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Experimental Investigation on Influence of High Strength Glass Fiber on the Behavior of Concrete

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ABSTRACT

In the present study, a mix design high strength grade concrete of M60 is produced by using binary blending technique by the utilization of Silica fume(SF) and Metakaolin(MK) as partial replacement by weight of cement at different blended percentages ranging from 0-30% in the increments of 10% along with glass fibers having aspect ratio of 100. The different proportions of glass fibers are added in the volume fraction percentages of 0.5-2% in the increments of 0.5%. The test results of fiber reinforced specimens with different percentages of binary blend are compared with control specimens to study the behavior of FRC properties with various percentages of the blends as partial replacement by weight of cement. The test results concluded that the optimum blended percentage of silica fume and metakaolin is 15% i.e., 7.5%SF+7.5%MK along with SP percentage as 1.5% and glass fiber percentage as 1.5%when compared with the control mix. Further, light weight aggregate i.e., pumice stone is replaced to this mix to coarse aggregate at percentages of 25%,50%,75%and100%respectively and the compressive strength characteristic along with density of concrete was studied and reported.

Keywords-Blending, Glass Fibers, Mechanical Properties.

1. INTRODUCTION

InConcrete is a composite material consist of coarse aggregate and fine aggregate bonded in to be shared mutually by fluid cement that hardens done in time. Maximum concretes usage are lime-based concretes, for example Portland cement concrete or concretes composed by other cement fondue. However, asphalt concrete that is frequent usage for road surfaces is also a type of concrete, where the cement material is bitumen, and polymer concretes are usage where the cementing material is a polymer. HSC is referred to be as High strength concrete and is basically utilized for concrete which has a compressive strength more than 41 MPa. The committee of ACI has given a definition of HSC that it is a type of concrete which has the capacity to acquire a compressive strength of design with a minimum of 41

MPa or greater. With the design of high strength grade cement and feasibility with various types of mineral and chemical admixtures, the researchers are able to produce the concrete with morethan100MPastrength.

FIBER REINFORCED CONCRETE (F.R.C):

The word F.R.C defined by the ACI committee 544 as a concrete which is prepared from the hydraulic cements that contains coarse and fine aggregate materials and some randomly spaced short fibers. Such concrete behaves as a brittle material under the split-tensile loading. The mechanical strength characteristics also enhance with the addition of fibers.

Fibers are generally utilized for different purposes in cement matrix in order to provide ductility and toughness. Concrete reinforcing methodology with one fiber can improve the required properties to a substantial level. F.R.C is a concrete type that consists fibrous matrix that imparts structural integrity to the structures. The concrete that contains short and randomly spaced fibers which are distributed uniformly is termed to be as fiber reinforced concrete. Such concrete is resistant to both micro and macro cracking.

FIBER TYPES:

The below mentioned fiber types can be extensively utilized in F.R. Casasingle one or multiple ones.

1.Glass
2.Steel
3.Synthetic
4.Carbon

OBJECTIVES OF THE STUDY:

a. To design hybrid fiber reinforced high strength concrete by using optimized content of hybrid fibers and multi-mineral admixtures.

b. To study the mechanical strength characteristics of HSC [M60] hybrid fiber reinforced high strength light weight aggregate concrete.

NEEDOFTHESTUDY:

Because of the good durability and strength characteristic properties, cement concrete is the generally utilized construction material all over the world. Despite of the fact that the generation of cement produces huge amounts of green house gases into atmosphere, it is being utilized. Keeping this aspect in view, the utilization of pozzolanic materials into the concrete as replacement to cement is found to be an effective alternative for this problem.

The industrial waste exhaust material from the glass industry is GGBS which is termed as ground granulated blast furnace slag and is obtained by the quenching of the molten iron slag under the blast furnace with in a steam bath or water bath. It has high durable

Properties and it can be used to prepare good concrete. It is being extensively utilized in various areas of the world, due to its superior durable properties.

SCOPE

The investigation was performed on High Strength Grade ie., M60 grade concrete by using hybrid fibers and silica fume and Metakaoline as mineral admixture. The OPC was replaced by a combination of silica fume and Metakaoline in the proportions of 0,10%, 20% ,and hybridization of fibers in the range of 0.5%,1%,1.5%,2% with a SP dosage of 1.5% by weight of cement for mix Mixes were prepared, cured and tested for identifying the mechanical strength characteristics of concrete after 28 days of conventional curing and the percentage replacement of light weight aggregate i.e., pumice stone at various percentages i.e., 25%-100%in the increments of25% respectively were studied and reported.

