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A Study on High Strength Concrete by using Metakaolin and Hybrid Fibers

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***Abstract*: Concrete is the most common as well as important component in construction field. Among the types of concrete, High Strength Concrete (HSC) has predominant features compared to the Conventional Concrete. The present study involves hybridization technique to enhance the performance of HSC. The mixing of different fibers having different properties comes under hybridisation technique .The hybrid fibers used in the present study are polypropylene fibers and hooked end steel fibers in the presence of metakaolin for 70 Mpa grade concrete. HSC specimens with different fiber proportions of 0.25%,0.50 %,1% are casted for testing mechanical and durability properties .At 15% of metakaolin as cement replacement and total hybrid fiber of 1 % has an increase of 24%compressive strength, the tensile strength at an increase of 12 % and durability properties are high when compared to conventional concrete.**

Keywords: Hybrid fibers, metakaolin, steel fibers, polypropylene.

INTRODUCTION:

Concrete ,based on strength parameter classified as Normal Strength Concrete(NSC),high strength concrete (HSC) and ultra high strength concrete(UHSC).There are no specific limits for HSC and UHSC. Due to incorporation of exceptional material components and mixture proportions the HSc performance differs from NSC in its fresh and hardened states. HSC includes high quality binder, low water content , a greater fine aggregate,fibers etc.., to make it better performing concrete. The latest remarkable development was implemented by using fiber hybridisation technique. Two or more types of fibers are blended together to obtain the advantageous performance. this enhancement is achieved by using fibers that influence the cracking process during the different stages of loading which often involves different sizes and types of fibers.

2. MATERIALS USED AND EXPERIMENTAL PROCEDURE:

2.1 MATERIALS:

2.1.1 CEMENT: In this study Ultratech of OPC 53 grade confirms to Indian standards 12269-1987 was used. The properties of cement are given in table.1

TABLE 1: PROPERTIES OF CEMENT

PROPERTY	RESULT
Specific gravity	3.13
Normal consistency	33.75%
Initial setting time	55 min
Final setting time	245 min
Fineness%	4%

2.1.2 METAKAOLIN: Meta in Metakaolin indicates the transformation of Kaolinite mineral through loss of hydroxyl ions. This process is known as hydroxylation or calcination. Calcining Kaolinite at the temperature range of 700 ºC -800 ºC (IS 1344-1981) for 4 hours and grinding to have a specific surface area of 20 m^2/g makes the clay highly reactive.it is also used as alternative to micro silica.mk reduces permeability and the penetration of chloride ions. It achieves low RCP values. MK helps in chemical resistance which helps in strength and toughness. The chemical analysis of metakaolin is given in table 2.

TABLE-2 : CHEMICAL ANALYSIS OF METAKAOLIN

MINERALS	PERCENTAGE(%) PRESENT
SiO_2	52-54
Al_2O_3	44-46
Fe_2O_3	0.6-1.2
TiO_2	0.65
CaO	0.09
MgO	0.03
Na_2O	0.10
K_2O	0.03

METAKAOLIN

2.2 AGGREGATES:

2.2.1 COARSE AGGREGATE (C.A): For this present investigations, coarse aggregate is used 12.5mm as nominal

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size and angular shape brought from local crushing units. Physical properties of coarse aggregate are given in table.3

TABLE 3: PROPERTIES OF C.A

PROPERTY	RESULT
Bulk density	1536 Kg/m3
Specific gravity	2.80

COARSE AGGREGATE

2.2.2 FINE AGGREGATE (F.A): In present investigations, the well graded fine aggregate is used from the bed of Tungabhadra river. Physical properties of Fine aggregate are given in the table 4.

TABLE 4: PROPERTIES OF F.A

PROPERTY	RESULT
Bulk density	1674 Kg/m3
Specific gravity	2.63

FINE AGGREGATE

2.3 CHEMICAL ADMIXTURE: Super plasticizer (SP) is the main use of water reducing agent and also enhances the workability properties. Poly Carboxylite ether based (Glenium B-233) Super plasticizer is used in this present investigations. Physical properties of SP are given in the table 5.

TABLE 5: PROPERTIES OF CHEMICAL ADMIXTURE

PROPERTY	RESULT
Appearance	Light brown coloured liquid
Specific gravity	1.08
P.H	6.9
Type	Poly Carboxylite ether

2.4 FIBERS: In the present investigations, the steel and polypropylene fibers are used in addition to cement to improve the mechanical properties of HSC. The properties of fibers are given in table 6.

