Improvement on Compressive Strength of Pervious Concrete

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Abstract: Pervious concrete (PC) is a special type of concrete, which consists of cement, coarse aggregates, water and if required, admixtures and other cementitious materials. As there are no fine aggregates used in the concrete matrix, the void content is more which allows the water to flow through its body. So, the pervious concrete is also called as Permeable concrete and porous concrete. Numerous studies are being carried out in in connection with PC. Due to its voids and porosity, Compared to regular concrete, PC has a less compressive strength. Because of this, pervious concrete is not utilized very frequently, even though it has many advantages. Increases in pervious concrete's flexural and compressive strengths will enable it to be utilized in more applications. Pervious concrete is now primarily used on roadways with low traffic volumes. It can also be applied to inflexible pavements with medium and heavy traffic if the characteristics are improved. In addition, pervious concrete makes efficient use of the available land, stops the surface discharge of storm water, and aids in groundwater recharge. Our project's primary goal is to enhance pervious concrete's strength properties. However, it should be remembered that pervious concrete's permeability will decrease as its strength increases. Therefore, the permeability property should not be impacted by strength development because it is the characteristic that fulfils its function.

Keywords: *Pervious Concrete, No Fines, Compressive Strength, Storm Water, Permeability.*

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I. INTRODUCTION

In numerous fields of environmental and civil engineering today, including water management systems, pervious concrete (PC) is utilized as a sustainable alternative. In light of this and the fact that PC offers various environmental advantages, including reducing soil and water pollution, regulating stormwater runoff, and replenishing groundwater supplies, its use has grown over the past 30 years in many nations, particularly in the US, Japan, and Europe. Additional benefits of using PC pavements include preserving natural ecosystems, lowering noise levels from pavement tires, minimizing glare on road surfaces, and lowering lifetime costs. Pervious concrete is a particular versatile substance solution to reduce the runoff from paved areas and recharging the ground water. Compared to typical concrete, pervious concrete has a faster rate of uprooting storm water. Retention ponds, swales, and storm water management

measures are not necessary because it recharges the ground water immediately. Additionally, it is getting rid of expensive piping infrastructure and storm water retention vaults. Thus, reduce construction expenses, safety issues and maintenance cost. The waste management problem has already become severe in the world. The challenge is made worse by the exponential growth in industrial wastes of various types and compositions. For emerging nations like India to grow, energy is essential. The significance of using industrial waste cannot be overstated, especially given the limited supply of non-renewable energy supplies and the high energy requirements for building materials like cement. The Waste's feasibility and environmental acceptability materials are the subject of intensive investigation by numerous research organizations. Thus, the primary goal of this research is to enhance the mechanical qualities of Making pervious concrete with rice husk ash and fly ash components to create a combination proportion. About 24 million tonnes of rice husk and 6 million tonnes of rice husk ash are produced annually in India alone in 2020, along with about 70 million tonnes of flyash and 120 million tonnes of rice paddy.

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II. LITERATURE REVIEW

Water permeability is typically between 0.2 and 0.6 cm/s, and PC's void content can be estimated to be between 15% and 25%. Only some applications, such as parking lots, walkways, subbases for conventional pavement and leisure squares, can make use of PC with low strength. Cement, which is utilized as a raw material and caused significant amounts of CO2 to diffuse into the surrounding environment, is one of the most crucial components in the creation of PC. Reducing the use of unfriendly cement in building projects is therefore crucial for the concrete sector. [1]

Researchers from around the world are very interested in exploring the idea of using pozzolanic materials, particularly FA, as a partial substitute for cement, given the numerous economic and environmental drawbacks of using cement in the production of PC. The use of fly ash to partially substitute cement in the creation of the use of PC has not yet been thoroughly examined, though. Thus, the purpose of this review study was to talk about previous research on using FA to partially substitute cement in the production of PC. [2]

In this regard, replacing cement with alternative materials like silica fume, fly ash (FA), blast furnace slag (BFS), etc. is a suitable way to reduce CO2 emissions and move towards sustainable growth. By substuting cement with pozzolanic additives, CO2 emissions can be significantly decreased. Utilizing waste materials offers a chance to cut CO2 emissions worldwide by about 22%. [3]

III. SCOPE & RESEARCH OBJECTIVES

- *Enhance Mechanical properties:*
  It can significantly increase the pervious concrete mixture's compressive strength

- *Investigate effects of additives:*
  In order to examine how various additives affect the compressive Pervious concrete's strength.

