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A Study on Pervious Concrete Pavement with Fibers and Replacement of Cementious Materials

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ABSTRACT

Pervious concrete pavement is a unique and effective means to address important environmental issues and support green, sustainable growth. By capturing storm water and allowing it to seep into the ground, porous concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting U.S. Environmental Protection Agency (EPA) storm water regulations. In fact, the use of pervious concrete is among the Best Management Practices (BMPs) recommended by the EPA—and by other agencies and geotechnical engineers across the country—for the management of storm water runoff on a regional and local basis. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, pervious concrete has the ability to lower overall project costs on a first-cost basis.

Pervious Concrete for the asphalts ends up being a profitable and along-term reply for the frequent difficulty of abnormal abatement of floor water table. Pervious Concrete has a one of a sort combination design and giving extraordinary houses to the stable which makes the stable permeable, allowing water from precipitation and one-of-a-kind sources to go legitimately through, there via lessening run off extent and increasing floor water table. In order to reduce the damage being triggered to the earth through the utilization of concrete , in pervious concrete , concrete is supplanted with pozzolanic materials, for example, GGBS , silica sand to extend exceptional and power , glass strands in targeted share are delivered to the stable blend. In this investigation, the combo structures, for example, M30 and PC30 are viewed . The great complete is supplanted with coarse aggregate through a number proportions like 0% , 5% , 10% ,15%. by using which includes various pozzolanic materials like GGBS, silica fume with glass fibers. To find out the viability of the utilization of pozzolanic and glass fibers , compressive excellent directed. The accompanying Conclusions can be summed up by means of inspecting exams carried out on PC examples. A large minimize of usefulness. Furthermore, A dynamic enlargement in compressive fantastic by using increasing the degree of first-class totals and pozzolanic substances in blend. The end of excellent complete substance in the instance builds the thickness and increment the pozzolanic substances expansion. Furthermore, choice of silica smoke and GGBS in the blends enhance high-quality , compressive first-rate increments notably in the wake of such as pozzolanic materials. Because of increment of fantastic whole substance. For all supplanting levels of PC with extraordinary blends continues diminishing in pleasant when contrasted and dad or mum grade ofM30. While contrasting and PC with Pozzolanic materials, For 7 days there is an wonderful alternate for equal substitution, and for 28 days it suggests comparative sample for 25% pozzolanic concrete and continues diminishing for exceptional for compressive quality. For all supplanting stages of PC with pozzolanic continues diminishing in best when contrasted and father or mother contrast of M30. Compressive first-class extremely multiplied through including glass filaments to the all blends.

KEYWORDS: pervious concrete, GGBS, silica fume, glass fibers, Compressive strength, split tensile strength.

1. INTRODUCTION

Concrete is a mixture of paste and aggregates, or rocks. The paste, composed of Portland cement and water, coats the surface of the fine (small) and coarse (larger) aggregates. So, concrete is the favorite choice as a construction material among civil engineers around the globe for decades. It is preferred for its better performance, longer life and low maintenance cost. Concrete is the most widely used construction material all over the world. It is difficult to find out alternate material for construction which is as suitable as that of such material form durability and economic point of view. The quantity of the water plays an important role in the preparation of concrete. Impurities in water may interfere the setting of the cement and may adversely affect the strength properties. The chemical constituents present in water may participate in the chemical reactions and thus affect the setting, hardening and strength development of mixture. The IS: 456-2000 code stipulates the water quality standards for mixing and curing. In some arid areas, local drinking water is impure and may contain an excessive amount of salts due to contamination by industrial wastes. When chloride does not exceed 500ppm, or SO3 does not exceed 1000 PPM, the water is harmless, but water with even higher salt contents has been used Satisfactorily (Building research station1956).

Pervious concrete pavements (PCP) are permeable pavement structures, simultaneously serving storm water management and bearing pedestrian/traffic loads, depending on the application. In this pavement system, a 150– 300 mm pervious concrete (PC) layer with a high air void content is placed on a highly voided stone bed as the base layer, to allow for a rapid infiltration of runoff through the pavement system rather than allowing it to pond or run on the surface. For sidewalks, reduced icing and therefore pedestrian slipping, and for parking lots/bike trails and light traffic streets, reduced hydroplaning and wet weather accidents are among the additional expected outcomes of using PCP. PC's prominent characteristic is the high content of hardened air void, typically ranging between 15 and 25 percent of the total volume. Porosity is an essential property of PC, impacting its hydraulic, mechanical and durability characteristics, and is highly dependent on the mixture design parameters and the method of compaction. PC mixture design is based on limiting the coarse aggregate grade to single-sized or grade 9.5–19 mm, and either completely removing or using a minimal amount of fine aggregate for added strength.

