Review of Compaction Energies, Fiber Reinforcement and the Function of Human Hair in Improving Pervious Concrete Properties

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ABSTRACT. Innovative material known as pervious concrete has a porous structure that allows water to pass through it and provides a number of environmental benefits. The goal of the current laboratory investigation is to evaluate the properties of various pervious concrete mixtures subjected to different compaction energies. Various amounts of cement, reinforcing fibers, and aggregates with various physical, chemical, and mechanical qualities have been added to the mixtures, changing the water-to-cement ratio while keeping the aggregate size distribution and paste content constant. Pervious concrete (PC) use has a number of positive effects on the environment, the economy, and society. This study aims to assess the mechanical performance of pervious concrete by adding human hair as a reinforcing component. Fiber-reinforced concrete addresses the inherent tensile weakness of traditional concrete by increasing flexural strength and reducing crack development.

KEYWORDS: Human Hair, Compressive Strength, Pervious Concrete, Fiber-reinforced Concrete

1. INTRODUCTION

Pervious concrete can be defined as an open-graded or concrete allows rainwater to percolate to the underlying sub-base due to its high permeability. Pervious concrete is a form of lightweight porous concrete, obtained by eliminating the sand from the normal concrete mix. The advantages of this type of concrete are lower density, lower cost due to lower cement content, lower thermal conductivity, relatively low drying shrinkage, no segregation and capillary movement of water. Water/cement ratios between 0.27 and 0.30 are used routinely with proper inclusion of chemical admixtures and those as 0.34 to 0.40 have been used successfully. The relation between strength and water/ cement ratio is not clear for pervious concrete because unlike conventional concrete. However, the strength of material is relatively low because of its porosity. The compressive strength of the material can only reach about 20 to 30mpa. Such materials cannot be used as pavements due to low strength [11]. Rainwater is seen getting wasted on the roads due to lack of proper design of drainage system. Construction of Pervious concrete pavement (PCP) is one of the best methods to solve this problem. Due to lack of proper design of drainage system, rain water accumulates on the road. This happens mainly as the drainage systems are already clogged in most of the cities. This problem is serious in large cities and industrial areas, where roads are constructed without designing a sewerage system. It may cause erosion of the road and decrease in lifespan of the road [1]. It is observed that cement can be effectively replaced by fly ash which reduces the cost of pervious concrete. On the other hand, the addition of coal fly ash in the concrete mix is reported to increase the compressive strength of concrete. When added to the mixture, coal fly ash reduces the water demand of the concrete by 5–15 percent. It also has a retarding effect which is gainful in concreting in warm weather [19]. Pervious concrete pavement is a unique and effective means to meet growing environmental demands. Pervious concrete has the same basic constituents as conventional concrete that is, 15% - 30% of its volume consists of interconnected void network, which allows water to pass through the concrete [14]. The condition of parking area infrastructure which in the rainy season occurred water puddles which is a common problem that arises this is due to high rainfall is also not able to absorb rainwater runoff into the soil. The use of natural materials for pavement construction is a must in supporting the achievement of green roads [18]. This paper proposes a new mixture design method for porous concrete, named PCD (porous concrete design), and derived from the ACI 522R-10 and ACI 211.3R-02 standards. The aim is to improve mechanical strength in porous concrete mixtures, while ensuring enough permeability for its use in urban roads. There are various types of porous pavement materials, of which the most common and widely studied ones are porous concrete (PC) pavements. However, it is possible that just by changing the dosage method, the mechanical characteristics of porous concrete could improve, while maintaining sufficient permeability for use in permeable pavement systems (PPS). To make a comparison between the mixtures and methodologies, considering mechanical, hydraulic, and safety issues, such as skid resistance [3]. Fiber reinforced concrete provides good flexural strength with less crack developments. Since concrete is weak in tension. So, an attempt has been made to achieve improved strength results using hair as fiber in

conventional concrete. Human hair is strong in tension, non-degradable and is available in high quantity. Present studies have confirmed the effect of human hair on cement concrete for compressive & flexural strength and various experiments were conducted on concrete cubes and beams with different percentages of hair fiber as 0%, 1%, 2%, 3%, 4% and 5% by weight of cement. By testing of concrete cubes with human hair as fiber cement concrete an improved strength is obtained. Since concrete is weak in tension. For every combination of proportions of concrete cubes and beams were tested for their compressive and flexural strength [16]. Human hair fibers (HHF) have been used extensively in concrete, but in this research, a human hair is used as fiber in concrete by the volume of cement [15]. 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 are another factor contributing to the increasing popularity of this material, as PC demonstrates potential to resolve these issues. Therefore, it is promoted as a construction material for parking lots and road surfaces. The purpose of this article is not to repeat these reviews, but rather to promote the concept of sustainable pervious concrete pavement (SPCP) [17]

