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Experimental Investigation on High Strength Pervious Concrete with Partial Replacement of Coarse Aggregate by Marble Aggregate

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Abstract : The concrete technology has made tremendous strides in past decades. Pervious concrete plays a different role which is an exceptional case[1]. Normal concrete does not allow water to pass through it whereas pervious concrete allows water to pass through it. The principal reason to develop these type of concrete is to use this concrete in pavement, open floors, since rain water may pass through it and thus helps to increase the ground water level. Water logging and depleting ground water table are the two-major problem faced by the people all over the world. So, this research projects objective is to maintain the permeability as well as strength of the concrete. In this investigation, the pervious concrete is obtained by removing the fine aggregate wholly (0%) and replacing with 6.3mm waste marble aggregate and partially as, 10% replacing the coarse aggregate and partially as 10% and 20% of waste marble aggregate of 10-12mm. With water cement ratio of 0.4. Suitability of pervious concrete as a pavement material is discussed.
Keywords : Pervious concrete, Permeability, Strength, Marble aggregate.

1.0 Introduction

The annual rainfall in India, according to 2015 report is 1,204mm. From this only 5-10% of water is being recharged as ground water. As the land usage is being increased tremendously, the Rainwater Harvesting pits are not that much effective in collecting rainfall[2,6]. In order to overcome this situation, "PERVIOUS CONCRETE" should be provided to harvest the storm run-off. Pervious concrete is a permeable concrete which allows to penetrate the water to the sub-surface, so that water table level may increase. Since porosity of concrete will reduce the strength of concrete, an attempt will be made to increase the strength of concrete by adding grading of aggregates to it.

Based on the report from the Customized Rainfall Information System (CRIS)2013 rainfall is 741.1mm, 2014 rainfall is 913mm, 2015 rainfall is 1204mm. Due to urbanization, the pervious lands become impervious which results in flash floods and the ground water recharge by rainwater has rapidly decreased from 15% to 5%.As urban sprawl continues to dominate the landscape 35% to 70% of our construction sites are being covered by paved surface and roofs.

Pervious concrete, also known as porous concrete (enhanced porosity) or gap-graded concrete has little to no fine aggregates. Pervious concrete mixes consist of cement, single sized coarse aggregate and water (water/cement ratio ranging 0.3 to 0.4). It is reported that, the 28-day compressive strength of such mixes range from 800 psi to 3,000 psi based on compressive strength testing per ASTM C39. In addition, pervious concrete mixes vary among batch manufacturers with varying strengths and permeability rate. Since the mid-1970's,

interest in the use of pervious concrete has grown throughout the United States. The benefits from its use are its potential to:

- Reduce the quantity of runoff water
- Improve water quality
- Enhance pavement skid resistance, especially during storm events by rapidly draining rain water

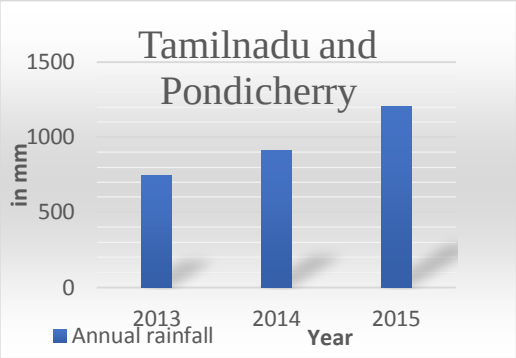


Figure 1.1: Statistics report on rainfall in Tamilnadu and Pondicherry

Several agencies, including the National Concrete Pavement Technology Center at Iowa State University, U.S. Environmental Protection Agency (EPA), Boston Metropolitan Area Planning Council, California Storm Water Quality Association, Colorado Ready Mix Concrete Association, and Middle Tennessee State University have conducted research and/ or compiled research studies on pervious concrete pavements in their local jurisdictions[5]. The studies conducted at Iowa State University Technology Center found that in cold climatic regions with hard wet freeze environments, the use of pervious concrete is limited.