- *Maintain permeability*
  To guarantee that pervious concrete's permeability is not seriously jeopardised by increases in compressive strength.

- *Material optimization:*
  To ascertain the ideal ratios of cement, coarse aggregate, and additives to achieve the required strength To assess how well Ash from rice husks and fly ash work to increase the pervious concrete's compressive strength

IV. METHODOLOGY

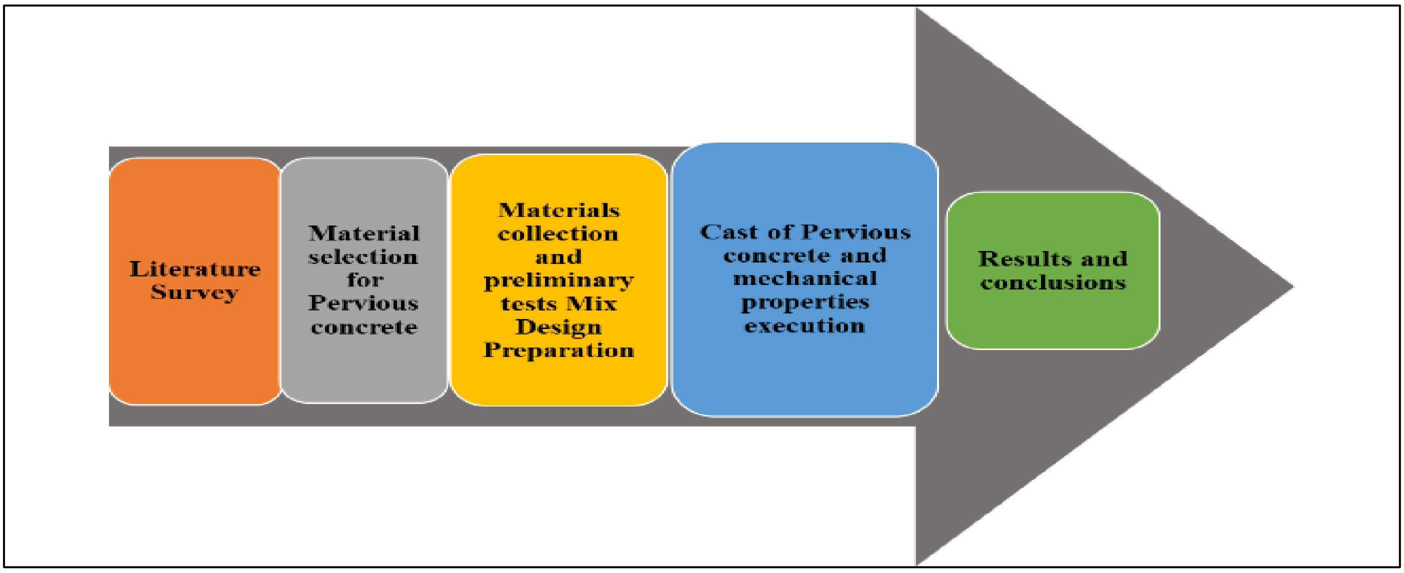

Fig 1 Methodology

V. PRELIMINARY TESTS ON MATERIALS

- *Cement:*
  The cement that was utilized in this experimental investigation is ordinary Portland Cement of 53 grade confirming to IS:12269: 1987.

- *Fly Ash:*
  Coal combustion Fly ash serves as a industrial waste which is generated from thermal power plants disposed from burning coal. Over 70 Millions of metric tonnes of fly ash is been produced per year in India which is not utilized and dump in the empty lands near power plants which causes land, water and air pollution which detoriates human health. In point of sustainability flyash is developed in construction materials in recent times. The fly ash (Class F) used in this investigation was obtained from S.I.E.L. located at Muthukuru, SPSR Nellore, Andhra Pradesh.