AUTHOR	**YEAR**	**TITLE**	**DESCRIPTION**
Tejas joshi ,et.al	2020-21	Construction of pervious concrete pavement stretch.	This case study demonstrated the step by step process of construction of pervious concrete stretch.
Kathleen Dall Bello De Souza Risson,et.al	2020-21	Moulding procedure for pervious concrete specimens by density control.	This study made it possible to establish an efficient procedure for the molding of cylindrical and prismatic specimens of PC
Elizondo-Martinez, et.al	2018-19	Proposal of a new porous concrete dosage methodology for pavements.	This paper introduces a modified dosage methodology for porous concrete design (PCD) for use as pavement surface layers with the purpose of balancing the mechanical, hydraulic, and safety properties of mixtures in comparison with the ACI methodologies
Singh, H. P,et.al	2015-16	Enhancement the strength of pervious concrete with different water cement ratio and admixture.	In this research work we observed that we can achieve the compressive strength of pervious concrete with 10 mm single size aggregate around 100 kg/cm2
Susana Viana Bittencourt,et.al	2020-21	Mechanical behavior and water infiltration of pervious concrete incorporating recycled asphalt pavement aggregate.	Its 28-day compressive strength is approximately 11 MPa, the flexural strength is 2.1 MPa and the water infiltration is 2.9 *10^-3m/s. With those characteristics it is suitable for light traffic pavement application.
Gersson F.B. Sandoval,et.al	2020	Hydraulic behavior variation of pervious concrete due to clogging. Case Studies in Construction Materials.	The experimental results indicate that, PC with recycled aggregates presents worse mechanical performance than PC with natural aggregates but higher hydraulic performance
Sonia Rahman,et.al	2015	Developing a framework for low-volume road implementation of pervious concrete pavement international journal of transportation science and technology.	Pervious concrete can be a potential alternative for sustainable low volume roads and provide a dust free, smooth, cost effective, and safe alternative to traditional pavements.

Bonicelli A,et.al	2016	Improving pervious concrete pavements for achieving more sustainable urban roads.	The type of fibers or the percentage of sand needs to be calibrated depending on the w/c ratio of the mixes for reaching the most favorable effects
Shigemitsu Hatanaka,et.al	2019	Construction of a nonlinear permeability model of pervious concrete and drainage simulation of heavy rain in a residential area.	In this research, the summary of previous researches on nonlinear permeability behavior of pervious concrete (PC) was presented.
Bheel N,et.al	2020	Sustainable composite development: Novel use of human hair as fiber in concrete.	This study presented sustainable composite development based on a novel use of human hair as fiber in concrete.
Praveenkumar Patil,et.al	2014	Study on the properties of pervious concrete.	The compressive strength of pervious concrete increases as the w/c ratio decreases up to optimum w/c ratio of 0.38
Maguesvari M,et.al	2013	Studies on characterization of pervious concrete for pavement applications.	It is observed that the increase in fine aggregate results in reduction of volume of voids which in turn increase of compressive strength, flexural strength and split tensile strength.
Yogesh N.Sonawane,et.al	2017	Experimental Study on Pervious Concrete: An Eco Friendly Concrete Pavement.	The pervious concrete is suitable only for low volume road pavement like foot path, parking slots. Due to voids in pervious concrete it is difficult obtained required compressive strength.
Tajamul Islam Wani,et.al	2016	Mechanical properties of pervious concrete.	This work was directed towards investigating the performance of pressure molded fiber reinforced pervious concrete by determining the mechanical properties and permeability.
Achal Agrawal,et.al	2016	A concept of improving strength of concrete using human hair as fiber reinforcement.	It was noted that a maximum of improvement in strength of concrete can be achieved by adding human hair as fiber reinforcement in concrete mix.
Yu Chen,et.al	2013	Strength, fracture and fatigue of pervious concrete.	High strength pervious concrete, 32-46 MPa at 28 days depending upon the porosity, can be achieved through both SCM modification using silica fumes and superplasticizer.
Paul D,et.al	2004	Pervious concrete pavements.	Pervious concrete as a paving material has seen renewed interest due to its ability to allow water to flow through itself to recharge groundwater and minimize storm water runoff.

