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An Experimental Study on Improving the Compressive Strength of Permeable Concrete

[1]Yogendra Onkar Patil, [2]Rakesh Amar More, [3]Ishwar Tukaram Patil

[1]Civil Engineering Department, D.N.Patel College of Engineering, Shahada
Yogen99@gmail.com
[2] Civil Engineering Department, D.N.Patel College of Engineering, Shahada
Rakeshmore8491@gmail.com
[3] Civil Engineering Department, D.N.Patel College of Engineering, Shahada
Patilishwar095@gmail.com

ABSTRACT

Pervious concrete is a special type of concrete, which consists of cement, coarse aggregates, water and if required, admixtures and other cementations 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. The main aim of this work is to improve the strength characteristics of pervious concrete. But it can be noted that with increase in strength, the permeability of pervious concrete will be reduced. Hence, the improvement of strength should not affect the permeability property because it is the property which serves its purpose.

Keywords: Pervious Concrete,

I. INTRODUCTION

Pervious concrete which is also known as the no-fines, porous, gap-graded, and permeable concrete and Enhance porosity concrete have been found to be a reliable storm water management tool. By definition, pervious concrete is a mixture of gravel or granite stone, cement, water, little to no sand (fine aggregate). When pervious concrete is used for paving, the open cell structures allow storm water to filter through the pavement and into the underlying soils. In other words, pervious concrete helps in protecting the surface of the pavement and its environment.

As stated above, pervious concrete has the same basic constituents as conventional concrete, 15 -30% of its volume consists of interconnected void network, which allows water to pass through the concrete. Pervious concrete can allow the passage of 11.35-18.97 litres of water per minute through its open cells for each square foot (0.0929m2) of surface area which is far greater than most rain occurrences. Apart from being used to eliminate or reduce the need for expensive retention ponds, developers and other private companies are also using it to free up valuable real estate for development, while still providing a paved park.

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Pervious concrete is also a unique and effective means to address important environmental issues and sustainable growth. When it rains, pervious concrete automatically acts as a drainage system, thereby putting water back where it belongs. Pervious concrete is rough textured, and has a honeycombed surface, with moderate amount of surface ravelling which occurs on heavily travelled roadways. Carefully controlled amount of water and cementitious materials are used to create a paste. The paste then forms a thick coating around aggregate particles, to prevent the flowing off of the paste during mixing and placing. Using enough paste to coat the particles maintain a system of interconnected voids which allow water and air to pass through. The lack of sand in pervious concrete results in a very harsh mix that negatively affects mixing, delivery and placement. Also, due to the high void content, pervious concrete is light in weight (about 1600 to 2000 kg/m3). Pervious concrete void structure provides pollutant captures which also add significant structural strength. It also results in a very high permeable concrete that drains quickly.

Pervious concrete can be used in a wide range of applications, although its primary use is in pavements which are in: residential roads, alleys and driveways, low volume pavements, low water crossings, sidewalks and pathways, parking areas, tennis courts, slope stabilisation, sub-base for conventional concrete pavements etc.,

II. METHODS AND MATERIAL

Cement: Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property.

In our project work, we have used Ordinary Portland Cement (OPC) of grade 53. It is a higher strength cement to meet the needs of the consumer for higher strength concrete. As per BIS requirements the minimum 28 days compressive strength of 53 Grade OPC should not be less than 53 MPa. For certain specialised works, such as pre stressed concrete and certain items of precast concrete requiring consistently high strength concrete, the use of 53 grade OPC is found very useful.

Typical Composition of Ordinary Portland Cement

Name of compound	Chemical Composition	Abbreviation
Tricalcium Silicate	3CaO.SiO2	C3S
Dicalcium Silicate	2CaO.SiO2	C2S
Tricalcium aluminate	3CaO.Al2O3	C3A
Tetracalcium alumino ferrite	4CaO.Al2O3.Fe2O3	C4AF

Aggregates: Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However, it is now known that the type of aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. They can form 80% of the concrete mix so their properties are crucial to the properties of concrete. Aggregates can be broadly classified into four different categories: these are heavyweight, normal weight, lightweight and ultra-lightweight aggregates. However in most concrete practices only normal weight and lightweight aggregates are used. The other types of aggregates are for specialist uses, such as nuclear radiation shielding provided by heavyweight concrete and thermal insulation using lightweight concrete.

