Performance assessment of pervious concrete using marble dust and silica fumes

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Abstract — **Pervious concrete is one of the most promising sustainable materials nowadays. Pervious concrete is the mixture of cement, smaller size coarse aggregate, water and admixture. As cement industry is one of the most polluted industry, so for helps in reducing the pollution. The permeability and strength of pervious concrete depend on the particle sizes and proportions of the constituent materials of which the concrete is made of. In this Experimental study the Behaviour and permeability of pervious concrete made with different coarse aggregate sizes is presented, and to increase the strength of the concrete adding marble dust and silica fumes. As the void ratio increase the strength of concrete decrease in order to reduce the voids at the same time without disturbing the permeability marble sludge powder is used in this experimental study.The present study was conducted to investigate pervious concrete performance. In this study, Silica fume was used as a admixture and 10% of cement was replaced with Marble dust and the pervious concrete specimens were tested for Porosity.**

***Keywords* — *Pervious concrete; marble dust; Silica fumes and Porosity*.**

I. Introduction

Concrete is a homogenous mixture of Cement, Aggregate (Fine and Coarse aggregate) and Water. Now a day, Special Concrete is more preferred in the construction industry.

Pervious Concrete is a mixture of gravel or granite stone, cement, water, little to no sand (fine aggregate) with or without admixtures. Pervious concrete pavement in rural areas is a unique and effective means to achieve important environmental issues by capturing the storm water but allowing it into the ground. Pervious concrete helps to reduce the storm water runoff.

In many cases, pervious concrete roadways and parking lots can double as water retention structures, reducing or eliminating the need for traditional storm water management systems such as retention ponds etc.,

The present study was conducted to investigate pervious concrete performance. In this study, Silica fume was used as a admixture and 10% of cement was replaced with Marble dust and the pervious concrete specimens were tested for Porosity, Compressive Strength and Flexural Strength

Pervious concrete used in pavement systems must be designed to support the intended traffic Load and contribute positively to the site specific Storm Water Management Strategy. They select appropriate material properties appropriate pavement thickness and other characteristics needed to meet the hydrological requirements (permeability, volume of voids, amount of rainfall expected, underlying soil properties) and anticipated traffic loads.

II. Preliminary Test on Materials

A. *Testing of cement*

1. *Fineness Test of Cement*

Correctly 100grms of cement was weighed and taken in a standard IS sieve no.9 (90 microns).The lumps were broken down and the material was sieved continuously for 15 minutes using sieve shaker. The residue left on the sieve was weighed .This weight does not exceed 5% for ordinary cement. Percentage of residue left on sieve = (weight retained/weight taken) x 100

Result: Percentage of residue left on sieve = 3.45

B. *Testing of Coarse Aggregate*

1. *Sieve Analysis of Coarse Aggregate*

The sample was brought to air – dried condition before weighing and sieving was achieved after drying at room temperature. The air – dry sample was weighed and achieved successively on the appropriate sieves starting with the largest size sieve.

Result: Fineness modulus =6.16

C. Testing of marble dust.

COMPOSITION OF MARBLE POWDER	
Sio_2	25-30
Al_2o_3	0.3-0.5
Fe_2o_3	8-10
Cao	38-45
Mgo	15-18
Specific gravity	2.5
Fines modulus	2.735

D. Testing of Silica fumes

COMPOSITION OF SILICA FUMES	
Sio_2	85-98 %
Zn	< 0.1 %
Mn	< 0.1 %
Pb	< 0.1 %
RCS	< 0.1 %
CaO, MgO, Na_2O, K_2O, C, Cl	< 5%
Al2O3, Fe2O3, SO3, SiC, Si	< 5%

2. *Specific Gravity Test of Coarse Aggregate*

The container was dried thoroughly and weighed as W_1 gram. 800 gram of fine aggregate was taken in the container and weighed as W_2 gram. The container was filled with water up to the top. Then it was shacked well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed the container r was completely filled with water up to the mark. The outside of container r was dried with a clean cloth and it was weighed as W_3 grams. The container was cleaned thoroughly. The container was completely filled with water up to the top. Then outside of the container was dried with a clean cloth and it was weighed as W_4 grams.

Result: Specific Gravity of Coarse Aggregate (G) = 2.7

III. MIX DESIGN

Four mix designs were used to prepare the samples. Initial design was prepared with 10mm aggregate using traditional concrete mixing procedure in ACI method in which cement, coarse aggregate and water were combined. The second mix design was prepared by adding 10% of marble dust. Then the Third mix design was prepared by addition of silica fume as an admixture. Finally, the Fourth mix proportion was designed by adding 10% of marble dust and adding silica fume as an admixture.

In this investigation, we incorporate the procedures of IS-10262-2009. It is based on the limit mix design of M20 grade of concrete is obtained. We add different portion of silica fumes and marble dust.