LITERATURE REVIEW

P. MuthuPriya et al., (2011) [1] conducted a study on the short columns behavior that are casted with HPC i.e., high performance concrete and in their study, M60 grade was chosen with general concrete ingredients and mineral ad mixtures that were utilized are silica fume and fly ash at different replacement levels in cement and SP dosage was confined to 1.5% by weight of cement. The w/c ratiofollowedis0.3. The mechanical strength characteristics were determined by using specimens of cube, cylinder and prism. The total numbers of casted specimens were 7 and are designated as M1 toM7. The percentage levels of replacement of mineral admixture to cement was 0%,5%,7.5% and 10% respectively and similar replacement levels were also followed for another mineral admixture i.e., fly ash. The mechanical strength characteristics were found after 3, 7, 28, 56 and 90 days of conventional curing. The test results indicated that the optimal replacement levels of mineral admixtures are 7.5%.

B.B. Patil and P.D. Kumbhar et al., (2012) [2] conducted a study on the strength and durability characteristics of HPC by including high reactivity metakaolin. In their study, M60 grade HPC was casted with general ingredients of concrete and additionally mineral admixture was utilized in terms of replacing the cement with metakaolin at different replacement levels along with chemical admixture 0.73% by weight of the cement. The W/C ratio is 0.31. A total of 6 mixes were prepared and standard cube specimens were casted by replacing the cement content with metakaolin at replacement levels of 0%, 5%, 7.5%, 10%, 12.5% and 15% in order to study the compressive strength of concrete at 28 days. The test results indicated that the strength and durability characteristics of concrete optimal replacement level of metakaolin at7.5%.

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A. Ravichandran et al., [2009] [3] studied the effect of hybrid fibers on the strength characteristics of high strength concrete. In their study, M60 grade concrete was prepared by using hybridization of fibers i.e., a combination of glass and polyoefin fibers at different volume fractions ranging from 0.5-2% at an increase of 0.5%. The mechanical strength characteristics were identified for these mixes and were compared with that of the control mix. The test results indicated that the utilization of fibers in high strength concrete enhanced the toughness property of the HSC when compared with the control mix. The maximum strength characteristics were achieved at a volume fraction of fibers of 1.5% and the split-split-tensile and flexural strength enhanced remarkably along with increase in young's modulus.

EXPERIMENTAL WORK:

<u>Cementitious Materials:</u>

Cement : The Cement used in this project is Ordinary Portland Cement (OPC) of 53 grade.

Silica Fume: It is a byproduct which is obtained during the production of silica metal or alloys of ferro silicon.

Metakaolin:Metakaolin is a pozzolanic additive/product which can providemany specific features

Glass Fibers:Glass fiber (or glass fiber) is a material consisting of numerous extremely fine fibers of glass.

Pumice Stone:Pumice stone is a lightweight aggregate of low specific gravity. Its water absorption is as high as 55% since it is a highly porous material.

TESTS ON MATERIALS:

<u>Tests on Cement</u>

- ✓ SPECIFIC GRAVITY OF CEMENT
- ✓ NORMAL CONSISTENCY OF CEMENT
- ✓ FINENESS OF CEMENT
- ✓ INITIAL AND FINAL SETTING TIME

<u>TESTS ON FINE AGGREGATE</u>

- ✓ SIEVE ANALYSIS OF FINE AGGREGATE
- ✓ SPECIFIC GRAVITY OF FINE AGGREGATE
- ✓ WATER ABSORPTION OF FINE AGGREGATE

MIX DESIGN:

The design of concrete mix is defined as the process of selection of the possible and suitable materials that are used to prepare concrete by estimating and determine their relative proportions with the objective of preparing the concrete by means of achieving the aspects such as durability, strength and economical.

In the present study, M60 grade concrete with the mix proportions of 1:1.11:2.09 (design mix) with w/c ratio of 0.3 was adopted and is the process of mix design that is carried out as per the specifications of IS 456:2000 methodology.

M60 grade concrete Mix Design stipulations

Aggregate size = 20mm

Specific gravity of cement=3.15

Specific gravity of F.A. = 2.67

Specific gravity of C.A. =2.81

Bulk density of F.A.=1705kg/m3

Bulk density of C.A.=1675kg/m3

Average design strength=fck=60Mpa

MIX PROPORTION

CEMENT	F.A.	C.A.	W/C
577	640.8	1206	173.3
1	1.07	2.05	0.3

TESTS CONDUCTED:

After the mix design, the casting of specimens is the next step in this experimental study. The various types of specimens, such as Cubes, Beams, and Cylinders, were casted using standard procedures. The prepared samples were tested in the laboratory to determine their strength characteristics according to the standard procedures specified in the respective IS codes.

Compressive Strength

Casting of Cubes

Cube specimens were casted for calculating 7 days and 28 daysstrengths. The dimensions of specimen for cube are of 150mm x 150mm x 150mm.

Split Tensile Strength

Casting of Cylinders

Cylinder specimens were casted for calculating 7 days and 28 days strengths. The dimensions of the cylindrical specimen are of (a) Height = 300mm

(b)Diameter = 150mm

Flexural Strength

Casting of Beams

Beam specimens were casted for calculating 7 days and 28 daysstrengths. The dimensions of the beam specimen are of 500mm x 100mm x 100mm.