2.MATERIALS

Pervious concrete uses the same materials as conventional concrete, with the exceptions that the fine aggregates typically is eliminated entirely of the size distribution (grading) of the coarse aggregates is kept narrow, allowing for

relatively little particle packing this providing the useful hardened properties, but also results in a mix that requires different considerations of mixing, placing, compaction & curing. The mix properties proportions are somewhat less For giving than conventional concrete mixtures tight controls on batching of all the desired result so materials used –
1) Cement
2) Coarse Aggregates
3) Water
4) Fibers -human hair
5) Plasticizers.
6) Fly ash cement, fine aggregate & silica fume

2.1. Cement: - Cement or cementing materials provide good durability & strength to the concrete. The thickness of cement coating plays a vital role in knowing structural & hydrological performance of pervious concrete. Pervious concrete has zero slumps when compared to conventional concrete [4,5].

2.2. Coarse Aggregates: - Igneous rocks specially granite aggregates are preferable due to their higher strength. The physical properties of aggregates to be used in pervious concrete should be similar to conventional concrete. The blend of two sizes of aggregates retained on 4.75mm sieve and 9.5mm sieve [the blend ratio is 4 (4.75mm): 6 (9.5mm)] are supposed to be good for mix. Typically, higher strength is achieved with angular aggregate. The increase in the size of aggregates reduces the amount of cement coating which firmly reduces the strength and increases the permeability [1,4,11].

2.3. Water: - Water to cement ratio between 0.27 to 0.30 is used successfully. The stronger paste may not increase the overall strength. (mechanical properties) The relation between strength and water to cementitious materials ratio is not clear for pervious concrete because unlike conventional concrete, the total paste content is less than the voids content between the aggregates. Therefore, making the paste stronger may not always lead to increased overall strength. Water content should be tightly controlled. The correct water content has been described as giving the mixture sheen, without flowing off of the aggregate. A handful of pervious concrete formed into a ball will not crumble or lose its void structure as the paste flows into the spaces between the aggregates (pervious concrete pavement) [4,10].

2.4. Fibers: – The different types of fibers which are natural or waste byproduct very useful to to increase the strength of pervious concrete. And these fibers not affect the permeability of concrete on large scale [19,20].

- **Human Hairs: -** With the observed properties, it is clear that the performance of human hair is somewhat comparable to the natural fibers. Considering that the quality control of human hair would be key issue for its application to concrete and in addition, that human hair can be naturally decayed. The hair was adequately washed two times with washing powder to separate unwanted ingredients. Also ensuring that there was greasy texture on the hair. Then, it was spread for dying under the sunlight. After that, it was mixed thoroughly in concrete by volume of cement [11,16].

2.5. Plasticizers: - The only use of plasticizers in pervious concrete is to make concrete workable. Because of very less percentage of water in concrete the use of some amount of plasticizers is useful to make concrete workable and reduce the harshness of concrete. [4,17]

2.6. Fly Ash: - Fly ash is used to replace the cement in some percentage to reduce the use of cement and increase the use of waste material. It may reduce the strength especially compressive strength but in this project we study that on how much extent the percentage of fly ash to the volume of cement can affect the compressive strength [5].

3.PROPERTIES

3.1. Compressive strength: - Some studies are referred that, the size of big aggregate has a high Compressive strength as compared to small size of aggregate but some studies are referred that small size aggregate give high strength as Compared to big size of aggregate. [4]. Pervious concrete mixtures can develop Compressive strength in the range of 3.5 mpa to 28 mpa which is suitable for a wide range of application. Typical value is around 17mpa properties and combination of specific material as well as placement Techniques & environmental conditioned get direct impact on strength [18].The standard 150mm Concrete cubes are used for this test. At each percentage of hair three Cubes are taken for crushing strength and finally take average as of three as ultimate results. In experiment it is observed that we increase the hair fiber content it decreases compressive strength [11]. Cubes are casted for compressive strength of Concrete. Three cubes for each mix proportion Were Casted. These tests are conducted in compressive testing ability machine of concrete Compressive strength is the ability of concrete to resist a crushing force. Maximum load at failure was recorded divided by the area under compressive strength. Cubes are of 2sizes150mm X150mm X150min &100mm x 100m x100mm have been used [16].

