements, residential roads, alleys, driveways, sidewalks and pathways, parking lots, low water crossings, tennis courts, subbase for conventional concrete pavements, patios, artificial reefs, slope stabilization, well linings, tree grates in sidewalks, oundations/floors for greenhouses, fish hatcheries, aquatic amusement centers and zoos, hydraulic tructures, swimming pool decks, pavement edge drains, groins and seawalls, noise barriers, and walls [7].

II. Literature review

Since the pervious concrete has several benefits as mentioned above, and the most important of these benefits is the environmental benefit, the focus of this article will be on the fresh characteristics, mechanical characteristics and durability characteristics of this type of concrete.

2.1 Fresh characteristics

According to literature the consistency there is no or little slump for pervious concrete [8]. This behavior is due to low cement paste content leading to create a thin film of layer surrounds the aggregate particles [3]. To get this type of concrete it's recommended to use low water to cement (w/c) ratio ranging between 0.2-0.25 in addition to superplacticizer and a good mixing [9]. However, in pervious concrete mixtures the w/c ratio between 0.27-0.34 can be considered as the most widely used and common [5]. According to Kováˇc and Si˘cáková [10] reducing the w/c ratio from 0.35 to 0.25 lead to decrease unit weight and increases hydraulic conductivity and void content.

When comparing normal concrete with pervious concrete in the plastic state, we find that pervious concrete is stiffer. Slumps of pervious concrete are less than 20mm but, sometimes reach 50mm. While, the densities of pervious concrete are ranging between 1600 – 2000 kg/m^3. However, void contents (porosity) are about 20-25% [5, 4, and 5]. On the other hand, some research found that the porosity of pervious concrete should be between 18-23% [5]. After placing and compacting, the aggregates are tightly adhered each other and showed the property of open matrix such as popcorn [4].

2.2 hardened characteristics

Compressive strength of pervious concrete can be ranged from 3.5 to 28 Mpa, this range provide a wide range of applications [4]. Some researchers showed that 17 Mpa compressive strength is typical for pervious concrete [4, 5], however other researchers concluded that the compressive strength of pervious concrete for pavement applications must not less than 20 Mpa and 10-20 Mpa for nonpavement applications [11]. According to Slovak Office of Standards [12], explained that the minimum compressive strength for drainage layer is 10 Mpa and 25 Mpa for the abrasive top layer of pavement. Joshi and Dave [13] and Haselbach and Freeman [3] declared that when the w/c ratio decrease the compressive strength of pervious concrete decreases and that opposite the behavior of conventional dense concrete also, they showed that

the pervious concrete mixtures with w/c ratio more than 0.3 can be mixed without need to plasticizers while, when w/c ratio less than 0.3 it needed water-reducing admixtures. Kováˇc and Siˇcáková [2] concluded that the w/c caused only very little differences in strength properties of pervious concrete, though practically sufficient values were achieved: 14.5–17.5 MPa of compressive strength and 1.6–2.0 MPa of splitting tensile strength for w/c ratio between 0.25-0.35. Flexural strength of pervious concrete can be exceeds 3.5 Mpa and this is more enough for low volume pavement applications comprehensive fire trucks and axle loads for garbage trucks [1]. While, some articles shows that it ranges between 1.0 and 3.8 Mpa [3]. Porosity, degree of compaction, and the aggregate-cement ratio are factors that effected on the flexural strength [1].

The permeability which is the flow through pervious concrete depends on the materials properties and placing operations. The permeability of pervious concrete ranges from 0.2 cm/s to 0.54 cm/s and it can be reached to 1.2 cm/s in the laboratory [14].

Drying shrinkage of pervious concrete increases rapidly but it's still less than conventional concrete. It depends on the materials properties and mixtures design, in general Malhotra [15] reached $200x10^{-6}$ drying shrinkage for pervious concrete this behavior may be attributed to low paste and mortar content. Also, Malhotra showed that 50 to 80% of shrinkage occurs in the first 10 days for pervious concrete comparing to 20 to 30% of shrinkage for conventional concrete at the same time, for this behavior and surface texture previous concrete can be made without joints.

2.3 Durability characteristics

Durability of concrete can be defined as the capacity of concrete to withstand abrasion, weathering action, and chemical attack whereas remaining consists of its required engineering characteristics.

The saturation level of the voids in the pervious concrete at the time of freezing effect on freeze-thaw resistance. Neithalath [16] noticed that after 80 cycles of freezing and thawing cycles for pervious concrete (one cycle/day) the previous concrete remained with 95% of dynamic modulus however, it losses more than 50% of their dynamic modulus when subjected to rapid cycles of freezing and thawing (5 to 6 cycles/day). Research which done by Neithalath [16] and Malhotra[15] indicates that the addition of entrained air in the paste will enhance the protection of pervious concrete against freezing and thawing cycles. NRMCA [17] recommended using entraining air in addition to put the pervious concrete on 150-450mm thick of a drainable rock base in the places of freezing and thawing where fundamental moisture will be through conditions of freezing.

Chemical materials which present in soil and water are a source of concern for conventional concrete, so what do you think about an open structure concrete? That will pose a greater risk. However, the pervious concrete can be used in such climates if an insulating layer of concrete with a thickness of

150 mm and a maximum size of aggregate of 25 mm is used in order to serve as a base for storing rainwater and an insulating layer at the same time. If these precautions were not taken into consideration, the recommendations of ACI 201 should be taken into account regarding the proportions of materials and their types and the ratio of water: cement [(1)].

Due to the rough surface texture and open structure of the pervious concrete, the problem of corrosion and loss of cohesion between gravel and cement paste arises, especially when using snow sweepers when snow falls, and this is one of the reasons for which it is not recommended to use pervious concrete for paving in snowfall areas. However, the pervious concrete shows a great speed in melting snow. Most of the paving of the pervious concrete does not suffer from the phenomenon of loss of cohesion between the gravel and the cement paste until after several weeks and by increasing the volume of traffic. To reduce the impact of this problem, special techniques must be found for compaction and curing of the pervious concrete.

III. Conclusions

From the above literatures, it can be abbreviated the following:-

1- Pervious concrete have many applications especially as reservoirs for groundwater and filters for water.
2- Since this type of concrete has low cement paste content, the consistency of it has no or little slump (20-50) mm.
3- w/c ratio ranging between 0.2 to 0.27 and sometimes it can be reached 0.34.
4- All articles agree that the density of the pervious concrete should range between 1600-2000 kg/m^3.
5- In general, compressive strength of pervious concrete ranged between 3.5 to 28 Mpa but, some authors related the compressive strength with the use of pervious concrete. While the splitting tensile strength reached 2.0 Mpa and flexural strength can be exceeds 3.5 Mpa.
6- Permeability of pervious concrete varies between 0.2 to 0.54 cm/s but, in the laboratory it reached 1.2 cm/s.
7- For durability properties, pervious concrete have little durability properties since pervious concrete have open structure and low adhesive forces between cement paste and gravel however, it can utilize pervious concrete for durable purposes but after taking precautions for that.

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