S.No	Mix Designation	Slump Cone Results(mm)	Compressive Strength (MPa)			Split-tensile Strength MPa			Flexural Strength hMPa		
			07 days	14 days	28 days	07 days	14 days	28 days	07 days	14 days	28 days
1.	M60 Control Mix	37	30.21	47.54	60.65	1.12	2.68	4.13	3.54	5.12	7.94
2.	(5+5)(SF+MK)1%SP	34	33.32	50.64	65.76	1.07	2.10	3.55	3.47	5.04	7.86
3.	(5+5)%(SF+MK)1.5%SP	38	31.54	48.00	61.32	1.98	2.72	4.25	3.86	5.24	8.11
4.	(5+10)% (SF+MK)1%SP	36	33.76	49.76	64.41	1.64	2.54	3.67	1.98	3.96	5.39
5.	(5+10)% (SF+MK)1.5%SP	37	29.32	45.77	57.77	1.49	2.09	3.52	3.76	5.10	7.85
6.	(10+5)%(SF+MK) 1%SP	33	30.65	49.32	59.19	1.32	2.07	3.41	1.85	3.12	5.41
7.	(10+5)% (SF+MK)1.5%SP	33	31.10	48.43	61.54	1.24	1.96	2.83	2.12	3.64	5.8
8.	(7.5+7.5)% (SF+MK)1%SP	35	33.21	49.76	65.77	2.10	2.74	4.24	3.18	5.10	8.00
9.	(7.5+7.5)%(SF+MK)1.5%SP	38	33.84	50.21	67.11	2.16	2.89	4.38	4.10	5.98	8.75
10.	(10+10)% (SF+MK)1%SP	34	30.66	49.31	58.67	1.51	2.15	3.54	1.79	3.78	5.62
11.	(10+10)%(SF+MK)1.5%SP	36	33.12	48.87	63.56	1.09	1.84	2.55	3.31	5.04	7.75

S.No	Mix Designation	% of Glass Fibers	Compressive Strength MPa	Split-tensile Strength MPa	FlexuralStrengthMPa
1.	(7.5+7.5)% (SF+MK) 1.5%SP	0.5	72.4	5.09	9.75
2.	(7.5+7.5)% (SF+MK) 1.5%SP	1.0	74.6	5.37	11.25
3.	(7.5+7.5)% (SF+MK) 1.5%SP	1.5	77.7	5.65	12.25
4.	(7.5+7.5)% (SF+MK) 1.5%SP	2	76.8	5.51	11.75

S.No	MixDesignation	% ofpumicestone	Weightofcube(Kgs)	CompressiveStrengthMPa	split-tensileStrength MPa	FlexuralStrengthMPa
1.	(7.5+7.5)% (SF+MK) 1.5%SP 1.5%GF –M1	0	9.98	77.7	5.65	12.25
2.	(7.5+7.5)% (SF+MK) 1.5%SP 1.5%GF -M2	25	8.61	76.8	5.24	9.75
3.	(7.5+7.5)% (SF+MK) 1.5%SP 1.5%GF -M3	50	8.20	74.21	5.10	8.68
4.	(7.5+7.5)% (SF+MK) 1.5%SP 1.5%GF -M4	75	7.96	68.69	4.87	8.43
5.	(7.5+7.5)% (SF+MK) 1.5%SP 1.5%GF -M5	100	7.45	65.12	4.62	7.98

CONCLUSIONS:

Depending on the experimental investigation conducted, the following conclusions were drawn

1. Inclusion of multi-mineral admixtures Metakaolin and Silica Fume apparently influenced the mechanical strength characteristics of HSC.
2. HSC prepared with (7.5+7.5) % (SF+MK) with 1% SP showed superior properties in terms of compression, split-tension and flexural strengths when compared with the control mix and the percentage increase is found to be 8.3%,2.40% and 0.61% respectively.
3. HSC prepared with (7.5+7.5) % (SF+MK) with 1.5% SP showed superior properties in terms of compression, split-tension and flexural strengths when compared with the control mix and the percentage increase is found to be 10.6%, 5.79% and 10% respectively.
4. HSC prepared with (7.5+7.5) % (SF+MK) with 1.5 % SP and 1.5% glass fibers showed superior properties in terms of compression, split-tension and flexural strengths when compared with the control mix and the percentage increase is found to be 28.6%,36.46% and 54.07% respectively. Further, 50% replacement of natural aggregate with pumice stone is found to be appreciable in terms of mechanical strength characteristics of prepared concrete mix.
5. The inclusion of glass fibers in HSC mix has significantly enhanced the split-tensile as well as flexural strength of the high strength concrete along with compressive strength

Conflict of interest statement

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

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