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Study on Porous Concrete with Course Aggregate and Fine Aggregate Mix Proportions

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***Abstract* - Porous concrete also known as gap graded concrete is a special type of concrete obtained by the mixture of Portland cement, uniform coarse aggregate with or without fine aggregate and water. Porous concrete has an interconnected pore structure that allows freely the passage of water to flow through.**

The use of Porous Concrete will reduce the need for large detention ponds, skimmers, pumps, drainage pipes and other storm water management systems, expensive irrigation systems can be downsized or even eliminated. Porous Concrete is a durable material; parking areas properly designed and constructed will last 20-40 years with little or no maintenance.

Key words : Porous concrete, pervious concrete, gap graded concrete, Drain concrete, thirsty concrete, water absorption.

I. INTRODUCTION

1. Introduction

Porous concrete is a concrete with continuous voids which are intentionally incorporated into the concrete. It belongs to a completely different category from conventional concrete and hence its physical characteristics differ greatly from those of normal concrete.

This porous concrete mixture has little to no sand which creates an open-cell structure that allows rain water to filter right through to the underlying soil.

Porous concrete is one of the leading materials used by the concrete industry as GREEN industry practices for providing pollution control, storm water management and sustainable design. Porous concrete can be used in numerous civil engineering and architectural application. It has been called as the green construction material for pavement because it has been recognized by the LEED (Leader shipping Energy and Environmental Design).

The increased interest in porous concrete is due to those benefits in storm water management sustainable development.

Impervious nature of bituminous and concrete used for the construction of pavements, walkways, open car parks contributes to the increased water runoff to the drainage system, over-burdening the infrastructure and causing excessive flooding in built-up areas. With the changing climatic conditions and increasing urbanisation had resulted in flooding in major cities around the world. Porous concrete is an engineered concrete to have very high permeability to allow the rain water to drain rapidly. Hence porous concrete may be considered as a sustainable choice in civil engineering.

Porous Concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation & other sources to pass directly through, thereby reducing the runoff from a site & allowing groundwater recharge.

Porous concrete is a mixture of Portland cement, uniform coarse aggregate, building demolition waste & water in suitable proportion.

Carefully controlled amounts of water and cementations materials are used to create a paste that forms a thick coating around aggregate particles without flowing off during mixing and placing. Using just enough paste to coat the particles maintains a system of interconnected voids.

Fig (1). Porous concrete

1.1 Background History of Porous Concrete

Porous concrete was first used in 1800 s in Europe as pavement surfacing and load bearing wall. The initial use of porous concrete was in the United Kingdom in 1852 with the construction of two residential houses and a sea groyne. Cost efficiency seems to have been the primary reason for its earliest usage due to the limited amount of cement used. It was not until 1923 when porous concrete re surfaced as a viable construction material. This time it was limited to the construction of 2-story homes in areas such as Scotland, Liverpool, London and Manchester.

Use of porous concrete in Europe increased steadily, especially in the World War II era. Since porous concrete use less cement than conventional concrete and cement was scare at that time. It seemed that porous concrete was the best material for that period. Porous concrete continued to gain popularity and its use spread to areas such as Venezuela, West Africa, Australia, Russia and the Middle East (Wanielista et al. 2007). After World War II, porous concrete became wide spread for applications such as cast-in-place load-bearing walls of single and multi-storey houses and, in some instances in high-rise buildings, prefabricated panels, and stem-cured blocks (Ghafoori et al. 1995). Also applications include walls for two story houses, load-bearing walls for high-rise buildings (up to 10 stories) and infill panels for high-rise buildings (Tennis et al. 2004).

India is facing a typical problem of ground water Table falling at a faster rate due to reduced recharge of rain water into subsoil and unplanned water withdrawal for agriculture and industry. It would be beneficial for India to exploit the potential of porous concrete.

1.2 Need Of Porous Concrete

In rural areas larger amount of rainwater ends up falling on impervious surfaces such as Parking lots, driveways, sidewalks, and streets rather than soaking into the soil. This creates an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion and pollution of rivers, as rainwater rushing across pavement surfaces picks up everything from oil and grease spills to de-icing salts and chemical fertilizers.

A simple solution to avoid these problems is to stop constructing impervious surfaces that Block natural water infiltration into the soil. Rather than building them with conventional concrete, we should be switching to Porous Concrete or Porous Pavement, a material that offers the inherent durability and low life-cycle costs of a typical concrete pavement while retaining storm water runoff and replenishing local watershed systems. Instead of preventing infiltration of water into the soil, porous pavement assists the process by capturing rainwater in a network of voids and allowing it to percolate into the underlying soil.