Fly ash: Fly ash, also known as "pulverised fuel ash", is one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

Rice husk: Rice husk can be burnt into ash that fulfils the physical characteristics and chemical composition of mineral admixtures. RHA that has amorphous silica content and large surface area can be produced by combustion of rice huskat controlled temperature. Suitable incinerator/furnace as well as grinding method is required for burning and grinding rice husk in order to obtain good quality ash. Although the studies on pozzolanic activity of RHA, its use as a supplementary cementitious material, and its environmental and economical benefits are available in many literatures, very few of them deal with rice husk combustion and grinding methods. The optimized RHA, by controlled burn and/or grinding, has been used as a pozzolanic material in cement and concrete. Using it provides several advantages, such as improved strength and durability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions. For this reason, this study investigates the strength activity index of mortars containing residual RHA that is generated when burning rice husk pellets and RHAas received after grinding residual RHA. The effect of partial replacement of cement with different percentages of ground RHA on the compressive strength and durability of concrete is examined.

Table: Chemical Properties of RHA

S.No	Particulars	Proportion
1	Silicon Dioxide	86.94%
2	Aluminium Oxide	0.20%
3	Iron Oxide	0.10%
4	Calcium Oxide	0.3 – 2.25%
5	Magnesium Oxide	0.2 – 0.6%
6	Sodium Oxide	0.1 -0.8%
7	Potassium Oxide	2.15 – 2.30%

Table: **Typical mix design of pervious concrete as suggested by ACI 522 R-10**

Materials	Proportions (Kg/m^3)
Cement (OPC or blended)	270 to 415
Aggregate	1190 to 480
Water: cement ratio (by mass)	0.27 to 0.34
Fine: coarse aggregate ratio (by mass)	0 to 1:1

Table: Compressive strength of different grades of concrete at 7 and 28 days

Grade of Concrete	Minimum compressive strength N/mm^2 at 7 days	Specified characteristic compressive strength (N/mm^2) at 28 days
M15	10	15
M20	13.5	20
M25	17	25
M30	20	30
M35	23.5	35
M40	27	40
M45	30	45

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RESULT AND DISCUSSION

Optimised Mix Design of Pervious Concrete (With 20mm Aggregates, No Sand),Tested At NEC Nellore concrete technology laboratory.

Table: Mix Proportions

Materials	Proportions (Kg/m^3)
Cement (OPC-53 grade)	390
Aggregate (20mm)	1669.2
Water: cement ratio (by mass)	0.3
Fine aggregates	0

Table: Comparison of strength between normal concrete and pervious concrete

S.NO	Age of concrete (days)	Normal Concrete of M20 (MPa)	Pervious Concrete(MPa)
1	7	18.53	16.72
2	14	25.67	19.26
3	28	28.20	21.06

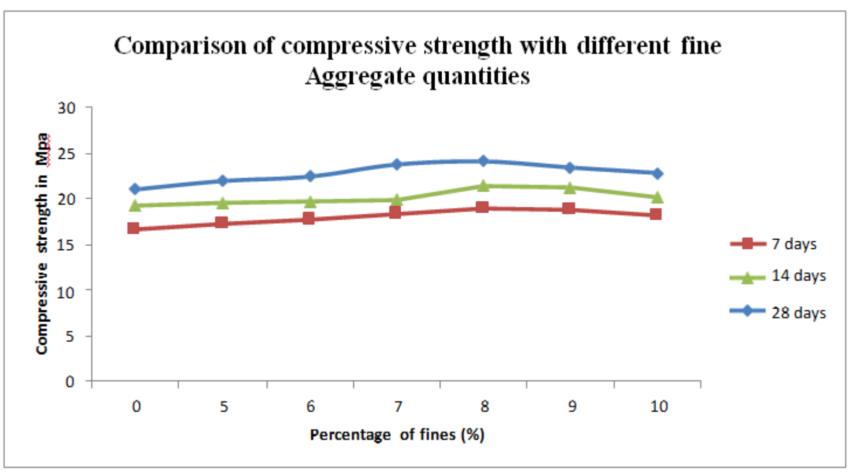
Table: **Comparative Study of strength of pervious concrete with different quantities of Fine aggregates**