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➢ *Rice Husk Ash:*

Rice Husk Ash (RHA) is an agricultural waste product which is produced in large quantities globally every year and due to the difficulty involved in its disposal, can RHA be becoming an environmental hazard in rice producing countries. Production of rice paddy is associated with the production of rice bran and rice husk, which are basically two byproducts. The outer shell that covers the rice kernel is known as the husk, or hulls. For every 1000 kg of paddy milled, about 220 kg (22%) of husk is produced. This rice husk is mostly used as a fuel in the boilers for processing paddy. When this husk is burnt in the boilers, about 55 kg (25%) of RHA is generated. The Rice husk ash used in this investigation was obtained from Sri Lakshmi rice mill. located at Jonawada, SPSR Nellore, Andhra pradesh.

Figure 2 show case the chemical composition of three binding agents utilized in pervious concrete. Physical property tests are conducted for cement OPC 53 grade, FA and RHA described below Table 1.

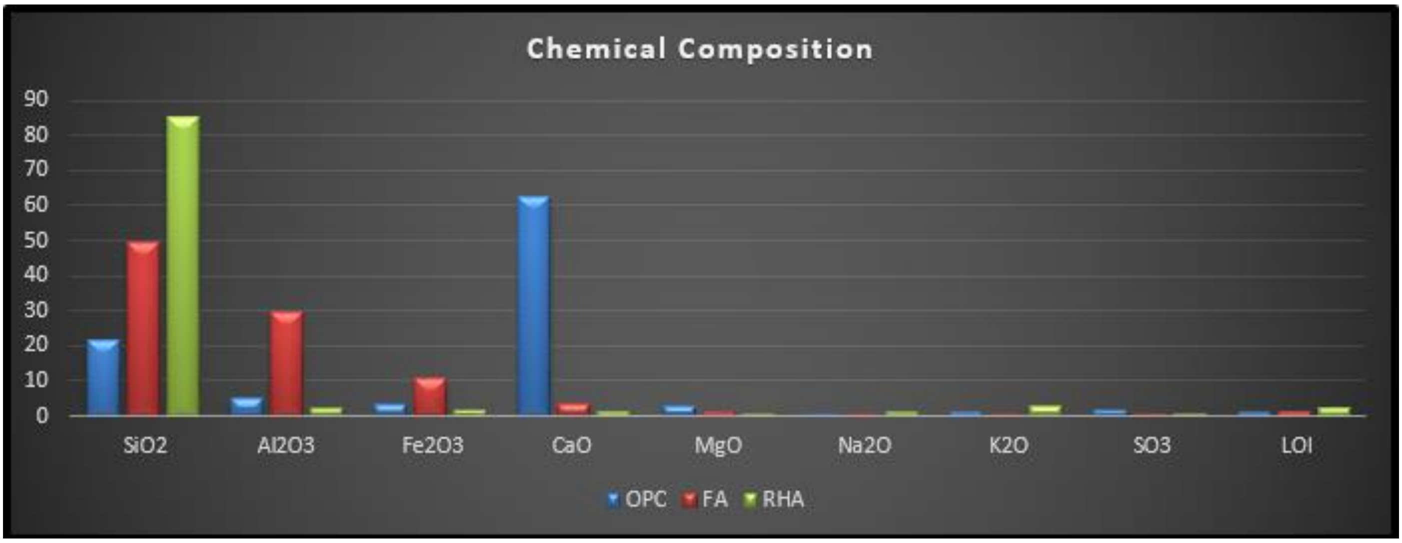

Fig 2 Chemical Composition of OPC, FA & RHA

Table 1 Physical Characteristics of Cement, FA &RHA

S. No	Property	Cement	FA	RHA
1	Specific Gravity	3.10	2.4	2.6
2	Fineness (%)	5	4.5	6
3	Consistency (%)	32	35	35
4	Initial Setting Time(min)	35	40	42
5	Final Setting Time(min)	178	215	240

➢ *Coarse aggregate:*

Aggregate occupies most of the volume of the concrete show they are the important constituents of concrete. They give body to the concrete, reduce shrinkage and effect economy. In this study, aggregate of two sizes was used. To achieve the necessary range, the coarse aggregate utilised in the study was sieved. Table 2 describes the aggregate's physical characteristics. There are two sizes taken. aggregate with 100% retention on a 10 mm filter and 100% passing a 20 mm sieve, as well as aggregate with 100% retention on a 4.75 mm sieve.

