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Water Absorbing Pavements by using Porous Concrete

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ABSTRACT— Water Absorbing pavement is a smart technique used in pavement construction, offering solutions for various challenges like low groundwater levels, efficient rainwater management, and agricultural issues. Porous concrete, a key component of this approach, finds its place in low-traffic areas, footpaths, as a sub-base for concrete pavements, and even as interlocking material."

Porous concrete is remarkable for its ability to let water seep through, helping recharge groundwater and reducing surface runoff. This feature drives its diverse applications and engineering attributes, emphasizing environmental advantages and robustness. Comprising cement, coarse aggregates, water, and optional additives, its lack of fine aggregates results in higher void content, facilitating water permeation. Hence, it's often dubbed as Permeable or Pervious concrete.

Pervious concrete serves a myriad of purposes, including parking lots, sidewalks, residential roads, driveways, medians, underpasses, pool decks, slope stabilization, and footpaths. Its versatility and permeability make it a go-to solution for enhancing sustainability and functionality in urban and rural settings a like.

Keywords-pervious/porous concrete, mix-design, strength, material

I. INTRODUCTION

Pervious Concrete is pretty unique compared to regular concrete. Instead of using fine aggregates, it swaps those out for gravel as the coarse aggregate. It's basically a mix of cement, gravel, water, and sometimes just a tiny bit of sand. What makes it stand out is its open-cell structure, which lets water and air flow right through it. You might hear it called different names like "Porous concrete", "Permeable concrete", "No fines concrete", or even "Porous pavement" concrete.

One specific type of porous pavement is porous concrete, characterized by carefully controlled amounts of water and cement materials. This mixture forms a paste that coats aggregate particles, creating a dense layer with substantial void

Content. Often referred to as "No fines Concrete," porous concrete.

The pervious concrete pavement possesses many Advantages that improve city environment as follows:

I. When it rains, the water can easily seep into the ground, ensuring that groundwater resources are replenished promptly. Since the pavement allows air and water to pass through, the soil underneath stays moist. This helps maintain a healthy environment for plants and other living organisms that rely on groundwater for survival.

II. Porous concrete, serves as an environmentally friendly solution that actively contributes to water management, groundwater replenishment, and temperature regulation while potentially reducing overall project costs through more efficient land use.

III. The porous nature of conventional concrete, coupled with its ability to retain moisture, creates ideal breeding grounds for mosquitoes and other insects.

IV. Pervious concrete acts as a natural filter, preventing pollutants from seeping into groundwater. Its porous structure allows water to flow through, trapping contaminants as it percolates. Integrated filtration layers enhance purification, while promoting natural drainage and reducing runoff. This eco-friendly solution protects groundwater quality, supporting a sustainable future.

II. OBJECT: -

The main goal of this investigation is to achieve maximum compressive strength in pervious concrete without compromising its permeability characteristics. To accomplish this, we conduct experiments using specially prepared test cubes measuring 150x150x150mm. These experiments cover a range of tests including aggregate analysis, sieve analysis, permeability testing, and compression testing. Understanding how different loading conditions affect

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pervious concrete is crucial for its design, and this research delves into that aspect as well.

III. EXPERIMENTAL MATERIALS: -

Pervious Concrete is basically a mix of Cement, Coarse Aggregate, and Water, with very little to no sand involved. Unlike traditional concrete, it doesn't use fine aggregates to maintain its permeable properties. Sometimes, we add admixtures to enhance its strength and other special features.

When making Pervious concrete, we ensure that all the materials—cement, coarse aggregate, and water—meet the right IS Specifications. We can also use a mix of different cementations materials, as long as each meets the required specifications. Chemical admixtures play a key role too, helping to improve various aspects of the concrete. Of course, they need to meet the relevant IS Specifications or other accepted standards.

IV. EXPERIMENTAL METHODOLOGY: -

We make different mixes of pervious concrete. The cubes we use for testing are 150mm x 150mm x 150mm in size. First, we carefully mix the concrete with just the right amount of water. Then, we pour it into the mould in three layers, making sure it's compacted properly. After just 30 minutes, we place the samples in a quiet spot where they won't be disturbed for about 24 hours. Once that time's up, we take them out of the moulds and put them into clean water until we need them for testing. When it's time to test, we take the cubes out of the water, dry off any extra water, and get them ready.

Curing the concrete is super important for its strength. To see how strong our pervious concrete is, we test it at different stages of curing: after one day, seven days, and 28 days. We use a Compressive Testing Machine for this. We put the cube samples in the machine and slowly apply pressure, increasing it at a rate of 10kN/m2 per minute. We keep going until the concrete starts to crack. Then, we note down the highest load it withstands and use that to figure out the strength of the cubes.

$$Strength\ of\ Specimen = \frac{Maximum\ load\ applied\ till\ failure\ (N)}{Area\ of\ Specimen(mmXmm)}$$

We test Specimen for Compressive Strength after 7 and 28 days of Curing.

TABLE 1: -IS Recommendation for Compressive strength of Cube after various days of curing.