1.3 Advantages

a) Reduction in storm water infrastructure (Piping, Catch-Basins, Ponds, Curbing, etc.)
b) Suitable for cold-climate applications, maintains recharge capacity when frozen
c) No standing water or black ice development during winter weather conditions
d) Maintains traction while wet
e) Reduced surface temperatures, minimizes the Urban Heat Island Effect
f) Extended pavement life due to well drained base and reduced freeze-thaw
g) Less lighting needed due to highly reflective pavement surface
h) Prevents water and polluted water from entering into stream.

1.4 Applications

a) Porous concrete has had numerous useful non-pavement applications including buildings, tennis courts, drains & drain tiles, floors in greenhouses, slope stabilization ,swimming pools decks, zoo areas etc.
b) The majority of porous concrete applications are parking lots, sidewalks, pathways, parks, shoulders, drains, noise barriers, friction course for highway pavements, permeable based under a normal concrete pavement and low volume roads.
c) Water and Power resources services in America successfully tested the use of drains and drain tiles constructed from porous concrete beneath hydraulic structures.
d) The use of porous concrete in parking lots helped in controlling water runoff in situations where flash flooding frequently occurs.
e) The reduced runoff eliminates the problems of downstream flooding caused by traditional impervious concrete surfaces.
f) The use of porous concrete as an edge drain or porous hard shoulders has been undertaken extensively in France. Excessive uplift pressures produced in concrete pavements lead to the development of methods to rapidly drain water from the pavement base.
g) Porous concrete in European countries is used for cast-in-place load bearing walls in houses, multi-storey and high-rise buildings as prefabricated panels and steam cured blocks.
h) Because water is allowed to percolate into the ground, nearby vegetation is watered &reduces irrigation needs, groundwater is recharged & storm water runoff is reduced.
i) Pervious Concrete as a Road pavement Low-volume pavements Sidewalks and pathways Residential roads and driveways Parking lots Noise barriers Slope stabilization Hydraulic structures Swimming pool decks Tennis courts.

II. SCOPE AND OBJECTIVES

2. Scope

a) It is the evident that the fines of different grades and normal aggregates which are not used in preparations of concrete.
b) It is yielded good permeability results but suffered in satisfactory compressive strength and the split tensile values.
c) In these study to know that effect of river aggregates and the mix proportions to be obtain higher strength, higher permeability and properties of concrete.

2.1 Objectives of the Study

a) The main objective of study includes to carry out the various test on porous concrete.

b) To study the different properties in the permeability and compressive strength.

c) To be consider permeability as the design parameter in designing pavements.

III. MATERIALS AND METHODOLOGY

3.1 Materials

In the study of porous concrete the following materials have to be selected

1 Cement
2 Normal aggregate
3 Fine aggregate
4 Water

3.2 Methodology

The methodology consisting of collecting the specified coarse and fine aggregate grouping them according to different standard size like 12 mm passing size of coarse aggregates. Similarly fine aggregate like (4.75-1.18) mm and mixing them in a standard proportions as that of M20 grade concrete of 1:3:0.3 with w/c of 0.3 and specimens were casted of by following standard procedure and properties have been evaluated for the analysis.

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1V. EXPERIMENTAL PROGRAMME.

4.1 Tests Carried Out On Porous Concrete Are

1. Density
2. Compression test
3. Split tensile test
4. Permeability Test

1. Density

The density of porous concrete depends on the properties and proportions of the materials used, and on the compaction procedures used in placement. In-place densities in the order of 1600 kg/m³ to 2000 kg/m³ are common, which is in the upper range of lightweight concretes. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through porous concrete are typically around 0.34 cm/s, although they can be much higher. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures.

$$\text{Density} = \frac{M}{V} \text{ in kg/m}^3$$

Where, M = Mass of concrete in kg.

V = Volume of concrete in m^3.

Table 1. showing density of porous concrete

AGGREGATE SIZE PASSING	F.A SIZE (mm)	w/c ratio	DENSITY (Kg/m^3)				AVERAGE DENSITY (Kg/m3)
			S1	S2	S3	S4	
12 mm	4.75-1.18	0.3	2003	2023	2009	2029	2016
12 mm®	-	0.3	1748	1763	1822	1807	1785

Note: ® refers for conventional porous concrete without fine aggregates.

2. Compression Test

The comparison of the 3, 7, 14, and 28 days cube strength results represents that.