Flood is one of the major disaster as far as the low-lying areas are considered. Flood can lead to mass destruction of the valuable resources and human lives (example- Chennai flood during NOV-DEC 2015). Pervious Concrete will drain water into the sub-surface where it is laid and will help in reducing storm water runoff. Pervious pavements will reduce the effects of floods and increase the water table level which will guarantee a sustainable and eco-friendly environment.

2.0 Research Objectives

The use of pervious concrete to date has been limited to low volume and low speed traffic areas such as parking lots and sidewalks. These facilities are not typically subjected to high volume and standard wheel loads. Many jurisdictions are now considering the use of pervious concrete on low volume roads such as residential streets and alleys.

- To study about properties of Pervious concrete.
- Creating an eco-friendly pavement.
- To provide a sustainable environment.
- Result analysis in the strength and permeability.

3.0 Literature Survey

The main motive behind this paper is to obtain the maximum strength with sound permeability rate, that would help in replacing the paver block. Also, this research deals with the environmental waste reduction by using dumped marble aggregate waste as coarse aggregate.

The authors Arun H[8], and otherspaper titled ‘Experimental Investigation on Incresing the Strength of Pervious Concrete by Varying the Mix Ingredients’ published in 2016 tells Pervious concrete or no fine concrete can be used as pavement generally and the usage of admixture with conventional Nano silica increases the strength and bonding between material plays a role in strength. Pervious concrete with Nano silica holds good for strength characteristics.

Prof.M.UmaMaguesvaria[6] and others investigated on the Characterization of Pervious Concrete for Pavement Applications. They reported that angularity number influenced the properties and behaviour of pervious concrete with fine aggregate and coarse aggregates. The range of compressive strength varied between 10 N/mm2 to 26 N/mm2. Increasing the aggregate size increased the angularity number. Coefficient of permeability increase from 0.4 cm/sec to 1.26 cm/sec when the angularity number was in the range of 4 to 8. They identified optimum mixes for each coarse aggregate size based on the compressive strength, Void present in aggregate (based on angularity number) and permeability

Prof Darshan S[5]. and others made an investigation on pervious concrete pavement in rural areas and reported that they reduce the storm water runoff, increase the ground water level, and eliminate the costly storm water management practices. They concluded that there will be considerable saves in the construction of storm water drains as the size of the drain will be much smaller due to pervious pavements.

4.0 Research Methodology and Data Collection

The first part of this study focused on testing pervious concrete mix designs to determine the mix with the optimal compressive strength and permeability.Three design mixes were tested and compared with a control mix.The three design mixes were achieved by varying the sand content and introducing marble to potentially improve the compressive strength of pervious concrete

A. Materials Used

General pervious concrete consists of only Cement & Coarse aggregate. Cement is the only binder material used in the project and hence OPC53 grade cement is used. Coarse aggregate size of 12mm to 20mm is used in the project to obtain maximum permeability.

Apart from Cement and Aggregate, Marble aggregate with gap grading system, 6.3&12.5mm are graded and used in this research project.Which helps to improve the strength of the concrete.

B. Mix Design

Although pervious concrete contains the same basic ingredients as the conventional concrete, the proportions of the ingredients can vary. One major difference is the requirement of increased void content within the pervious concrete. The amount of void space is directly correlated to the permeability of the pavement. The need for void space within the mix design correlates with using little to no fine aggregates. The porous concrete mix designs adopted for this study were based on materials that were readily available in the metropolitan area.

The mix design based on 10262-2009 guidelines for mix design, replacement of fine aggregate fully with graded 6.3mm marble aggregate with partially replacement 20mm coarse aggregate by 12.5mm graded marble aggregate, as the main theme of the project is to utilize the dumped waste marble aggregate into the concrete. As marble is a metamorphic rock which is help full improving the strength properties of the concrete.

