Experimental Study on Pervious Concrete using Palm Jaggery

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Abstract

This paper reports the results of pervious concrete (PC) with use of Ordinary Portland Cement (OPC) as a binder with palm jaggery as an admixture for sustainable pavement construction. Aggregate to binder ratio and water to binder ratio was considered as 3.3 and 0.35. Mechanical and Physical properties were examined and relationships between various mixes Vs strength parameters, coefficient of permeability, void ratio and density properties of OPC binder PC were drawn to evaluate the effect of palm jaggery in pervious concrete (PC). The results indicated that addition of 0.05% and 0.1% palm jaggery increases the mechanical strength properties of pervious concrete.

Keywords: Pervious concrete (PC), Ordinary Portland Cement (OPC), binder, Coarse aggregate (CA), Coefficient of permeability, Durability, Void ratio, density

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I. INTRODUCTION

Pervious concrete is a structural concrete pavement with a large volume (15 to 35 percent) of interconnected voids. Like conventional concrete, it is made from a mixture of cement, coarse aggregates, and water. However, it contains little or no sand, which results in a porous open-cell structure that water passes through readily (figure 1). Portland Pozzolana Cement is a kind of Blended Cement which is produced by either inter grinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions. Pozzolana is a natural or artificial material containing silica in a reactive form. It may be further discussed as siliceous or siliceous and aluminous material which in itself possesses little, or no cementitious properties but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cement properties. It is essential that Pozzolana be in a finely divided state as it is only then that silica can combine with calcium hydroxide (liberated by the hydrating Portland Cement) in the presence of water to form stable calcium silicates which have cement properties.

Numerous sources have affirmed how population growth, urbanization and wasteful consumption of natural resources are leading to worldwide global warming. Due to a lack of permeability in common concrete pavement, storm water cannot easily penetrate through to the ground beneath. Over the past few decades, this has resulted in increased runoff and pollution from urban storm water. Groundwater is a natural thermostat, adjusting the heat and moisture in cities; and a lack of groundwater can lead to greenhouse and hot land effects. Several researchers have documented the negative impact that a lack of groundwater can have on streams. For over thirty years, in the US and Japan, pervious concrete has been used to reduce surface runoff by permitting rain water to drain into the ground. The low strength of pervious concrete limits its uses to applications, such as sidewalks, parking lots, recreation squares and as a sub-base for conventional pavement. In addition to recycling old concrete pavement, many projects have demonstrated how buildings and other structures may provide an additional resource for recycled aggregate (RA). Liv Haselbach and his associate discussed Pervious concrete is an alternative paving material that may alleviate many of the environmental problems caused by urban runoff from developed areas. This research shows that there is a vertical distribution of porosity in slabs placed with certain placement techniques. The vertical variation of porosity can affect the

strength distributions within the material and the permeability of the system and its potential for clogging. This studies indicate that for slabs approximately 15 cm (6 in.) in height and placed with an approximately 10% surface compaction technique, the porosity increases significantly from top to bottom. A series of vertical porosity distribution equations have been developed to effectively model this using the percent compaction and average cored porosities.

GuoliangJiang and his associate (2015) investigated that a pervious concrete pavement material used for roadway is introduced. Using the common material and method, the strength of the pervious concrete is low. Using smaller sized aggregate, silica fume (SF), and superplasticizer (SP) in the pervious concrete can enhance the strength of pervious concrete greatly. The pervious pavement materials that composed of a surface layer and a base layer were made. The compressive strength of the composite can reach 50 MPa and the flexural strength 6 MPa. The water penetration, abrasion resistance, and freezing and thawing durability of the materials are also very good. It can be applied to both the footpath and the vehicle road. It is an environment-friendly pavement material. Sun zhen-ping, et. al has discussed that the effects of some factors such as gradation and particle size of aggregate, mass ratio of aggregate to cement, mass ratio of water to cement, admixtures and mixing process on the properties of porous pervious concrete(PPC) including porosity, permeation coefficient and compressive strength were studied. The results indicate, gradation and particle size of aggregate, mass ratio of aggregate to cement are the key factors affecting porosity, permeation coefficient and compressive strength of PPC. Mass ratio of water to cement has minor effect on properties of PPC. Admixtures such as water-reducing admixture, silica fume and polymer latex improve properties of PPC. The mixing process of cement paste encapsulating aggregate method could improve the compressive strength of PPC and reduce its porosity while keeping its permeation coefficient stable. Chindaprasirt, et al (2008) noticed that an increase in mixing time increased the flow value of paste and its strength. The incorporation of water reducer and super plasticizer slightly affects the flow characteristics. The super plasticizer was very effective in increasing viscosity and yield stress of paste and also the use of high void ratio with low flow paste produces porous concrete with relatively low strength. Polymer modified pervious concrete has higher flexural strength and flexural to compressive strength, fracture toughness and fatigue life. Typical Pervious Concrete is shown in Figure 1.

Fig. 1: Pervious Concrete

II. MATERIALS AND METHODS

A. Materials

1) Cement

Ordinary Portland Cement of 43 grade Confirming to IS12269-2013 was procured locally from market and Physical property results are presented in Table 1.