S.No	Age of concrete	Standard pervious concrete(0% fines), MPa	Pervious concrete with 5% fines, MPa	Pervious concrete with 6% fines, MPa	Pervious concrete with 7% fines, MPa	Pervious concrete with 8% fines, MPa	Pervious concrete with 9% fines, MPa	Pervious concrete with 10% fines, MPa
1	7	16.72	17.36	17.75	18.32	18.98	18.76	18.28
2	14	19.26	19.60	19.73	19.93	21.47	21.23	20.23
3	28	21.06	21.98	22.47	23.79	24.13	23.47	22.87

The above table clearly shows that the compressive strength of pervious concrete increases with increase in age and percentage of fines up to 8%. Beyond this value, the compressive strength starts to decrease.

A graph showing the variation in compressive strength of pervious concrete by using the above values by taking percentage fines on x-axis and compressive strength on y-axis for 7,14 and 28 days as shown below.

Graph of compressive strength of pervious concrete with different quantities of fine aggregates



The 7 days compressive strength of 5% fines pervious concrete is less than the standard pervious concrete with 0% fine aggregates. It may be due slow development of early strength due to mixing

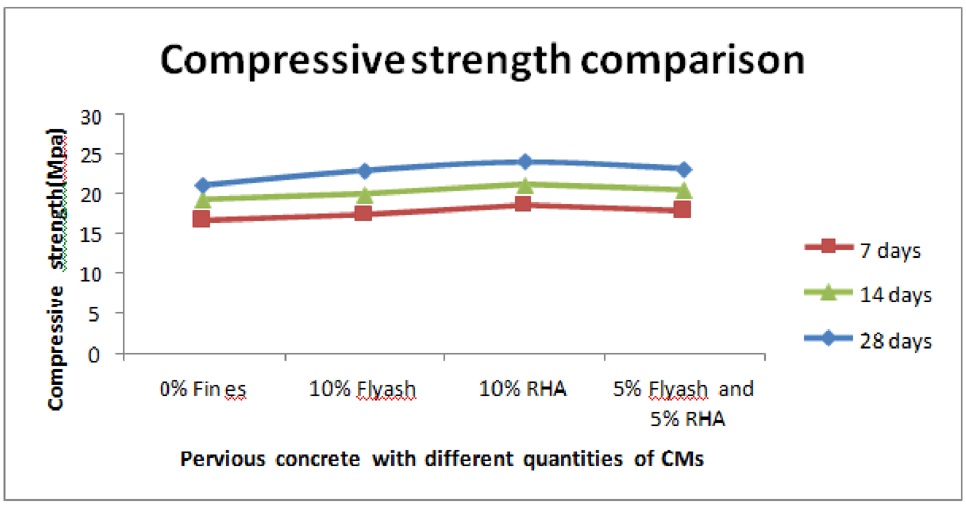
The pervious concrete with 8% fine aggregates gives highest compressive strength beyond which the compressive strength begins to fall.

Compressive Strength Comparison of Standard Pervious Concrete and Pervious Concrete with cement replacement:

Table: compressive strength of pervious concrete with cement replacement

S.No	Days	Standard pervious concrete with 0% fines, MPa	Pervious concrete with 10% FA as cement replacement, MPa	Pervious concrete with 10% RHA as cement replacement, MPa	Pervious concrete with 10% FA and RHA as, MPa
1	7	16.72	17.26	19.92	17.79
2	14	19.26	19.92	21.13	20.33
3	28	21.06	22.87	23.93	23.12

Graph of Age of concrete Vs compressive strength value comparisons with the cementitious materials



The pervious concrete with 10% Rice husk ash as cement replacement gives highest value of compressive strength when compared to fly ash replacement and standard pervious concrete.