TABLE 6: PROPERTIES OF ST& PP FIBERS

TYPE	LENGTH	DIAMETER	ASPECT RATIO
ST	30 mm	0.65	46
PP	12 mm	0.05	240

2.5 OBJECTIVE OF PRESENT INVESTIGATIONS: The present study investigates about mechanical & durability properties of high strength concrete with hybrid fibers and metakaolin. The mechanical properties includes compressive strength, split tensile strength, flexure strength and durability properties includes RCPT, sorpitivity of mixtures containing Metakaolin and hybrid fibers. In the present study the combination of different fiber proportions of steel and polypropylene in the presence of Metakaolin(15%) for a 70 MPa grade concrete at fiber volume fractions of 0.25%, 0.50% and 1% are investigated.

2.6 MIXES, CASTING, CURING AND TESTING:
All the dry ingredients were mixed in a pan until the uniformity will be appeared .The water is added gradually during the mixing time. After the mixing is done the concrete has been casted to cubical moulds of size 100mmx100mmx100mm for compressive test. Cylindrical moulds of size 100mmx200mm were used for determining split tensile strength ,prismatic moulds of size 100mmx100mmx500mm were used to determine flexural strength .After the filling of concrete, compaction is done and the surface is levelled. The moulds are kept in lab for 24 hours. After that the cubes are kept in water for 28days.

TABLE 7 : MIX PROPORTIONS

s.no	Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water liters	metakaolin	Super plasticizer kg/m^3	Steel fibers	Polypropylene fibers	Hybrid fibers
Mix -1	580.4	722	1044.48	145.11	0	5.804	0	0	0
Mix - 2	580.4	722	1044.48	145.11	58.4 (10%)	5.804	0	0	0
Mix - 3	580.4	722	1044.48	145.11	87.06 (15%)	5.804	0	0	0
Mix - 4	580.4	722	1044.48	145.11	116.8 (20%)	5.804	0	0	0
Mix -5	580.4	722	1044.48	145.11	87.06	5.804	0.25	0	0
Mix -6	580.4	722	1044.48	145.11	87.06	5.804	0.50	0	0
Mix -7	580.4	722	1044.48	145.11	87.06	5.804	1	0	0
Mix -8	580.4	722	1044.48	145.11	87.06	5.804	0	0.25	0
Mix - 9	580.4	722	1044.48	145.11	87.06	5.804	0	0.50	0
Mix - 10	580.4	722	1044.48	145.11	87.06	5.804	0	1	0
Mix -11	580.4	722	1044.48	145.11	87.06	5.804	0.25	0.25	0.50
Mix -12	580.4	722	1044.48	145.11	87.06	5.804	0.50	.050	1
Mix – 13	580.4	722	1044.48	145.11	87.06	5.804	1	1	2

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 09, September-2019

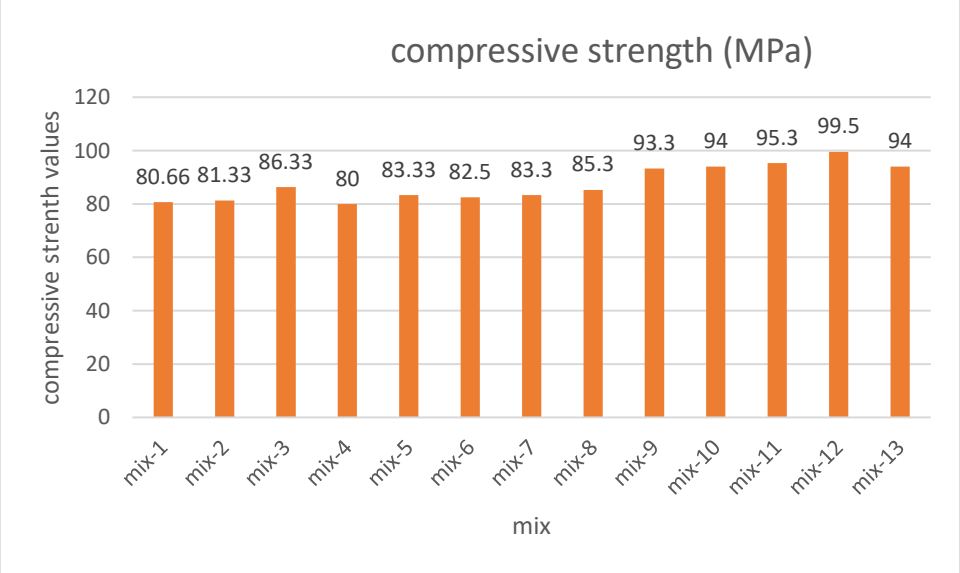
3. RESULTS AND DISCUSSIONS:

TABLE 8 COMPRESSIVE STRENGTH ,SPLIT TENSILE STRENGTH AND FLEXURE STRENGTH RESULTS

Mix	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural strength (MPa)
1	80.66	5.04	6.21
2	81.33	5.37	6.42
3	86.33	5.66	6.52
4	80	5.51	6.93
5	83.33	5.31	6.36
6	82.5	4.89	6.16
7	83.3	5.39	6.49
8	85.3	4.63	6.31
9	93.3	4.94	6.10
10	94	4.56	6.36
11	95.3	5.61	6.50
12	99.5	5.80	7.12
13	94	5.01	6.32

3.1 COMPRESSIVE STRENGTH:

From the compressive test results, it is observed that replacement of metakaolin and addition of hybrid fibers have increased the strength parameter of HSC. Metakaolin improves the bond between cement paste and aggregate particles. Mix 1 is the conventional concrete strength as the required target strength. Mix 2 to mix 4 are the concrete by replacement of cement with metakaolin of 10 15 and 20 respctively. Concrete with 15% replacement of metakaolin (mix -3) has high compressive strength so that optimum % of metakaolin is fixed to 15%. Fiber reinforced concrete mixes are from mix 5 to mix 10,where the optimum fiber percentage is taken as 1% from mix 7 and mix 10 respectively. From mix 11 and mix 12, the increase in the compressive strength compared with required strength which is 19% & 24% respectively.



3.2 SPLIT TENSILE STRENGTH :

The variation of split tensile strength is similar to the compressive strength,the increase of split tensile strength values with metakaolin and hybrid fibers from mix 5 to mix 13 are tabulated. The split tensile values oh mix 5 to mix 7 are concrete with only steel fibers of 0.25,0.50 and 1 and mix 8 to mix 10 are concrete with only polypropylene fibers of 0.25,0.50 and 1. Mix 11 to mix 13 are concrete with hybrid fibers of 0.50,1 and 2 % respectively.from mix 7 and mix 10 the optimum % of steel fibers and polypropylene fibers is 1%.the increase of 12 to 19% of split tensile strength values can be observed from table.

International Journal of Engineering Research & Technology (IJERT)
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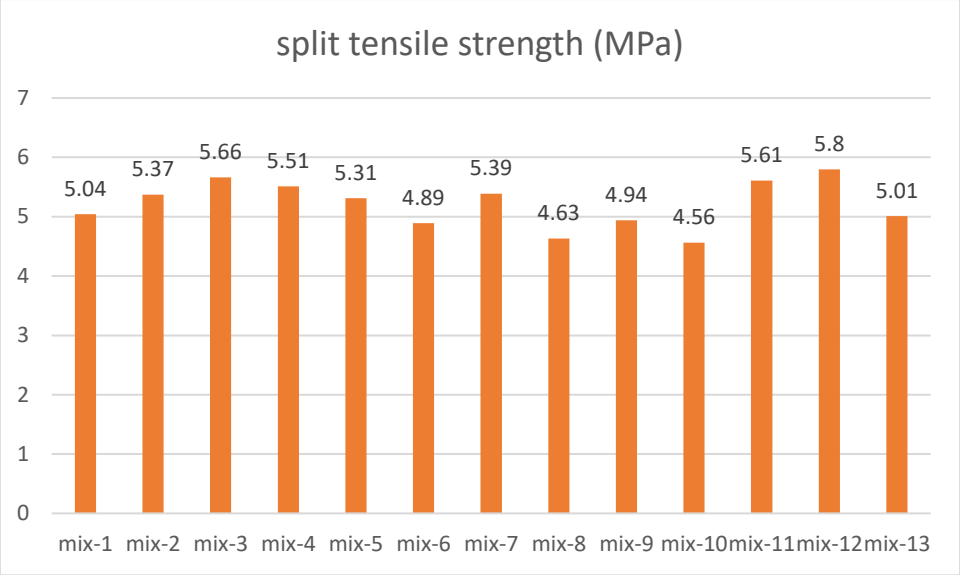
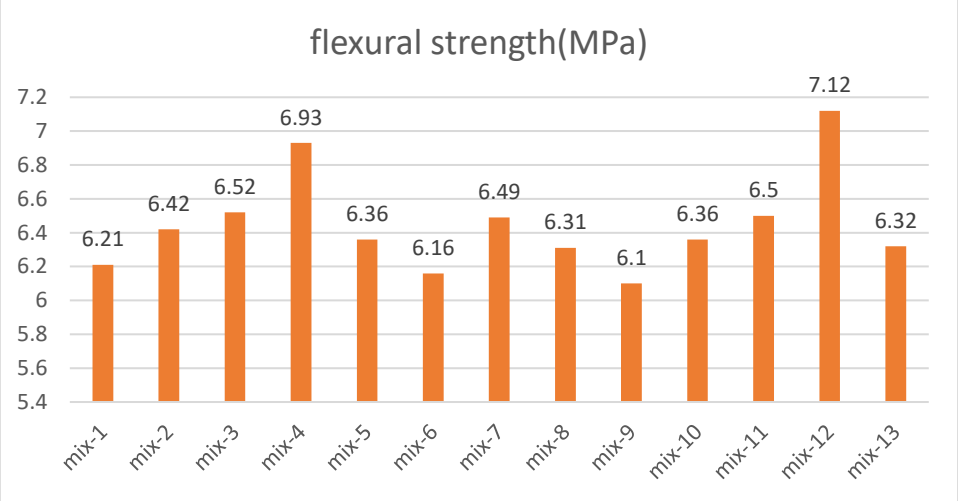