Table - 1
Physical Properties of Cement

Sl.no	*Tests conducted*	*Experimental results*	*Recommended values as per IS 12269-2013*
1	*Normal consistency (%)*	*34*	-
2	*Initial setting time (min)*	*48*	*Not less than 30*
3	*Final setting time (min)*	*240*	*Not greater than 600*
4	*Fineness (%)*	*3.5*	*<10*
5	*Specific gravity*	*3.07*	-

2) Coarse Aggregate

Crushed blue granite metal confirming to IS: 2386-1963 of size 20 mm was used. Physical Property results of coarse aggregate are tabulated in Table 2.

Table – 2

Physical Properties of Coarse Aggregate

Sl.no	*Test conducted*	*Experimental results*
1	*Specific gravity*	*2.68*
2	*Water absorption (%)*	*0.5*
3	*Moisture Content (%)*	*0.7*
4	*Fineness modulus*	*7.6*
5	*Impact value (%)*	*16.39*
6	*Crushing value (%)*	*24*
7	*Abrasion value (%)*	*22*

3) Water

Mixing water quality is required in accordance with the quality standards of drinking water and the Mixing Water used was taken from KPR Institute of Engineering and Technology, Coimbatore.

4) Palm Jaggery

Palm Jaggery used in this study was procured from local market, Coimbatore, Tamilnadu, India and the same was shown in Figure 2.

Fig. 2: Palm Jaggery

B. Mix Design

Three numbers of mixes were prepared with different combinations of Palm Jaggery. Table 5 represents mix proportion for various mixes. Furthermore, Mix M0 denotes the mix, with 0% Palm Jaggery (conventional control mix), M1 denotes mix, with 0.05% Palm Jaggery, M2 denotes mix with 0.1% Palm Jaggery. Proper care was taken to maintain the workability in pervious concrete for easy and proper mixing. The typical mix proportions arrived for all the mixes and the same is exposed. The mixing and casting process is shown in Figure 3.

Fig. 3: Casting of Specimens

C. Experimental Programme

Cube specimens of size 100 x 100 x 100 mm, cylinder specimen of size 150 mm diameter and 300 mm height and beam specimen of size 100 mmx100 mmx500 mm were used to determine various mechanical properties such as compressive strength, spilt tensile strength, Flexural strength and To study the physical properties such as permeability test, porosity and density

properties are determined at the age of 28 days cylindrical specimens of size 150 mm diameter and 150 mm height and cube specimens of 70.6 mm x 70.6 mm were used.

III. RESULTS AND DISCUSSIONS

A. Mechanical Properties

1) Compressive Strength Test

Compressive strength was tested at the age of 7 and 28 days. Table 3 represents compressive strength test results of various mixes. The results showed that, Mix (M1) Shows higher compressive strength when compared with conventional control mix (M0). Mix M2 also gives higher compressive strength when compared with mix M1. It has been observed that when the amount of Palm Jaggery addition increases there was a decrease in workability. The graphical representation of compressive strength parameters vs various mixes are presented in Figure 4.The attained compressive strength values met the requirements of pervious concrete.

Table – 3
Compressive strength of various Mixes

Sl.no	*Mix ID*	*Compressive strength (N/mm^2)*	
		7 days	*28 days*
1	*M0*	*17.0*	*24.5*
2	*M1*	*18.5*	*25.5*
3	*M2*	*19.2*	*27.0*

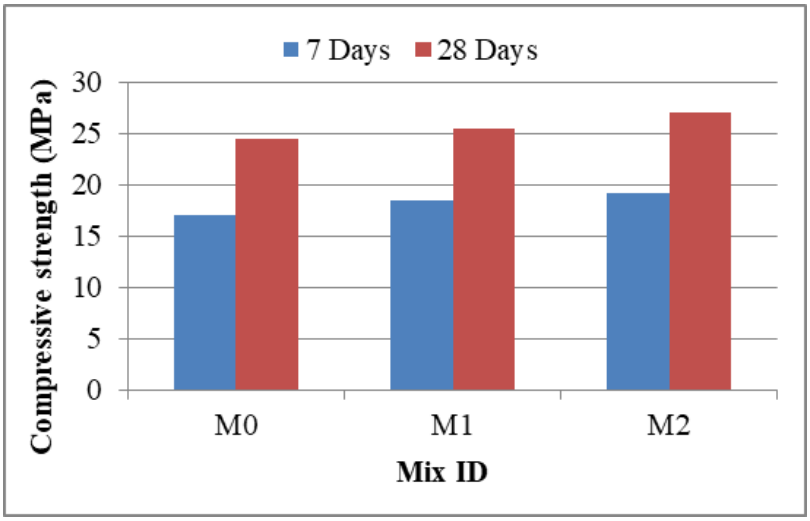

Fig. 4: Compressive strength of various Mixes

2) Split strength test

Split tensile strength was tested at the age of 7 and 28 days. Table 4 shows the split tensile results of various mixes. The results showed that, Mix (M1) Shows higher split tensile strength when compared with conventional control mix (M0). Mix M2 also gives higher tensile strength when compared with mix M1. In the case of workability the trend observed in compressive strength test is resembled here. The graphical representation of split tensile strength parameters Vs various mixes are presented in Figure 5.The attained compressive strength values met the requirements of pervious concrete.