The compressive strength of cubes is directly proportional to the period of curing as shown in fig (4.1)

Table 2. showing compressive strength of porous concrete for 3, 7, 14 and 28 days curing

DAYS	COMPRESSIVE STRENGTH			AVERAGE COMPRESSIVE STRENGTH (Kg/m3)
	S1	S2	S3	
3 DAYS	6.9	7.32	7.28	7.16
7 DAYS	17.1	17.16	17.31	17.19
14 DAYS	22.1	23.4	23.1	22.87
28 DAYS	25.73	25.9	26.19	25.94

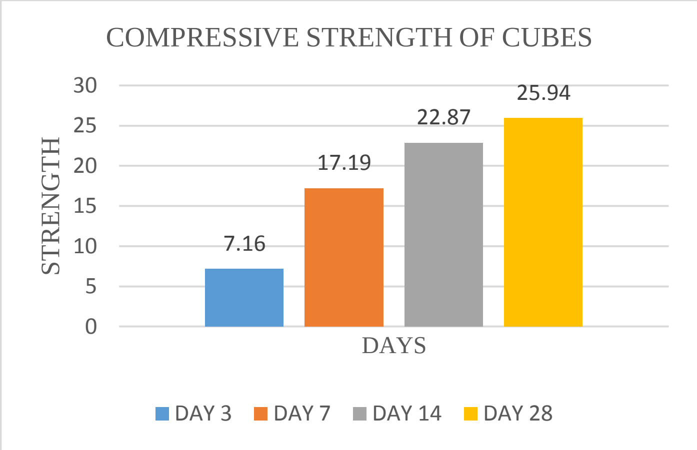

Fig (4.1) compressive strength of cubes

3. *Split tensile strength*

The comparison of the 3, 7, 14, and 28 days cylinder strength results represents that.

The fig (4.2) represents the split tensile value of cylinder is gradually increases with respect to the period of curing.

The splitting tensile strength of concrete cylinder is calculated using formula ,

$$\text{Splitting tensile strength} = t_{sp} = \frac{2P}{\pi L}$$

Where, P = Failure load in N.

D = Diameter of the cylinder in mm.

L = Length of the cylinder in mm.

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Table 3. showing splitting tensile strength of porous concrete for 3, 7, 14 and 28 days curing

DAYS	S1	S2	S3	AVERAGE SPLIT TENSILE VALUE
3 DAYS	1.2	1.1	1.2	1.166
7 DAYS	1.5	1.5	1.4	1.46
14 DAYS	1.7	1.6	1.6	1.63
28 DAYS	1.9	1.8	2	1.9

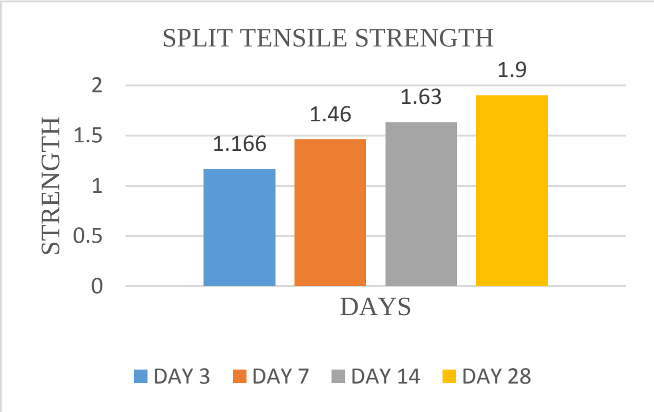

Fig (4.2) split tensile strength of cylinder.

4. *Permeability test*

The rate of flow under laminar flow condition through a unit cross sectional area of porous medium under unit hydraulic gradient is known as co-efficient of permeability. It is calculated using the following formulae

k= (Q x L)/ (T x H x A) cm/s

Where,

k = co-efficient of permeability
Q = total quantity of flow in a time interval, T
L = length of specimen, cm
T = time taken by the known amount of flow, sec
H = difference in the water levels of the overhead and bottom tank, mm
A = total cross sectional area of the sample, cm^2

Table 4. showing calculation of co efficient of permeability of Porous Concrete

SAMPLE	LENGTH (cm)	DIA (cm)	AREA (cm2)	DISCHARGE Q (ml)	HEAD H (mm)	TIME (sec)	CO-EFFICIENT OF PERMEABILITY (X 10-3cm/sec)
1	30	15	176.51	3800	270	18	132
2	30	15	176.51	3800	270	16	149
3	30	15	176.51	3800	270	17	140

V. CONCLUSIONS

a) The use of pervious concrete has increased significantly in the last several years, perhaps largely because it is considered an environmentally friendly, sustainable product.
b) The use of pervious concrete provides a number of benefits, most notably in the effective management of storm water runoff.
c) Other significant benefits include reducing contaminants in waterways, recharging groundwater supplies, reducing heat island effects, and reducing pavement–tire noise emissions.
d) Still, there are a number of areas that need additional developmental work to improve or enhance the capabilities of pervious concrete pavements.
e) One area is the continued monitoring of the performance of pervious concrete so that long-term performance trends can be documented.
f) This will also help in evaluating the suitability of pervious concrete for other applications, such as overlays.
g) conventional concrete are not generally applicable to pervious concrete.

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