2. LITERATURE REVIEW

Anush et al. [1] In the last few years, the use of pervious concrete as a pavement material in low-volume road applications has gained importance due to its positive environmental aspects. This paper reviews the developments and state-of-the-art pertinent to pervious concrete research and practices. The investigations on mechanical-hydrological-durability properties of pervious concrete performed in various studies have been reviewed. The storm water purification efficiency of pervious concrete has been documented. The field investigations of few test sections and in-service pervious concrete pavements have been discussed. A review has been made on rehabilitation techniques to increase the hydraulic efficiency of pervious concrete pavements. A note has been mentioned on the life cycle cost analysis of pervious concrete. Due to an increased use of pervious concrete in the pavement industry due to its multitudinous benefits, there exists an expansive scope for further research to understand the material better, which will make it a promising sustainable roadway material in future.

B. Radha Kiranmaye et al. [2] Conventional Portland cement Concrete is commonly used for pavement construction. The impervious nature of the concrete pavements contributes to the increased water runoff into the drainage system, over-burdening the infrastructure and causing excessive flooding in built-up areas. Pervious concrete is a special type of concrete with a high porosity used for concrete pavement applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing ground water recharge. The glass fiber can be the effective material to improve the properties of the pervious concrete. It will explore the use of glass fiber which is environmentally detrimental. The presence of glass fiber with cement content strengthens the concrete in greater extent. In this paper, glass fiber is used as partial replacement of cement in volume fraction of 1.5%. Pervious concrete with little or no fine aggregate in various proportions is used. The study evaluates the effect of fine aggregate in varying fraction of 0%, 10%

and 20% with coarse aggregate. The tests to be carried out to analyze the properties of pervious concrete are void ratio, compressive strength, flexural strength, split tensile strength and permeability test with varying fraction of fine aggregate.

B.V.R.Murthy, G.Rajeswari[3] Pervious Concrete Is A Concrete Containing Little Or No Fine Aggregate Provides Direct Drainage Of Rainwater, Helps To Recharge Groundwater In Pavement Applications. The Objective Of This Work Is To Improve Compressive Strength At Which The Strength Achieves Better Permeability. The Design Mix Is Prepared For M25 Consisting Of 53 Grade Cement, Two Different Sizes Of Coarse Aggregate Which Are Passing Through 25mm I.S Sieve Size And Retained On 16mm I.S Sieve Size As S1 And Aggregates Passing Through 10 Mm And Retained On 6mm Named As S2 Were Taken For This Work River Sand And Robo Sand Were Selected As Fine Aggregate And W/C Ratio Maintained As 0.35 In All The Cases. The Design Mix Is Developed With Constant Percentage Of Coarse Aggregate And Altering The Proportions Of Coarse Aggregate With Simultaneous Addition Of Percentages Of River Sand And Robo Sand In The Concrete. From The Experimental Results It Is Found That The Compressive Strength And Permeability Is Satisfactory At Adding Of 5% Robo Sand As A Fine Aggregate And Combination Of 80% S1 And 20% S2 As Coarse Aggregate In The Pervious Concrete.

Dang Hanh Nguyen et al. [4] As a new material type for pavement, pervious concrete should be designed to maintain both porosity and the structural strength. The actual mix proportions for pervious concrete depend on the application, the mechanical properties required and the materials used. Actually, the mix proportions of pervious concrete were determined for locally available materials based frequently on trial batching and experience. Another analytical method should be developed to facilitate the concrete producers. Based on the assumption that the cement paste only plays a role of coating, it does not fulfill the void among the grains of gravel; this paper focuses on one modified method for the design of the pervious concrete. The volume cement paste is divided by the surface area of the aggregates to determine the thickness of the excess paste. A scaling factor has been defined to evenly distribute the cement paste toward the size of gravel. Moreover, a binder drainage test is proposed to determine the critical w/c ratio towards to prevent the flow of cement paste to the lower layers of concrete under the action of vibration or compaction. The pervious concrete has been formulated according to this method to validate it. The mechanical and hydraulic tests are performed to characterize the pervious concrete. The obtained pervious concrete presents a large sufficient permeability (1 mm s_1) for draining rainwater and good mechanical resistance (Rc = 28.6 MPa) with regard to typical pervious concrete applications such as parking lots, walkways and low-traffic roadways. In addition, the mechanical strength of pervious concrete in this research is found higher than that generally reported by other authors. The results indicate that the theoretical mix design method is a successful theory for an optimizing composition of pervious concrete.

