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Durability Studies on Concrete by Partial Replacement of Cement with GGBS, Silica Fume and Addition with Fibers

Paidipala Aparna, Y Priyanka

Department of Civil Engineering, Visakha Technical Campus, Andhra Pradesh, India.

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ABSTRACT

The extensive use of concrete is not only in construction of residential buildings but also silos for many factories where sometimes chemicals may have to be stored and even the residential buildings are being constructed beside sea, marine structures like deck bridges etc. undergo contact with lots of salts thus care is to be taken for such constructions since durability of the structure may be affected. Thus many researches are being done for a better durable concrete feasible for use in construction of such structures. Blended concrete, which would reduce the contact area of cement with salts, would be a better solution to overcome any unwanted reactions between minerals in cement and salts in contact. GGBS and Silica fume blended concrete has evolved as an innovative technology, capable of achieving the status of being an outstanding advancement in the sphere of concrete technology. As so many construction companies are using the GGBS in their projects. The utilization of GGBS and Silica fume will reduce the dumping and as well as decrease the construction cost also.

In construction world concrete plays a vital role, around 60% of structure consists of Concrete. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amounts of CO_2, depletion of natural resources and environmental degradation. This paper investigates the compressive strength of concrete by replacing cement with GGBS and silica fume effect of glass fibers on performance of concrete is studied. In this present work a humble attempt had been made to evaluate and compare the compressive strengths of GGBS blended concrete cubes with controlled concrete cubes cured under ACID and BASE for 28 days. By conducting the tests on the cubes, conclusions were drawn after plotting and analyzing the results. Compressive strength test is conducted on the samples after 28 days. The optimum value is obtained at 15% replacement with GGBS and 5% with Silica fume. In this study again we trailed addition with Glass fibers with the percentage of 0.5%,1.0%,1.5%, compressive strength have been studied. Finally at 1.0% addition we get maximum strength compared to controlled mix.

Keywords: GGBS, Glass Fibers, Compressive Strength, Flexural Strength, Acid Base.

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 favourite 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).

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Sustainable concrete is a concrete capable of being maintained at a steady level without exhausting natural resources or causing severe ecological damage. With the wave of sustainability also impacting the construction industry, scientist and engineers throughout the world are looking for sustainable and reusable construction materials. One such material is C**oncrete** . Concrete is composited of cement, coarse aggregates, pozzolanic materials and fibers and small ratios.

By adding the glass fibers to concrete, it is possible to improve the compressive and tensile strength of the concrete. Reinforcing glass fibers can improve the durability of the concrete matrix by increasing the ductility and absorbing energy when subjected to impact loads and external vibrations. When mixing the glass fibers into the concrete mixture, the fibers will form clusters and the uniform distribution cannot be achieved. Clusters of fibers often trap considerable amount of air, which has an adverse effect on the mechanical properties of the fiber-reinforced concrete. Therefore researchers have adopted several chemical treatment processes to increase its surface energy.

REVIEW OF LITERATURE

B. Radha Kiranmaye et al. [1] 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.

LutfurAkand, Mijia Yang, Xinnan Wang [2] 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.

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Mahmoud MazenHilles, Mohammed M. Ziara[4] Effects of alkali resistant glass fiber (AR-GF) with various contents on the mechanical behavior of high strength concrete (HSC) were investigated on this study. Concrete mixtures were prepared with various contents of AR-GF typically 0.3, 0.6, 0.9, and 1.2 by weight of cement. The mixtures were cast and tested for compressive, splitting tensile and flexural strengths in accordance to ASTM standards. The experimental results showed that the strengths increase as fiber percentage increases until a threshold the compressive strength increased from 57.85 to 66.6 MPa when fiber percentage increased from 0.0 to 1.2 respectively, the splitting tensile strength increased from 3.06 to 4.92 MPa when fiber percentage increased from 0.0 to 1.2 respectively, and the flexural strength increased from 4.84 to 7.27 MPa when fiber percentage increased from 0.0 to 1.2 respectively. In comparison with plain HSC control specimens that showed destructive sudden failure, the formation of cracks that led to failure in the specimens with AR-GF was gradual as the fiber percentage increases. Hence it can be concluded that the presence of fibers in HSC matrix has contributed towards controlling sudden crack formation and thus enhancing concrete ductility.

M.UmaMaguesvari and V.L. Narasimha [5] This study presents the influence of fine aggregate and coarse aggregate quantities on the properties of pervious concrete. Materials used are OPC Type I, fine aggregate corresponding to grading II and four sizes of coarse aggregate namely, 4.75mm to 9mm, 9mm to 12.5mm, 12.5mm to 16mm, 16mm to 19.5mm. Mixes were prepared with the water cement ratio of 0.34, cement content of 400kg/m3 and maintaining the aggregate cement ratio as 4.75:1. Fine aggregate was replaced with coarse aggregate in the range of 50 - 100 % by weight. Various mechanical properties of the mixes were evaluated. Coefficient of permeability was determined by using falling head permeability method. The relationship between the strength, abrasion resistance, permeability and total void present in aggregate based on angularity number has been developed. Suitability of pervious concrete as a pavement material is discussed.

