A Sustainable Study on Permeable Concrete using Bagasse Ash and Rice Husk Ash as a Partial Replacement of Cement

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Abstract. Permeable concrete is a special concrete which consists of cement, coarse aggregate and water. Due to rapid growth of globalization and urbanization, the construction of concrete roads increasing day by day which leads to decrease in percolation of storm water, surface runoff occurring to the decrease in ground water table. In previous concrete, single sized aggregate is used to maintain the void ratio in the concrete. The cement paste is bonded with aggregate with a void ratio of 20%. In this investigation, concrete of M20 grade with water cement ratio of 0.38 is used. The properties of concrete were increased by using Rice husk ash and Bagasse ash in changed percentages (10%, 20%, 30%) by weight of cement and with the combination of rice husk ash and bagasse ash 10% (5%RA + 5%BA), 20%(10%RA+10%BA), 30%(15%RA+15%BA) are used. The compressive strength of cubes, split tensile of cylinders are casted, tested after 7 days and 28 days. After testing, the optimum percentages of replacement of admixtures are found in the Permeable concrete. Therefore the strength and durability properties of permeable concrete with the addition of bagasse ash and rice husk ash with partial replacement of cement are compared with conventional concrete.

1 Introduction

Due to construction of rigid pavements, the rainfall water in surface runoff can not be percolate in to the ground surface which leads to ground water depletion. As a rapid growth of industrialization and population, it implies the need of ground but the impermeable concrete in various applications such as road pavement and concrete structures which affect the ground water table. To over come the ground water depletion, the solution is Permeable pavements which percolates the runoff from rain and storm water and which increase the ground water table and aquifers to make the sufficient water for sustainable use.

Due to usage of cement in constructions, it releases CO_2 and which effects the environment. The emission of CO_2 can be minimized by using eco-friendly materials. i.e., byproducts from Rice and sugar industry.

Bagasse ash and Rice Husk Ash have pozzolonic property, which is about 62% and 90% silica dioxide (SiO_2) can be utilized as limited replacement with cement. Kawade et al [1] studied that utilization of bagasse ash will increase its strength up to 15% with replacement of cement beyond its limits it start decreasing its strength properties. Srinivasan et al [2] studied that bagasse residue, after combustion produces a chemical composition of silica dioxide which can be used as partial replacement. Pitroda et al, [3] in his experimental study, the effect of Rice Husk Ash properties of Permeable concrete with various w/c ratios 0.3, 0.36, 0.40; the compressive & flexural strength varies depending upon the w/c ratio. It has been shown that up to 10% replacement of RHA is increased beyond it starts decreasing.

Objective

- To control the emission of CO_2 through partial replacement of cement by using agricultural waste.
- To enhance the strength and durability of Permeable concrete and to make an eco-material for road pavement.
- To minimize the waste, reduce disposal problems, reduce cost and also to produce green material.
- To increase ground water table by improving the permeability of concrete.

2 Experimental Materials

Cement

It is a mineral powdered material binds easily when mixed with water .which act as a binder material in construction works. In this investigational work, an OPC cement of 53 grade is used. IS: 12269 – 1987, "Specifications for 53 grade ordinary Portland cement", Bureau of Indian Standards, New Delhi [7].

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Coarse Aggregate

Single Size aggregate are used passing from 20mm IS Sieve retained on 9.5mm sieve. Aggregate plays a major role in gradation, compressive strength, permeability. Uniformly graded aggregate gives higher compressive strength as well as higher void content. Sourabh Rahangdale et al,[4} in their investigation of study shows that aggregate between 12.2-16mm size of aggregate having much higher compressive strength & the split tensile strengths are good and the permeability properties as well.

Rice Husk Ash

India is a major paddy producing country. Annually, nearly 2,00,00,000 tonnes of rice husk ash is produced. Which creating a disposing problem and causing damage to environment. Rice Husk Ash has a pozzolonic properties so which can be used as cementious material up to certain percentage beyond it start losing its strength properties.

Table 1. Chemical properties of Rice Husk Ash.

Chemical Properties	**%**
Silicon dioxide (SiO_2)	90.7
Aluminium oxide (Al_2O_3)	0.4
Ferric oxide (Fe_2O_3)	0.4
Calcium oxide (CaO)	0.4
Magnesium oxide (MgO)	0.5
Sodium oxide (Na_2O)	0.1
Potassium oxide (K_2O)	2.2
quivalent alkali ($Na_2O+0.658K_2O$)	1.5
Phosphorous oxide (P_2O_5)	0.4
Itanium oxide (TiO_2)	0.03
Sulphur trioxide (SO_3)	0.1
Loss of ignition	4.8

Bagasse Ash

Bagasse ash is a by-Product of sugar factory. India is the second largest country to producer of sugar cane of about 29.5 million tonnes causing the disposal problem. It can be minimized by partial replacement of cement.