LutfurAkand, Mijia Yang, Xinnan Wang [5] Fiber reinforcement delays the crack generation and enhances the strength of the host matrix. However, the bonding mechanism between fiber and concrete matrix is controversial in literature and needs better explanation. Due to surface smoothness and inert chemical nature of commercially available fibers, several mechanical and chemical treatment techniques have been studied by researchers to increase the fiber-matrix bonding properties. The use of fibers in pervious concrete is even more challenging due to high porosity and insufficient fiber-matrix bonding interface. This study discusses the effect of chemical treatment on short polypropylene fibers and its uses in pervious concrete as reinforcement. The change in fiber surface due to the treatment is determined through fiber wettability test and Atomic Force Microscopy (AFM). Changes on the tensile strength of fibers by the treatment methods are also tabulated. Single fiber pullout tests are conducted to study the effect of the treatment type on fiber-cement interface properties. Treated fibers are then put into pervious concrete matrix for compressive and flexural strength tests. Chemical treatments are found to improve the surface roughness and cement matrix interface properties, as well as to enhance the overall strength of the fiber reinforced pervious concrete.

3. EXPERIMENTAL WORK

Cement:-

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel crushed stone to make a concrete. The ordinary cement contains two basic ingredients namely argillaceous and calcareous. In argillaceous materials, clay predominates and in calcareous materials calcium carbonate predominates. Ordinary Portland cement of grade – 53 (KCP cement) conforming to Indian standards (IS: 12269-1987) has been used in the present study.

Table: Physical Properties of ordinary Portland cement.

S.NO	Characteristics	Values obtained	Values as per Is Code
1	Specific gravity of Cement	3.136	3.15
2	Fineness of cement	7.2%	10% residue on 90 micron sieve
3	Standard consistency	33%	Minimum 23% as per present code
4	Initial setting time	35	Not less than 30 Minutes
5	Final setting time	330	Not greater than 600minutes
6	Compressive strength of cement (MPa)		
	3days	28.4	23
	7days	36.9	37
	28 days	54.2	53

GGBS:-

To produce GGBS, this granulated blast furnace slag is dried and ground to a fineness similar to that of Portland cement. GGBS is normally used in combination with Portland cement. The GGBS and cement are added into the concrete mixer as separate constituents. Where appropriate, the ratio of GGBS to cement can be varied according to the technical requirements for any particular application.

Tavle: Properties of ordinary GGBS

S.NO	Characteristics	Values obtained
1	Specific gravity of Cement	2.82
2	Fineness of GGBS	7%

Silica fume:-

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable

Table: Physical properties of silica fume

S.NO	Characteristics	Values obtained
1	Specific gravity of Cement	2.63
2	Fineness of GGBS	14%

Fine and Coarse aggregate

Fine aggregate used in this study was locally available river sand of Zone II compliing to IS 383:1970. The specific gravity, water absorption and fineness modulus of fine aggregate used was 2.55, 0.806% and 2.58.

Locally procured coarse aggregate from local quarry was used in this investigation. The specific gravity, Bulk density and Water absorption used was 2.9, 1738 kg/m^3 (compacted), 1512 kg/m^3 (loosely packed) and 0.502%.

Physical

Table: Properties of Fine aggregates

S. No	Property	Test Results	Standard Limits	IS Standard Testing Code
1	Specific gravity (Fine aggregate) Zone II Sand	2.5019	> 2.5	IS 2386-1963 Part III

2	Fineness modulus of Fine aggregates	**2.58**	2.6-3.2 (Coarse Sand)	IS 2386-1963 Part III
3	Bulk Density in Fine aggregates	**1.49**	1.5 ~ 1.7	IS 2386-1963 Part III
4	Water absorption	**0.47**	(0.5- 1) %	IS 2386-1963 Part III
Type of Fine aggregates - Natural river sand **Result –** The properties of the fine aggregates tested lie within the Indian standard limits and are considered to be suitable for production of concrete since the properties come under ZONE II category				