The ratio of 1:1.73:3.02 is used with water cement ratio of 0.4. as the pavement is good and reliable on dry mix of the concrete on observations, and the replacement level by 10,20&30 percentage to the coarse aggregate and fully replaced with the fine aggregate with 6.3mm coarse aggregate.

	Mix 1	Mix 1	Mix2	Mix3
Mix Ratio	1:1.73:3.02	1:1.73:3.02	1:1.73:3.02	1:1.73:3.02
Water Cement Ratio	0.4	0.4	0.4	0.4
percentage of replacement of fine aggregate with 6.3 Marble aggregate	100%	100%	100%	100%
percentage of replacement of coarse aggregate with 12.5mm Marble aggregate	0%	10%	20%	30%

5.0 Material Testing Results

Specific gravity of coarse aggregate is found to be 2.8 and as per IS 2386 (part3):1963, the specific gravity of coarse aggregate should be 2.6 to 2.9.

The specific gravity of marble aggregate=3.05
The specific gravity of cement obtained is 3.08.
Based on sieve analysis as per IS 383-1970 the zone of fine aggregate as ZONE II.
The percentage of water required for obtaining cement paste of standard consistency = 22.5%.

6.0 Testing Results

A. Comparative results for Compression

Comparing the results of compression from the 3 type of specimens it is typically found that the mix containing 30% of Marble aggregate has relatively high strength compared with that of the conventional one. It is clearly observed that even though there is a failure in the mix3 but the cubes underwent partial failure rather than complete failure.

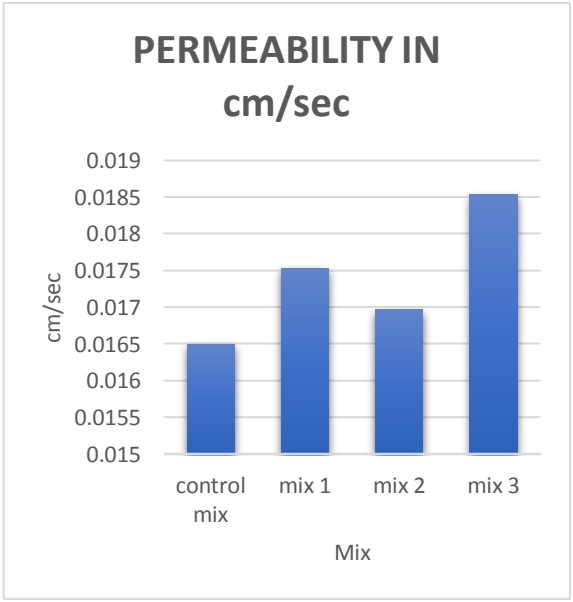
	COMPRESSION STRENGTH (N/mm^2)		
mix type	7 DAYS	14 DAYS	28 DAYS
controlled mix	3.3	10.829	16.66
Mix 1	2.488	10.1075	15.55
Mix 2	3.128	12.7075	19.55
Mix 3	3.5552	14.443	22.22

B. Permeability Test

Permeability test is an important test required for determining the permeability or draining capacity of pervious concrete, which is the core idea of the project. From the testing values it is found that the values of permeability are relatively higher for in 10% replacement of mix 1 as the permeability correlates with the void space in the concrete. As 20 and 30% of mix2, mix3 are just below the mix1.

Constant head and variable head permeability test are conducted on the samples.

mix type	PERMEABILITY IN cm/sec
control mix	0.0165
mix 1	0.0175
mix 2	0.0170
mix 3	0.0185



7.0 Results and Discussion

In this research study in theprevious concrete on the maximum compressive strength, and the optimal infiltration rate

- MIXl:3 showed a maximum compressive strength of 22.22 N/mm^2 compare with controlled concrete more than 28%
- Coefficient of permeability of 0.0185 cm/sec. compare with controlled concrete more than 10.8%
- Due to the variation in aggregate proportions based on gap grading method the voids are increased.
- And the strength increases by means of filling and bonding of 6.3mm,12.5mm Marble aggregate.

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