Table 2. Chemical properties of Bagasse Ash

Chemical properties	%
Silicondioxide (SiO_2))	62.42
Aluminium oxide (Al_2O_3)	4.39
Ferric oxide (Fe_2O_3)	6.99
Calcium oxide (CaO)	11.81
Magnesium oxide (MgO)	2.52
Potassium oxide (K_2O)	3.54
Sulphur trioxide (SO_3)	1.46
Loss of ignition	4.72

3. Methodology

Permeable concrete is also known as porous. It consists of cement, aggregate and water in different proportions (1:2, 1:4, 1:6) with a void ratio of 20%. Gaurav uttam shinde [5] studied that with increase in void ratio, infiltration increases besides decease in compressive strength and vice versa. Ajamu et al [6] the study shows with 1:6 Aggregate to cement ratio, the highest compressive strength was observed when compared to 1:8 and 1:10 ratios. From the optimum proportion of admixture the results are found. In this investigation, M20 grade of concrete with 0.36 water-cement ratio is used. The cubes are casted and tested with different percentages of (10%, 20%, and 30%) by cement weight using rice husk ash, bagasse ash and the combination of both. Besides, Compressive strength tests and split tensile strength tests, permeability tests are also considered in permeable concrete and compared with conventional concrete.

4. Experimental Study

The permeable concrete behavior with various types of proportion is studied through an experimental programme. The different mix proportion such as (1:2, 1:4, and 1:6) have been prepared and tested through M20 concrete grade with W/C ratio 0.36 From IRC: 44-2017, “Guidelines For Cement Concrete Mix Design For Pavements”. [8] The three samples are casted for each mix proportion to find the performance of Permeable concrete. After casting, the specimens are tested using compression testing machine, to evaluate the compressive strength of concrete. The split tensile strength of cylinders was determined for dimensions of 300mm x 150mm sample by testing with Universal Testing Machine. In addition to this, the permeability for designed Permeable concrete is tested and compared with conventional concrete.

5. Results and Discussion

The behavior of previous concrete with various types of proportion is studied through an experimental programme. The different mix proportion such as (1:2, 1:4, and 1:6) have been prepared and tested through M20 concrete grade with w/c ratio 0.36 From IRC: 44-2017, “Guidelines For Cement Concrete Mix Design For Pavements”. [8] The three samples are casted and tested for each mix proportions to find performance of Permeable concrete. After casting, specimens are tested for compressive strength and split tensile strength of concrete. In addition to this, the durability properties such as permeability for designed Permeable concrete is tested and compared with conventional concrete.

Compressive Strength

Compressive strength results of Permeable concrete is determined for 7 days and 28 days. The following graphs were drawn with respective % of replacement v_s compressive strength.

Fig. 1. Compressive strength test on cube specimen

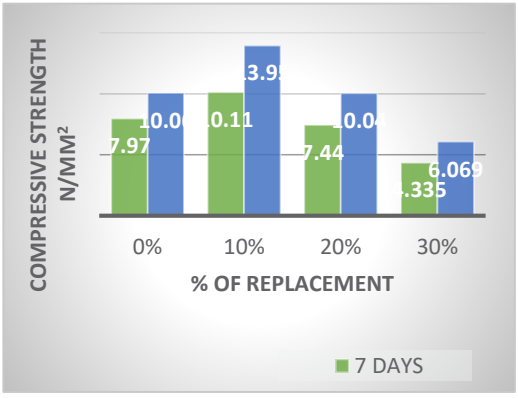

Fig. 2. Rice Husk Replacement Ash with Cement

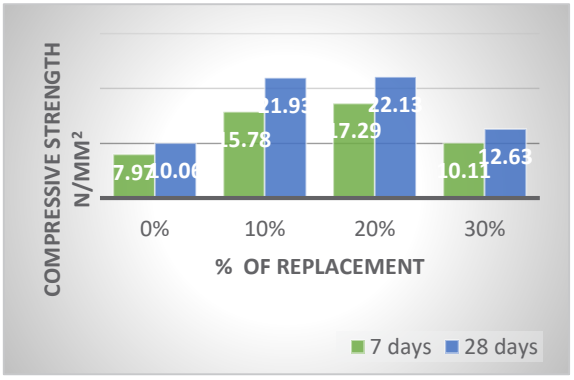

Fig. 3. Bagasse Ash Replacement with Cement

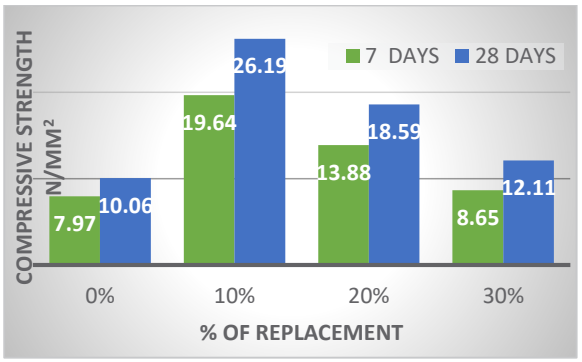

Fig. 4. Rice Husk Ash and Bagasse ash Replacement with Cement

Split Tensile Strength

Split tensile strength is conducted for cylinder of dimensions 300x150mm from optimum percentage of admixture found during compressive strength of cubes. Test results are for 7 days 2.02N/mm^2 and for 28 days 2.74 N/mm^2

Fig. 5. Split tensile strength on Cylinder specimen

6. Permeability Test

Permeability test are conducted on the Permeable concrete, the rate of water flow from Permeable concrete is 700 litre/hr/sq.m

7. Conclusion

In this experiment, the durability and permeability properties of Permeable Concrete has studied when the cement is replaced with Rice Husk Ash and Bagasse Ash in different percentages. The results shows that, the Compressive Strength is optimum at 10% (5%RHA+5%BA) replacement of cement with mixture of Rice Husk Ash and Bagasse Ash and strength increse is mainly due to the occurrence of more amount of Silica presence in Rice Husk Ash and Sugarcane Bagasse ash. Hence, it is a cost effective and environment friendly construction used for the sustainable use.

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