Experimental Study on Mechanical properties of porous concrete using marble powder

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Abstract— porous concrete pavement material used for roadway is introduced. Using the common material and method, the strength of the porous concrete is low. Using smaller sized aggregate, and marble powder in the pervious concrete can enhance the strength of porous concrete greatly. The porous pavement materials that composed of a surface layer and a base layer were made. The water penetration is very good. It can be applied to both the footpath and the vehicle road. It is an environment-friendly pavement material. Porous concrete is the less weight concrete in the field of pavement design as it has its own constituents. The behaviour includes the density and permeability. As the porosity directly proportional to the density of the concrete, the main objective is to develop the strength without affecting its permeability, porosity is also affected by aggregate / gravel size, shape and gradation 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 powder is used in this experimental study.

Keywords—marble powder; porous concrete; strength;.

I. INTRODUCTION

Porous concrete is a mixture of cement, aggregate (fine aggregate and coarse aggregate),marble powder and water. Now a day's special concrete is more preferred in the construction industry. Some of the special concretes are pervious concrete, transparent concrete, self-compacted and curing concrete because of their special properties which is better compared to conventional concrete. Pervious Concrete is a special type of concrete in which no fine aggregates are used and gravel has been used in place of the coarse aggregate. Porous Concrete is also called as **"no-fines"** concrete.

Compressive strength and Flexural strength of pervious concrete does depend primarily on the porosity, it is also affected by aggregate / gravel size, shape and gradation. The compressive strength of pervious concrete is in the range of 2.8 MPa to 28 MPa. So, pervious concrete cannot be used for structural work but it has so many other applications in which it should be significantly used.

Porous concrete which is also known as the no-fines, porous, gap-graded, and permeable concrete. By definition, pervious concrete is a mixture of gravel or granite stone, cement, marble powder and water. When pervious concrete is used for paving , the open cell structures allow storm water to filter through the pavement and into the underlying soils. In other words, pervious concrete helps in protecting the surface of the pavement and its environment.

Porous 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. Pervious concrete can allow the passage of 3-5 gallons of water per minute through its open cells for each square foot of surface area which is far greater than most rain occurrences. Apart from being used to eliminate or reduce the need for expensive retention ponds, developers and other private companies are also using it to free up valuable real estate for development, while still providing a paved park. Pervious concrete is also a unique and effective means to address important environmental issues and sustainable growth. When it rains, pervious concrete automatically acts as a drainage system, thereby putting water back where it belongs.

II. PRELIMINARY TEST ON MATERIALS

A. Testing of cement

1. *Fineness Test of Cement*

Correctly 1000grms of cement was weighed and taken in a standard IS sieve (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

2. *Consistency Test of Cement*

1000 grams of cement was taken and a paste was prepared with 25% quantity of water. After completely filling the mould, shake the mould to expel the air. A standard plunger 10mm diameter and 50mm long was attached and brought down to touch the surface of the paste in the test block and quickly released allowed it to sink to the paste by its own weight. The depth of penetration of plunger was noted down. The second trail was conducted by 25% of water and the depth of penetration was found out. Similarly number of trials was conducted till the plunger penetrates for a depth of 33 to 35mm from top.

Result: Consistence of given sample of cement = 34 %

B. Testing of marble powder

COMPONENTS 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

C. 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 =6.2

2. *Specific Gravity Test of Coarse Aggregate*

The container was dried thoroughly and weighed as W_1 gram. 1000 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) = 2.6

III. Mix Design

The mix design of porous concrete is a trial method. Many references available for mix proportioning of pervious concrete. Here we use mix proportioning based on previous investigation strength data using American method and also based ACI guidelines. In the American method coarse and marble powder contents are initially fixed so that pervious concrete ability is achieved by adjusting the water/powder ratio. Permeability requirements are assessed from field trials of pervious concrete at a later stage
In this investigation we incorporate the procedures of ACI guidelines. These guidelines gives the range for coarse aggregate and marble powder content and based on the limit the approximate mix design for M20 grade of concrete is obtained.

Proportion:

Cement = 1

Powder = 1.5

C.A = 3.5

Mix Ratio = 1: 0.5: 4.5

W/C = 0.35

IV. Properties of Porous Concrete

The pervious concrete mixture is compared to traditional concrete. Slumps, when measured, are generally less than (20 mm), although slumps as high as (50 mm) have been used. However, slump of pervious concrete has no correlation with its workability and hence should not be specified as an acceptance criteria. When placed and compacted, the aggregates are tightly adhered to one another and exhibit the characteristic open matrix that looks like popcorn. In-place densities on the order of 1600 kg/m3 to 2000 kg/m3 are common. Pervious concrete mixtures can develop compressive strengths in the range of 3.5MPa to 28MPa, which is suitable for a wide range of applications. Typical values are about 17MPa.The permeability of pervious concrete will vary with aggregate size and density of the mixture, but will fall into the range of 3 to 19 gallons per minute per square foot.