Table 2 Physical Characteristics of Coarse Aggregate

S. No	Property	Coarse aggregates	
		20mm	10mm
1	Specific Gravity	2.75	2.65
2	Water Absorption (%)	0.9	0.8
3	Abrasion Value (%)	22.5	21.4
4	Impact Value (%)	17.5	17.2

➢ *Water:*

To mix concrete, potable tap water that complied with IS: 456 - 2000 standards and had a pH value of 7.0±1 was available in the lab.

VI. DESIGN MIX OF PC

The mix proportion of pervious concrete replacing FA and RHA is given in Table3. For the design mix aggregate content is 1200 kg/m^3 and Cement: Aggregate ratio 1:3 is kept constant. Figure 3 showcase mix of pervious concreting process.

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Table 3 Mix Proportion of pervious concrete

S. No	Mix	Cement Content (kg/m^3)	Aggregate Content (kg/m^3)	W/C Ratio	Proportion of FA &RHA
1	FRHPC0	400	1200	0.35	Conventional
2	FRHPC1	360		0.36	5%FA+5%RHA
3	FRHPC2	340		0.38	10% FA +5%RHA
4	FRHPC3	340		0.38	5 % FA +10%RHA
5	FRHPC4	320		0.40	10%FA +10%RHA

Fig 3 Mix of Pervious Concrete, Cast and Curing

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VII. EXPERIMENTAL INVESTIGATION

The evaluation of FA & RHA for utilizes as a replacement of cement material begins with the concrete testing. Pervious concrete contains cement, water, coarse aggregate FA and RHA. In pervious concrete 5% and 10% of the cement is replaced with FA and RHA with different proportions. Three cube samples were cast on the mould of size 150*150*150 mm and three cylindrical samples were cast on the mould of size 300*150 mm for each concrete mix with partial replacement of cement with a w/c ratio of 0.35 0.36, 0.38 and 0.40. for each concrete mix with partial replacement of cement with a w/c ratio of 0.35 0.36, 0.38 and 0.40. The specimens were demolded after around 24 hours, and the water curing process was carried out until the corresponding specimens were tested for compressive and tensile strength following days 7, 14, and 28.

- *Pervious Concrete's Compressive Strength (IS:516-1959)*

Using cube samples, Tests of compressive strength were conducted on a compression testing equipment. The mean values of strength presented in this research were tested on 3 samples per mix. Comparative tests were conducted on every mix of concrete for partial cement substitution with FA & RHA at 5% and 10% W/C ratios of 0.35, 0.36, 0.38, and 0.40. The compressive capacity of PC is demonstrated in Figure 4.and Figure 5 displays the outcomes of the experiment.