Pankaj R. Teware1 , Shrikant M. Harle[6] Now a days the concrete industry is constantly looking for supplementary cementious material with the objective of reducing the solid waste disposal problem and economic in cost. The Fly ash and Ground granulated blast furnace slag (GGBS) are among the solid wastes generated by Thermal power plant and iron manufacturing industry. To overcome from this crisis, partial replacement of cement with Fly ash and GGBS can be an economic alternative. And the cement is partially replaced with Fly ash and GGBS by 10%, 20% up to 30%. The effect of paste density on properties of pervious concrete by addition of various cementitious admixtures such as Fly ash and Ground Granulated blast furnace Slag (GGBS). So the physical and mechanical properties of pervious concrete will be beneficial for the forthcoming use of Fly ash and GGBS in the construction field of pervious concrete which will lead to reduce the cement consumption, environmental issue and environmental benefit.

EXPERIMENTAL WORK

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% residueon 90 micronsieve
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 7days 28 days	 28.4 36.9 54.2	 23 37 53
Brand of cement – OPC 53 grade (KCP)			

Physical 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 l Part III
2	Fineness modulus of Fine aggregates	**2.58**	2.6-3.2 (Coarse Sand)	IS 2386-1963 Part III
3	Bulk Densityin Fineaggregates	**1.49**	1.5 ~ 1.7	IS 2386-1963 Part III
4	Water absorption	**0.47**	(0.5- 1) %	IS 2386-1963 Part III

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 2383-1986
2	Water Absorption	For 20 mm-0.3 For 10 mm-0.60	Not more than 0.6 %	IS 2383-1986
3	**Bulk density (kg/m^3)**	1738	1520 to 1680 kg/m^3	IS 2383-1986
4	Flakiness Index %	11.3%	Not more than 15 %	IS 2383-1963 Part 1
5	Elongation Index	18.9%	Not more than 15 %	IS 2383-1963 Part 1
6	Aggregate Impact Value	28.6%	Not more than 30%	IS 2383-1963 Part 1
7	Aggregate Crushing Value	26.459%	Not more than 30%	IS 2383-1963 Part 1
8	Fineness modulus	6.27	-	IS 2383-1963 Part 1

Chemical properties of silica fume

S.No	Chemical compositions	Silica fume
1	Silica Dioxide (SiO_2)	85%
2	Moisture content	3%
3	Cao content	< 1%
4	Alkalis as Na2O	1.50%
5	Loss on ignition	4.00%

Compressive strength values for different W/C.

Mix designation	Cement (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)	Water	Slump (mm)	Compressive strength(MPa) for 28 days
M40	350	896	1140	**148.50**	**61**	**48.27**

PHASE-I

Mix designation		MSN	MSS	M1N	M1S	M2N	M2S	M3N	M3S	M4N	M4S	Units
Cement		100	100	90	90	85	85	80	80	75	75	%
GGBS		0	0	5	5	10	10	15	15	20	20	%
Silica fume		0	0	5	5	5	5	5	5	5	5	%
Glass fibers		0	0	0	0	0	0	0	0	0	0	%
Fine aggregate		100	100	100	100	100	100	100	100	100	100	%
Coarse aggregate	20 mm	100	100	100	100	100	100	100	100	100	100	%
	10 mm	100	100	100	100	100	100	100	100	100	100	%
Normal water		100	0	100	0	100	0	100	0	100	0	%
Sp		100	100	100	100	100	100	100	100	100	100	%