Sr no.	Day of Curing	Compressive strength of specimen (%)
1	1	16
2	3	40
3	7	65
4	14	90
5	28	99

+

Mix Proportion for M15 Grade of Pervious Concrete

Stipulation for Proportioning:

- Mix Grade: M15
- Type of cement: Ambuja Cement 53 grade confirming to IRC-44-2017
- Maximum nominal size aggregate: 20 mm
- Minimum cement content: 365 kg/m^3
- Method of concrete placing:
- Maximum cement content: 365 kg/m^3
- Specific gravity of cement: 3.00
- Specific gravity of coarse aggregate: 2.74
- Condition SSD
- Slump value 0 mm

STEP 1: -TARGET STRENGTH FOR MIX DESIGN

From IS 10262: 2009 the target strength is given by

$$\mathbf{F/ck = fck + 1.65 \times S}$$

Where:
F/ck = target mean compressive strength at 28 days in N/mm2
Fck = characteristic compressive strength at 28 days in N/mm2
S = standard deviation in N/mm2
1.65 is tolerance factor
The value of standard deviation can be assumed from Table

Table 18 Assumed Standard Deviation Values for mix designs based on compressive strength (considering good quality control)

Sl. No.	Grade of concrete	Assumed Standard Deviation N/mm^2
1	M 10	2.5
2	M 15	3.0
3	M 20	4.0

STEP 2: SELECTION OF WATER- CEMENTITIOUS MATERIALS RATIO

In our research, we focused on the water-cementations material ratio (w/cm) as a crucial factor in determining the strength and void structure of pervious concrete. Based on experience, we selected two different w/cm ratios: 0.30 and 0.40. This range was chosen because it's been found to offer optimal aggregate coating and paste stability. By casting cubes with these specific ratios, we aimed to explore how variations in w/cm can influence the performance of pervious concrete.

STEP 3: Selection of Water content

Water content for 10mm aggregate =208 kg/m^3 (for 50mm slump without using super plasticizer's)
As superplasticizers is being used, the water can be reduced
Based on trials with high range super plasticizers actual water
Reduction was around 30%.
So arrived water content = 208-(30% X 208) kg/cum.
= 146.0 Kg/cu.m

STEP 4: Selection Of cement content

Arrived water content is = 146 kg/m^3
Water cementatious ratio = 0.400
Cement Content = 146/0.40
365.00 = say 365kg/m^3

Hence,

Cement (OPC)	365	Kg/m^3
Micro Silica	0	Kg/m^3
Free Water	146	Kg/m^3

STEP 5: DETERMINATION OF COURSE AND FINE AGGREGATE CONTENT:

j) Mix Calculations

a) Volume of concrete = 1m^3

b) Volume of cement $= \dfrac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \dfrac{1}{1000}$

$= \dfrac{365.00}{3.15*1000}$

$= 0.116\ m^3$

c) Volume of Micro Silica $= \dfrac{\text{Mass of Micro silica}}{\text{Specific gravity of MS}} \times \dfrac{1}{1000}$

$= \dfrac{0.00}{2.2*1000}$

$= 0.000\ m^3$

d) Volume of Water $= \dfrac{\text{Mass of water}}{\text{specific gravity of water}} \times \dfrac{1}{1000}$

$= \dfrac{146}{1.00*1000}$

$= 0.146\ m^3$

e) Volume of admixture = 0.004
(1.20% by wt. Of cementatious material)

f) Volume of all in aggregates = [a - (b+c +d+e)]
= 0.734 m^3

h) Mass of coarse aggregate
10mm = f X Vol of coarse aggregate Specific gravity of 10mm aggregate x 1000

Due to porosity considered 22% voids so volume of concrete is (1-0.22 = 0.78)
= 0.78*0.534*2.78*1000
= 1574.43
say 1575 Kg/m^3

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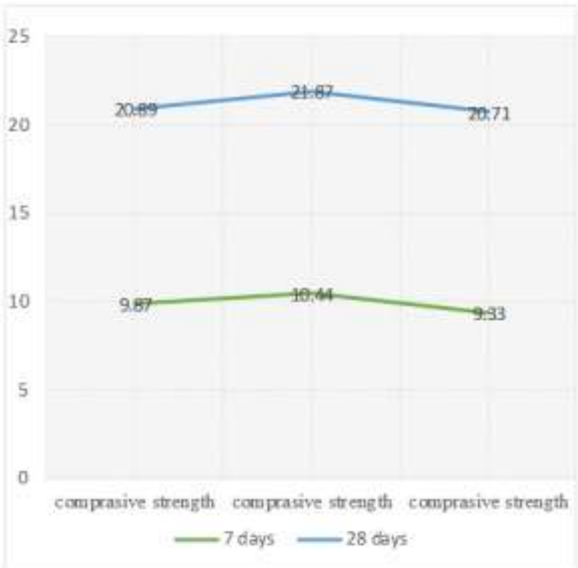
Mix Proportion in SSD Conditions	
	By Wt.
CEMENT	365 kg
Micro Silica	0.00kg
FREE WATER	146kg
Water binder ratio	0.40
Crushed Sand	0kg
Coarse Agg.20mm	0kg
Coarse Agg.10mm	1575kg
Chemical Admixture	2.30kg

Note: - Admixture dosage may vary depends upon climatic conditions and site requirements. The proportions of course and fine aggregate may be varying with in +/- 5 %. Absorption and moisture correction will be applied depend upon the aggregate condition.



V. CONCLUSION

The pervious concrete needs proper mix design. The mix design, crucial for casting concrete cubes, was meticulously determined by following the guidelines outlined in the Indian standard code (IS: 10262: 2009). This ensured precise proportions of cement, water, and coarse aggregate, along with maintaining the appropriate water-cement ratio. Through this meticulous process, the concrete's performance characteristics, including compressive strength, split tensile strength, and workability, were thoroughly evaluated. The insights gleaned from this research paper are invaluable, serving as a solid foundation for future concreting endeavors and procedures.

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