3.2. Tensile strength: -Tensile strength is one of the basic & important Properties of concrete Split tensile test are also Known as Brazilian test. Pc is a brittle material & develops cracks under tension [19]. In past Studies have split tensile strength of pc varies between 1to3 mpa, the optimum cement to aggregate proportion and aggregate size strictly based on tensile strength. The effect on tensile strength was higher with 24% porosity. It observed that split tensile strength increased, decreased in the aggregate size [13]. This improvement in strength may be due to fiber strength, sufficient physical or chemical bonding of human hair fibers with the matrix. Fibers can prevent the propagation of micro cracks & ultimately enhance the tensile Strength of concrete. The lower tensile strength during cracking maybe due to lower Density of concrete at higher fiber content, when fiber Content is higher, the density is low. The length of 2% of human hair may be sufficient to maintain cracks, which leads to an increase in flexural strength other factors the strength would have been higher with a higher proportion of fibers, but the strength would be reduced at 4% of human hairs [11].

3.3. Abrasion resistance: - Abrasion resistance of pervious concrete was determined by casting a specimen size of 6omm X 60mm x25mm and tested after 28 days of curing as per IS:2386 part 4[13]. Most pc pavements will have a few loses of aggregate on the surface of road after opening to traffic. These rocks are loosely bounded together initially & popped out because of traffic loading. After few weeks, the rate of surface Is decreases as compare to pavement surface because pavement surface is more stable & Proper Compaction & curing technique will reduce the accordance of surface raveling [18].

3.4. Flexural strength: - For measured flexural strength of concrete beams are casted and tested in flexural testing machine. Beam may be size of 150mm*150mm*700mm and 100mm*100mm*500mm. Beam molds kept ready before mixing concrete so assumed there is no loss of water or slurry. Two beams for each percentage variation are casted and tested for 7 days, 14 days and 28 days curing period. Flexural strength in pervious concrete generally range of 1 mpa to 3.8 mpa may factor are Impacted on flexural strength.

1) Degree of compaction
2) Porosity
3) The aggregate: cement (A/c) ratio [6]

3.5. Porosity: - Pervious concrete is high porosity of concrete used for flatwork application that allows water from precipitation and other source to pass through there by reducing the runoff from a site and recharging ground water level [15]. These pores affect the strength PC. Porosity plays very important role to control. Pervious concrete strength it impacts less effect on concrete strength in early ages (3 and 7days) as Compare to later ages (28, 56 and 90days) [17].

3.6. Permeability test: - Permeability is the ability of material to allow a flow of water through interconnected pores within internal formwork. Permeability is tested by using falling head apparatus. The rate of flow of pervious concrete depends on the materials and placing operation. Generally, Flow rates of water in pervious concrete is 3gal/ft²/min to 8gal/ft^2/min) [18]. Permeability for Pc varies from 0.2 to 0.54cm'/s permeability [15].

3.7. Shrinkage: - Drying shrinkage in pervious concrete develops very early but it is much lesser than conventional concrete (0.002, roughly half to that of conventional concrete mixture). Roughly 50-80% of shrinkage occurs in the first 10days, compared to 20-30% in same period for conventional concrete. Because of this lower shrinkage and the surface texture, many pervious concretes are made without control joints and allowed to crack randomly. [15].

3.8. Durability: - Concrete durability is one of the most important factors in the design of new structures and when assessing the condition of existing structure concrete construction is becoming complex and the main purpose of durability is about minimizing the rate of complication [20].

3.9. W/C ratio: - The applicability of w/c ratio on the mechanical properties of pervious concrete was studied. It shows that w/c ratio between 0.25 to 0.35 affects the consistency pervious concrete as reduced w/c ratio yield that more stiff Fresh pervious concrete [11].

4. CONCLUSION

Pervious concrete is a cost-effective and environmental friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete play a significant role. Due to its potential to reduce the runoff, it is commonly used as pavement material. The smaller the size of coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate. The mixtures with higher aggregate/cement ratio 8:1 and 10:1 are considered to be useful for a pavement that requires low compressive strength and high permeability rate. The ideal pervious concrete mix is expected to provide the maximum compressive strength, and the optimal infiltration rate.

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