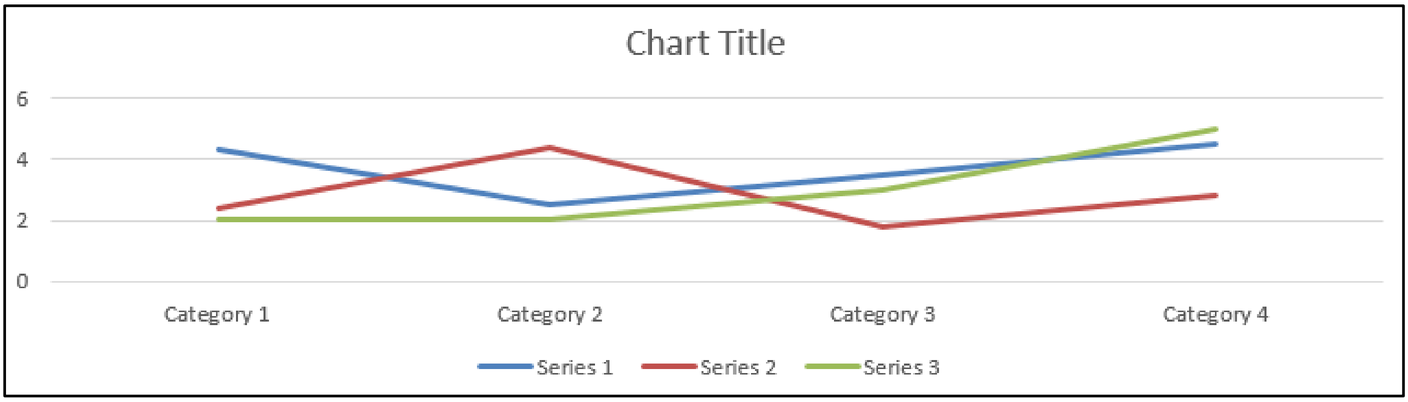

Fig 4 Compressive Strength Test of PC

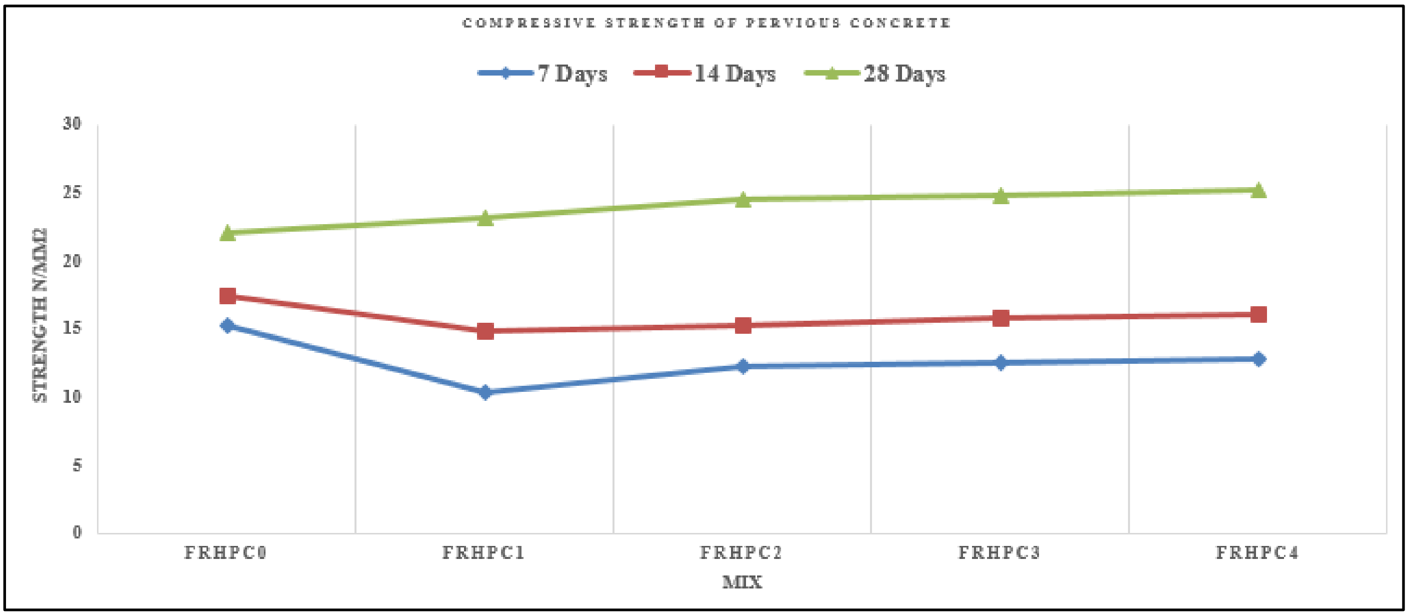

Fig 5 Graph Plot Between Compressive Strength and Pervious Concrete Mixes

➢ *Pervious Concrete's Tensile Strength (IS:516-1959)*

Cylindrical samples were used in tensile strength tests using a compressive testing machine. The mean average strength values provided in this research were tested on three samples per mix. Tensile strength tests were conducted on every concrete mix for partial cement substitution with FA & RHA at 5% and 10% W/C ratios of 0.35, 0.36, 0.38, and 0.40. Pervious concrete's tensile strength is seen in Figure 6. Figure 7 displays the outcomes of the experiment.