A porosity of pervious concrete pavement system will typically have a permeability of 4 gallons per minute per square foot. Converting the units to in. /hr. yields 336 in. /hr. (8534 mm/hr.). Perhaps nowhere in the world would one see such a heavy rainfall. In contrast the steady state infiltration rate of soil ranges from 1 in. /hr. (25 mm/hr.) and 0.01 in. /hr. (.25 mm/hr). This clearly suggests that unless the pervious concrete is severely clogged up due to possibly poor maintenance it is unlikely that the permeability of pervious concrete is the controlling factor in estimating runoff (if any) from a pervious concrete pavement. For a given rainfall intensity the amount of runoff from a pervious concrete pavement system is controlled by the soil infiltration rate and the amount of water storage available in the pervious concrete.

Generally for a given mixture proportion strength and permeability of pervious concrete are a function of the concrete density. Greater the amount of consolidation higher the strength, and lower the permeability. Since it is not possible to duplicate the in-place consolidation levels in a pervious concrete pavement one has to be cautious in interpreting the properties of pervious concrete specimens prepared in the laboratory. Such specimens may be adequate for quality assurance namely to ensure that the supplied concrete meets specifications. Core testing is recommended for knowing the in-place properties of the pervious concrete pavement. The relationship between the *w/cm* and compressive strength of conventional concrete is not significant. A high *w/cm* can result in the paste flowing from the aggregate and filling the void structure. A low *w/cm* can result in reduced adhesion between aggregate particles and placement problems. Flexural strength in pervious concretes generally range 1MPa to 3.8 MPa.

V. Mechanical Properties of Porous Concrete

A. *Split Tensile Test*

Tensile strength is one of the basic and important properties of the concrete. Tensile strength is define as " The resistance of a material to a force tending to tear it apart, measure as the maximum tension the material can withstand without tearing". However the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

This test is conducted on cylinder specimens of 30cm length and 15cm diameter. The split tensile strength is calculated by the following formula.

$F_t = 2P/Pi\ dl\ N/mm^2$ (or) MPa

Where Ft=Split Tensile strength

P=maximum load taken by the specimen

D=Diameter of specimen

L=length of specimen

The split tensile test is conducted on two specimens and the average tensile

Strength was calculated for each mix. The results are tabulated below

size of gravel (mm)	Ratio	7 days (N/mm^2)	28 days (N/mm^2)
10	1:1:3.5	0.83	0.94
10	1:0.5:4	0.61	0.79
12.5+10	1:1:3.5	1.08	1.27
12.5+10	1:0.5:4	0.87	1.02
12.5	1:1:3.5	0.73	0.92
12.5	1:0.5:4	0.69	0.85

B. *Compressive Test*

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

This test is conducted on cube specimens of 15cm length and 15cm breadth. The compressive strength is calculated by the following formula.

Compressive Strength= P/A (N/mm2)

Where, P = Failure Load (N)

A = Cross Sectional Area (mm2)

The compressive test is conducted on two specimens and the average tensile

Strength was calculated for each mix. The results are tabulated below

size of gravel (mm)	Ratio	7 days (N/mm^2)	28 days (N/mm^2)
10	1:1:3.5	9.24	11.53
10	1:0.5:4	7.87	10.1
12.5+10	1:1:3.5	10.74	13.55
12.5+10	1:0.5:4	7.98	11.44
12.5	1:1:3.5	8.79	11.78
12.5	1:0.5:4	6.98	9.66

C. *FlexureTest*

Flexural strength 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)

size of gravel (mm)	Ratio	7 days (N/mm2)	28 days (N/mm2)
10	1:1:3.5	2.91	3.03
10	1:0.5:4	1.65	1.89
12.5+10	1:1:3.5	2.97	3.02

12.5+10	1:0.5:4	2.67	2.75
12.5	1:1:3.5	157	1.82
12.5	1:0.5:4	1.75	2.05

D. Result and discussion

The basic properties of materials were tested and tabulated the results. In this project used marble powder. The porous concrete tests like split tensile and water absorption.

The casted cylinder is tested and then the mechanical Properties were found out, such as split tensile strength and Water absorption on various porous concrete mixes with marble powder (0, 0.5, 1) at 7 and 28 days.

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