The pervious concrete with mixture of fly ash and rice husk ash given least value of compressive strength. This may due to non homogeneity between the two cementitious materials.

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III. CONCLUSION

- The size of coarse aggregates, water to cement ratio and aggregate to cement ratio plays a crucial role in strength of pervious concrete.
- The void ratio and unit weight are two important parameters of pervious concrete in the context of mix design.
- The compressive strength and co-efficient of permeability of pervious concrete are inversely proportional to each other up to addition of 8% of fines.
- Among the two methods of increasing compressive strength of pervious concrete, the addition of fines has gave more value when compared to replacement of cementitious materials.
- The addition of fines and replacement of Cementitious will reduce the permeability capacity of pervious concrete.
- The compressive strength of pervious concrete is increased by 4.36% when 5% fine aggregates were added to the standard pervious concrete.
- The compressive strength of pervious concrete is increased by 6.69% when 6% fine aggregates were added to the standard pervious concrete.
- The compressive strength of pervious concrete is increased by 12.96% when 7% fine aggregates were added to the standard pervious concrete.
- The compressive strength of pervious concrete is increased by a maximum of 14.57% when 8% fines were added to standard pervious concrete.
- The compressive strength of pervious concrete is increased by 11.44% when 9% fine aggregates were added to the standard pervious concrete.
- The compressive strength of pervious concrete is increased by 8.59% when 10% fine aggregates were added to the standard pervious concrete.
- The compressive strength of pervious concrete is increased by 8.59% when 10% fly ash was replaced in the place of cement.
- The compressive strength of pervious concrete is increased by 13.62% when 10% Rice Husk Ash was replaced in the place of cement.
- The compressive strength of pervious concrete is increased by 9.78% when 5% fly ash and 5% Rice Husk Ash was replaced in the place of cement.
- The coefficient of permeability is decreased by 22.54% when 8% fines are added to standard pervious concrete.
- The coefficient of permeability is decreased by 51.96% when 10% fines are added to standard pervious concrete.
- The coefficient of permeability is decreased by 42.15% when 10% cement is replaced by Fly ash in standard pervious concrete.

- The coefficient of permeability is decreased by 48.03% when 10% cement is replaced by Rice Husk ash in standard pervious concrete.

Hence it is recommended that addition of 8% fine aggregates to the pervious concrete will satisfy both the compressive strength and permeability of pervious concrete.

REFERENCES

[1] ACI 552R (2010): "Report on Pervious Concrete", American Concrete Institute, Farmington Hills, Michigan Ajamu S.O., Jimoh A.A. "Evaluation of structural Performance of Previous Concrete in Construction", International Journal of Engineering and Technology Volume 2 No. 5, May, 2012

[2] Darshan S. Shah, Prof. J.R.Pitroda, "Assessment for use of Gravel in Pervious Concrete", International Journal of Engineering Trends and Technology (IJETT) ISSN No. 2231-5381, Volume: 4, Issue: 10, October 2013, Page: 4306 – 4310

[3] Ghafoori, N., and Dutta, S., "Building and Non pavement Applications of No-FinesConcrete," Journal of Materials in Civil Engineering, Volume 7, Number 4, November 1995.

[4] IS 8112:1989. Specifications for 53grade Portland cement, New Delhi, India: Bureau of Indian Standards.

[5] IS: 2386 (Part III) – 1963, Indian Standard, Method of Test for Aggregates for Concrete, (Part III); Specific Gravity, Density, Voids, Absorption and Bulking, (Eighth Reprint); Bureau of Indian Standard, New Delhi, India. March 1997.

[6] IS: 2386 (Part IV) - 1963, Indian Standard, Method of Test for Aggregates for Concrete, (Part IV); Mechanical Properties, (Tenth Reprint); Bureau of Indian Standard, New Delhi, India. March 1997.