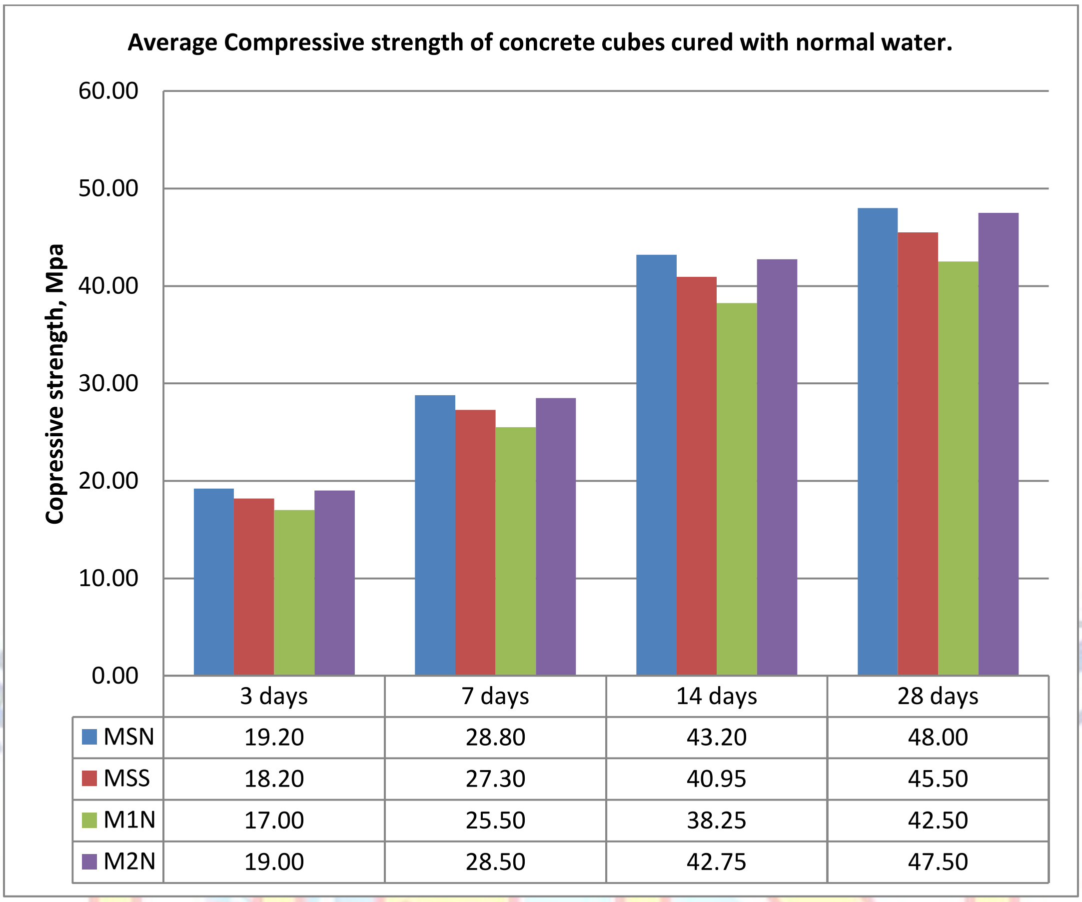
PHASE – II

Mix designation		MSN	MSS	M2N	M2NF 1	M2NF 2	M2NF 3	M2S	M2S F1	M2SF 2	M2SF 3	Units
Cement		100	100	85	85	85	85	85	85	85	85	%
GGBS		0	0	10	10	10	10	10	10	10	10	%
Silica fume		0	0	5	5	5	5	5	5	5	5	%
Glass fibers		0	0	0	0.50	1.00	1.50	0	0.5	1.00	1.50	%
Fine aggregate		100	100	100	100	100	100	100	100	100	100	%
Coarse aggregate	20 mm	100	100	100	100	100	100	100	100	100	100	%
	10 mm	100	100	100	100	100	100	100	100	100	100	%
Normal water		100	0	100	100	100	100	0	0	0	0	%
Acid attack		0	100	0	0	0	0	100	100	100	100	%
Base attack		0	100	0	0	0	0	100	100	100	100	%
Sp		100	100	100	100	100	100	100	100	100	100	%