Physical Properties of natural coarse aggregates

S.No	Property	Test Results	Permissible Limit	IS Standard Testing Code
1	Specific Gravity	For 20mm-2.80 For 10mm-2.68	2.5 to 3.0	IS 2386-1963
2	Water Absorption	For 20 mm-0.3 For 10 mm-0.60	Not more than 0.6 %	IS 2386-1963
3	Bulk density **(kg/m ^{3})**	1738	1520 to 1680 kg/m^3	IS 2386-1963
4	Flakiness Index %	11.3%	Not more than 15 %	IS 2386-1963
5	Elongation Index	18.9%	Not more than 15 %	IS 2386-1963
6	Aggregate Impact Value	28.6%	Not more than 30%	IS 2386-1963
7	Aggregate Crushing Value	26.459%	Not more than 30%	IS 2386-1963
8	Fineness modulus	6.27	-	IS 2386-1963

Water

Water is a key ingredient in the manufacture of concrete. And in this investigation water participates in the chemical reaction with NaOH pellets. Since it helps to the strength giving binder gel, the quantity and quality of water are required to be looked into very carefully.

Super Plasticizer

To improve the workability of the silica/RHA based geopolymer concrete, conplast SP 430 super plasticizer which is obtained from FOSROC Constructive Solution Company. And also it served as a high range water reducer. The colour of the conplast is brown liquid and dosage of conplast added as 3% by weight of binder material.

Glass fibre

Glass fibre is a recent introduction in making fibre concrete. Fig.5 shows glass fibre reinforced concrete (GFRC) much like you would find in fibreglass insulation, to reinforce the concrete. The glass fibre helps insulate the concrete in addition to making it stronger. Glass fibre also helps prevent the concrete from cracking over time due to mechanical or thermal stress. In addition, the glass fibre does not interfere with radio signals like the steel fibre reinforcement sdoes.

Test details

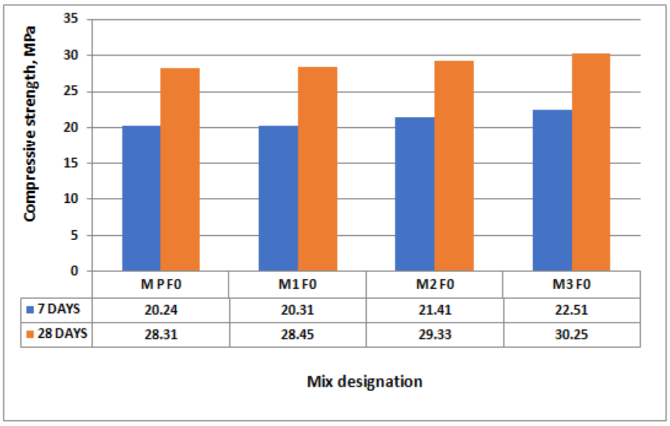
Compressive Strength Test

Compressive strength of hardened concrete is the most important of all the properties. The compressive strength test was carried out using 200 tonnes CTM. Testing procedure followed is as per IS 516:1959 [8].

4. RESULTS AND DISCUSSIONS

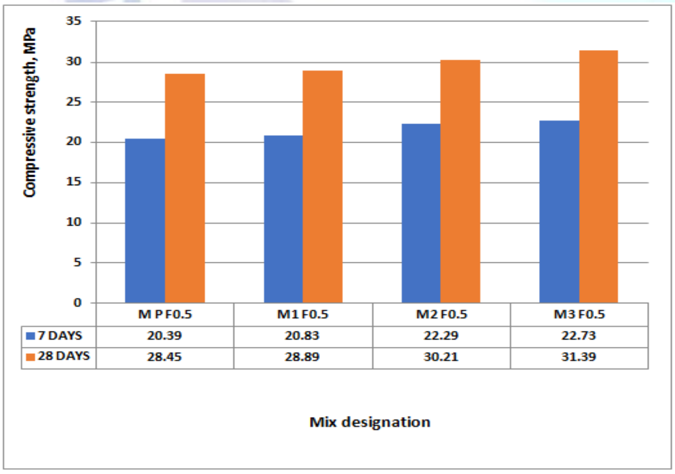
COMPRESSIVE STRENGTH OF PC 30 WITH & WITHOUT POZZOLANIC MATERIALS FOR 7 & 28 DAYS. (POZZOLANIC MATERIALS SUCH AS GGBS AND SILICA FUME)

S.No	Mix designation	Compressive Strength (n/mm2)	
		7 DAYS	28 DAYS
1	M P F0	20.24	28.31
2	M1 F0	20.31	28.45
3	M2 F0	21.41	29.33
4	M3 F0	22.51	30.25