Fig 6 Tensile Strength Test of Pervious Concrete

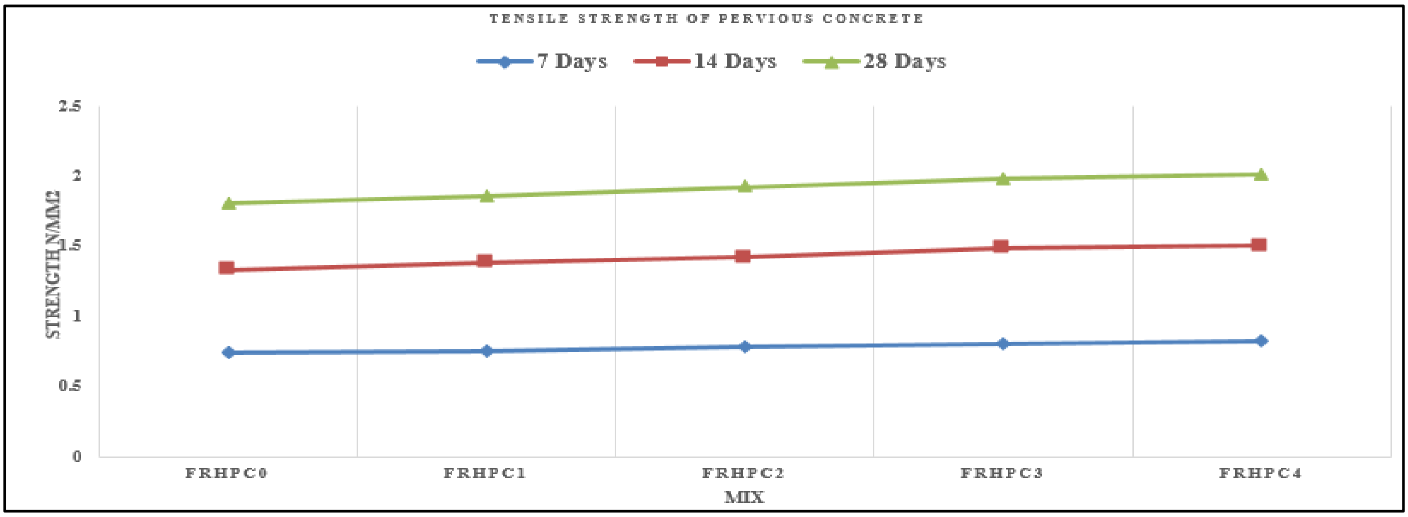

Fig 7 Graph Plot Between Tensile Strength and Pervious Concrete Mixes

VIII. CONCLUSIONS

The impacts of FA and RHA on the mechanical characteristics of PC have been examined in this experimental investigation. The following findings can be made in light of the thorough analysis of the research data.

- The inclusion of FA reduced pervious concrete's void ratio and water permeability. FA's filler nature and pozzolanic activity may be to blame, as they produced secondary C-S-H gels and decreased permeability and total voids.
- Since the concentrations of FA and RHA are more consistent than cement binder content, the W/C ratio of PC fluctuates for different proportions as the FA and RHA concentration increases.
- It was determined that 10–20% cement substitution with FA and RHA was the ideal level. However, if the replacement level is increased beyond the ideal range (30–50%), the hydration process is impacted, which results in a slower strength building; this process negatively impacts the strengths.
- Although adding FA and RHA as partial cement substitutes typically increases the compressive capacity of PC, pervious concrete that incorporates FA and RHA nevertheless has adequate strengths and permeability for a variety of applications. Using FA & RHA in PC is also beneficial from the perspective of waste reduction and environmental sustainability.
- On the other hand, using FA and RHA to partially substitute cement often results in a modest increase in tensile strength.

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