Table – 4
Spilt tensile strength of various Mixes

Sl.no	*Mix ID*	*Split tensile strength (N/mm^2)*	
		7 days	*28 days*
1	*M0*	*1.70*	*3.46*
2	*M1*	*1.86*	*2.65*
3	*M2*	*1.94*	*2.77*

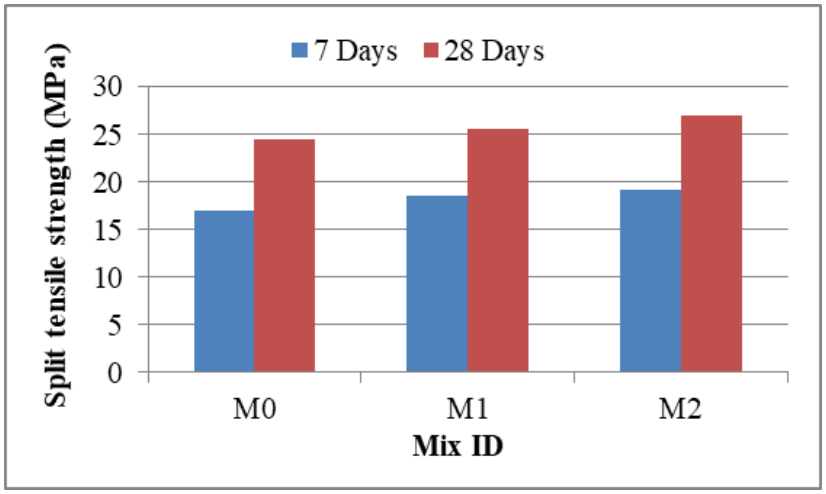

Fig. 5: Spilt tensile strength of various Mixes

3) Flexural strength test

Flexural strength was tested at the age of 7 and 28 days. Table 5 shows the flexural strength test results of various mixes. The results showed that, Mix (M1) Shows higher flexural strength when compared with conventional control mix (M0). Mix M2 also gives higher flexural strength when compared with mix M1. In the case of workability the trend observed in compressive strength test and split tensile strength is resembled here. The graphical representation of flexural strength parameters Vs various mixes are presented in Figure 6.The attained compressive strength values met the requirements of pervious concrete.

Table – 5

Flexural strength of various Mixes

Sl.no	*Mix ID*	*Flexural strength (N/mm2)*	
		7 days	*28 days*
1	*M0*	*2.88*	*3.46*
2	*M1*	*3.01*	*3.53*
3	*M2*	*3.06*	*3.63*

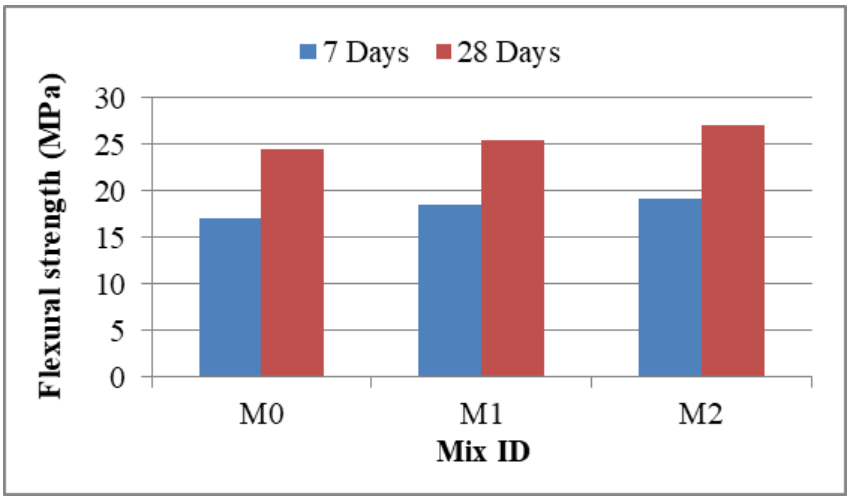

Fig. 6: Flexural Strength of Various Mixes

IV. CONCLUSION

Based on experimental study on Palm Jaggery Pervious Concrete the following conclusions can be drawn,

1) Mechanical properties such as compressive strength, split tensile strength, flexural strength were found and it satisfies the requirements.
2) It has been observed that 0.0.05% addition of Palm Jaggery gives higher strength properties when compared to conventional control mix OPC and M0.
3) When comparing to mix M1, mix M2 with Palm Jaggery Percentage 0.1% produces higher strength properties. But, it has been noticed that workability gets reduced when Palm Jaggery addition exceeds 0.05 %.
4) Regardless of all the mixes mix M1 mix was considered as optimum mix by considering workability property and the same mix was considered to carry out physical tests with proper water cement ratio.

5) Hence forth, Pervious Concrete made with Palm Jaggery is an admixture produces better results that can be effectively used in sustainable construction.

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