RESULTS AND DISCUSSIONS

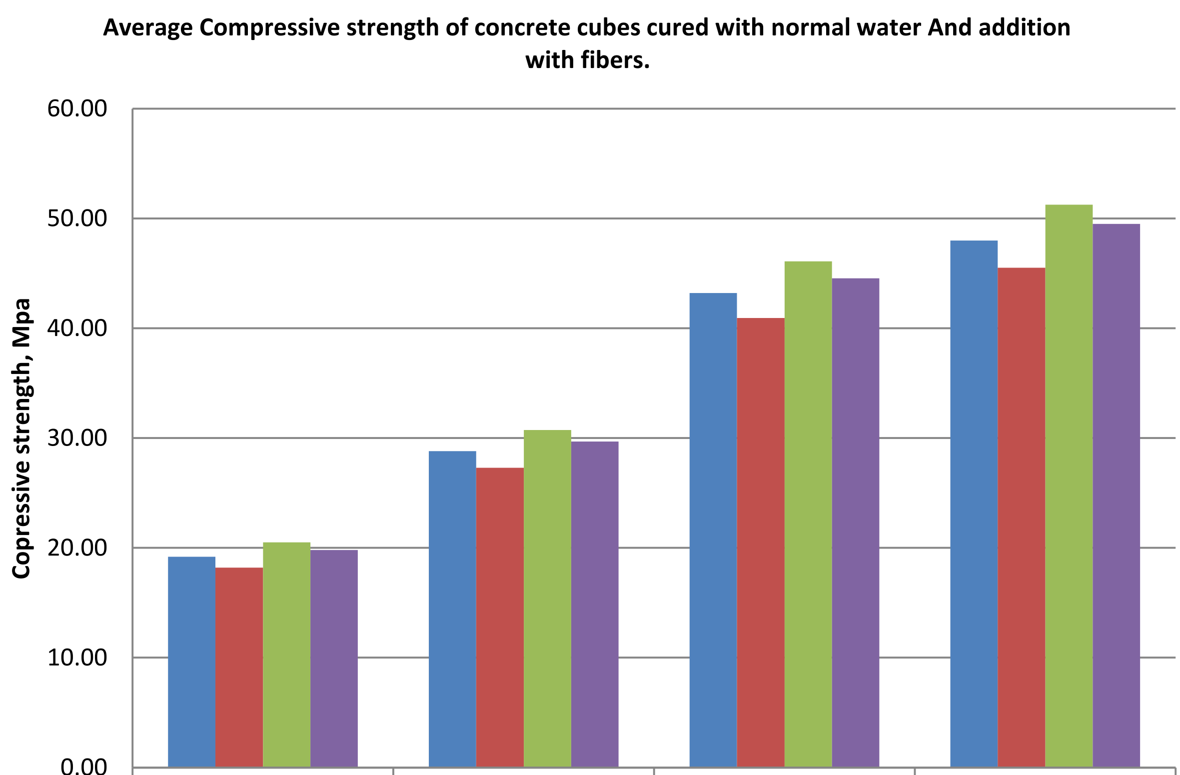
Average Compressive strength of concrete cubes cured with normal water.

S.No	Mix designation	Compressive strength (MPa)			
		3 days	7 days	14 days	28 days
1	MSN	19.20	28.80	43.20	48.00
2	MSS	18.20	27.30	40.95	45.50
3	M1N	17.00	25.50	38.25	42.50
4	M2N	19.00	28.50	42.75	47.50
5	**M3N**	**20.50**	**30.75**	**46.00**	**51.50**
6	M4N	19.00	28.50	42.75	47.50



Average Compressive strength of concrete cubes cured with normal water And addition with fibers.

S.No	Mix designation	Compressive strength (MPa)			
		3 days	**7 days**	**14 days**	**28 days**
1	MSN	19.20	28.80	43.20	48.00
2	MSS	18.20	27.30	40.95	45.50
3	M3N	20.50	30.75	46.10	51.25
4	M3NF1	19.80	29.70	44.55	49.50
5	**M3NF2**	**21.60**	**32.40**	**48.60**	**54.00**
6	M3NF3	20.40	30.60	45.90	51.00



	3 DAYS	7 DAYS	14 DAYS	28 DAYS
MSN	19.20	28.80	43.20	48.00
MSS	18.20	27.30	40.95	45.50
M3N	20.50	30.75	46.10	51.25
M3NF1	19.80	29.70	44.55	49.50

EFFECT OF ACID

The optimum mix is determined as M3N, thus the effect of Hydro chloric (HCL) acid is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to HCL acid.

The variation in the compressive strength of cubes before and after exposure to HCL acid at 28 and 90 days. The percentage decrease in the strength observed for 28 days and for 90 days.

EFFECT OF ALKALI

The optimum mix is determined as SCC 30, thus the effect of Sodium hydroxide (NaoH) alkaline is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to NaoH alkaline. The variation in the weight of cubes before and after exposure to NaoH alkaline at 28 and 90 days. The percentage decrease in the weight observed for 28 days and 90 days.

CONCLUSIONS

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

Based on results and discussions following conclusions were made.

- A significant reduction of workability.
- A progressive addition in compressive strength by increasing the percentage of GGBS and silica fume in mix.
- The inclusion of GGBS and Silica fume content in the specimen increases the density and increase the pozzolanic materials addition.
- The replacement of GGBS and silica fume in the mixtures enhances the compressive strength performance of the concrete,
- The addition of fibers in the mixtures improve strength.
- The Compressive strength increases even after adding pozzolanic materials. Due to increase the

fibers content. For all replacement levels of Concrete with other mixes goes on decreasing in strength when compared with parent grade ofM40.

- The optimum mix is determined as MSN, thus the effect of Hydro chloric (HCL) acid is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to HCL acid.
- The variation in the compressive strength of cubes before and after exposure to HCL acid at 28 and 90 days. The percentage decrease in the strength observed for 28 days and 90 days.
- The optimum mix is determined as SCC 30, thus the effect of Sodium hydroxide (NaoH) alkaline is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to NaoH alkaline.
- The variation in the weight of cubes before and after exposure to NaoH alkaline at 28 and 90 days. The percentage decrease in the weight observed for 28 days and 90 days.

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