Based on ACI 522R-06

Pervious concrete of strength 20Mpa

Design average cube strength at 28 days

20/0.75	= 26.66N/mm2
A/C	= 6
Optimum W/C ratio	= 0.34
Density of concrete	= 2500 Kg/m3
Bulk Density of Cement	= 1700 Kg/m3
Bulk Density of Coarse Aggregate (For 10 mm)	= 1600 Kg/m3
A/C ratio by weight	= (6X1600)/1700
	= 5.64

Cement	:	Aggregate	:	Water
1	:	5.64	:	0.34

Quantities of materials per m^3 concrete:

MATERIAL	WITHOUT ADMIXTURE	ADDING 10% OF MARBLE DUST	WITH ADMIXTURE	ADDING 10% OF MARBLE DUST AND ADMIXTURE
Cement	358 Kg/m^3	322 Kg/m^3	340 Kg/m^3	322 Kg/m^3
CA	2019 Kg/m^3	2019 Kg/m^3	1918 Kg/m^3	1918 Kg/m^3
Water	122 Kg/m^3	122 Kg/m^3	136 Kg/m^3	136 Kg/m^3
Marble Dust	NA	36 Kg/m^3	NA	36 Kg/m^3
Silica Fumes	NA	NA	114 Kg/m^3	114 Kg/m^3

IV. MECHANICAL PROPERTIES OF SAMPLE

A. Compressive Test

Compressive strength is one of the basic and important properties of the concrete. **Compression strength** is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate.

The cubes were tested for compressive strength at the specific age of 3, 7, 14, 28 days of curing.

The compressive strength is calculated by the following formula.

$$\text{COMPRESSIVE STRENGTH} = \frac{\text{CRUSHING VALUE}}{\text{AREA OFTHE CUBE}}$$

The test result is as follows.

Days (N/mm^2)	Without Admixture	Adding 10% of Marble dust	Adding 5% of Silica fumes	Adding both Marble dust and Silica Fumes
3	3.33	3.77	7.22	7.66
7	5.73	6.44	16.89	18.22
14	8.88	9.11	21	21.5
28	10.89	11.66	24.44	25.1

Result & discussion:

The test was carried out to obtain compressive strength of concrete at the age of 3, 7, 14 and 28 days without using admixture, adding 10% of marble dust, with admixture and using admixture and marble dust. The cubes were tested using Compression Testing Machine (CTM) of capacity 2000KN in concrete lab. There is a significant improvement in the compressive strength in concrete while using both 5% of silica fume as admixture and adding 10% of marble dust.

B. Flexural Strength Test

Flexural strength, also known as **modulus of rupture**, or **bend strength**, or **transverse rupture strength** is a material property, defined as the stress in a material just before it yields in a flexure.

Flexural Strength of Beam = M / Z (N/mm2)

Where, M = (P * 10160) * L / 4

Z = B * D2 / 6

P = Failure Load (N)

L = Length of beam (mm)

D = Diameter of beam (mm)

B = Width of beam (mm)

Days (N/mm^2)	Without Admixture	Adding 10% of Marble dust	Adding 5% of Silica fumes	Adding both Marble dust and Silica Fumes
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14	8.88	9.11	21	21.5
28	10.89	11.66	24.44	25.1

Result & discussion:

The test was carried out to obtain Flexural strength of concrete at the age of 3, 7, 14 and 28 days for without using admixture, adding 10% of marble dust, with admixture and for both using admixture and marble dust. There is a significant improvement in the flexural strength in concrete while using both 5% of silica fume as admixture and adding 10% of marble dust.

C. Porosity

The Aim of the test is to determine the porosity of pervious concrete. The cubes were tested for porosity at specify age of 28 days of curing. The porosity of pervious concrete is calculated thus

$$P\ (\%) = \frac{V_{T-}V_C}{V_T}$$

P = Porosity of sample (%)

V_T = Volume of Dry Sample, mm^3

V_T - V_C = Volume of void space, mm^3

SAMPLE DESCRIPTION	DAYS	POROSITY (%)
Without admixture	28	30.3
Sample with adding 10% of marble dust	28	28
Sample using admixture(silica fume)	28	25
Sample with both adding 10% marble dust and using admixture	28	23.2

Result & discussion:

The Test was carried out to obtain porosity of pervious concrete at the age of 28 days for without using admixture, adding 10% of marble dust, with admixture and for both using admixture and marble dust. There is a significant decrease in porosity of concrete while using both 5% of silica fume as admixture and adding 10% of marble dust.

V. CONCLUSION

Pervious concrete is a cost-effective and environmentally friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete to play a significant role. This study deals with the performance analysis of pervious concrete. For this purpose we have prepared concrete specimens without admixtures, using 5% of admixture, addition of 10% of marble dust and both addition of 10% of marble dust and 5 % of silica fume as admixture. From this study we have concluded that, concrete made with both marble dust and silica fume as admixture, made an initial increment in strength. If it gets utilized in Indian context then it proves to be very beneficial to solve environmental issues and water logging problems which are the major issues in India.

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