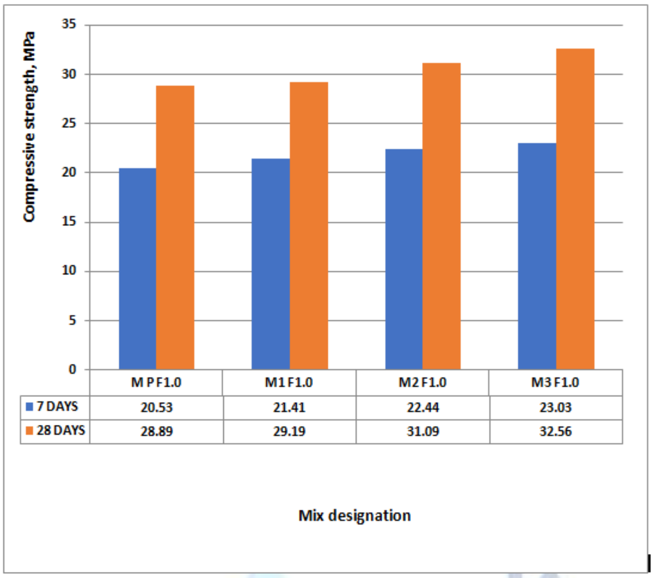
COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE : VARIOUS PERCENTAGE REPLACEMENTS OF CEMENT WITH OTHER CEMENTATIOUS MATERIAL AND DIFFERENT PERCENTAGE OF FINE AGGREGATE AND ADDITION WITH GLASS FIBERS

S.No	Mix designation	Compressive Strength (n/mm2)	
		7 DAYS	28 DAYS
1	M P F0.5	20.39	28.45
2	M1 F0.5	20.83	28.89
3	M2 F0.5	22.29	30.21
4	M3 F0.5	22.73	31.39



COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE : VARIOUS PERCENTAGE REPLACEMENTS OF CEMENT WITH OTHER CEMENTATIOUS MATERIAL AND DIFFERENT PERCENTAGE OF FINE AGGREGATE AND ADDITION WITH GLASS FIBERS

S.No	Mix designation	Compressive Strength (n/mm2)	
		7 DAYS	28 DAYS
1	M P F1.0	20.53	28.89
2	M1 F1.0	21.41	29.19
3	M2 F1.0	22.44	31.09
4	M3 F1.0	23.03	32.56



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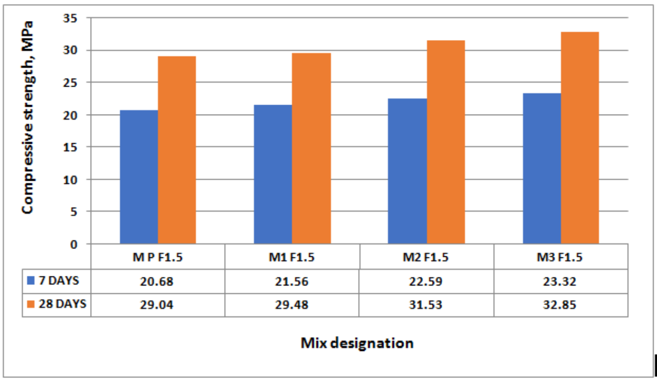
S.No	Mix designation	Compressive Strength (n/mm2)	
		7 DAYS	28 DAYS
1	M P F1.5	20.68	29.04
2	M1 F1.5	21.56	29.48
3	M2 F1.5	22.59	31.53
4	M3 F1.5	23.32	32.85



5. CONCLUSIONS

The following Conclusions can be summarized by analyzing tests performed on PC specimens:

- A significant reduction of workability.
- A progressive addition in compressive strength by

increasing the percentage of fine aggregates and pozzolanic materials in mix.

- The conclusion of fine aggregate content in the specimen increases the density and increase the pozzolanic materials addition.
- The addition of silica fume and GGBS in the mixtures improve strength.
- The compressive strength increases even after adding pozzolanic materials. Due to increase of fine aggregate content. For all replacement levels of PC with other mixes goes on decreasing in strength when compared with parent grade of M30.
- While comparing with PC with Pozzolanic materials, For 7 days there is a drastic change for same replacement, and for 28 days it shows similar trend for 25% pozzolanic concrete and goes on decreasing for strength for compressive strength.
- For all replacement levels of PC with pozzolanic goes on decreasing in strength when compared with parent grade of M30.
- Compressive strength slightly increased by adding glass fibers to the all mixes.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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