3.3 FLEXURAL STRENGTH:

The variation of flexural strength in the prescence of metakaolin and hybrid fibers of HSC at 28 days after curing depicts from mixes 7 , 10 and 13 with increase of 10 to 20% respectively.



3.4 RAPID CHLORIDE PENETRATION TEST: RCPT is a common test to determine the resistance of concrete against chloride ions penetration. The ability of concrete to resist the penetration of chloride ions is a critical parameter in determining the service life of steel reinforced concrete structures exposed to the marine environment. It is also quite important to investigate the behavior of concrete containing metakaolin and hybrid fibers with respect to resistance to chloride ion penetration .It could be observed that all the mixes have low penetrability to chloride ion. Coulomb values decreased with an increase in metakaolin upto 20 %. Beyond this, the chloride ion passage was increased slightly.

Mix no	Charge passed in coulombs	Chloride ion penetrability
mix-1	734	Very low
mix-2	638	Very low
mix-3	569	Very low
mix-4	675	Very low
mix-5	798	Very low
mix-6	855	Very low
mix-7	542	Very low
mix-8	656	Very low
mix-9	750	Very low
mix-10	800	Very low
mix-11	796	Very low
mix-12	850	Very low
mix-13	866	Very low

3.5 SORPTIVITY: The sorptivity test was conducted on 50mm×100mm dia size specimen. The sorptivity test was conducted on various mixes containing metakaolin and hybrid fibers. In hardened concrete the voids content is less due to replacement of cement by metakaolin the water absorption is less when to compared to conventional concrete.

International Journal of Engineering Research & Technology (IJERT)
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Vol. 8 Issue 09, September-2019

Mix no	Initial absorption ($mm/s^{1/2}$)
mix-1	0.00191
mix-2	0.00177
mix-3	0.00162
mix-4	0.00242
mix-5	0.00261
mix-6	0.00274
mix-7	0.00152
mix-8	0.00193
mix-9	0.00339
mix-10	0.00165
mix-11	0.00115
mix-12	0.00247
mix-13	0.00251

3.6 WATER ABSORPTION:

The water absorption test was conducted on 100 mm size cubes for all 13 mixes. The Results show that all the mixes have less surface water absorption.

Mix no	% of water absorption
mix-1	2.7
mix-2	1.56
mix-3	1.44
mix-4	1.65
mix-5	1.83
mix-6	1.86
mix-7	1.79
mix-8	1.52
mix-9	1.81
mix-10	2.12
mix-11	1.78
mix-12	2.55
mix-13	2.47

CONCLUSIONS

Based on the results and discussions presented in this paper the following conclusions can be drawn.

1. Workability of concrete decreases with the increase of metakaolin replacement, the optimum replacement is fixed to be 15%.
2. The mechanical and durability properties of HSC with metakaolin and hybrid fibers compared to conventional concrete has better results.
3. The compressive strength of HSC with 15% MK and hybrid fibers of 1% has an increase of 24% compared to conventional concrete.
4. The split tensile strength of HSC with 15% MK and hybrid fibers of 1% has an increase of 12 % compared to conventional concrete.
5. The flexural strength HSC with 15% MK and hybrid fibers of 1% has an increase of 15% % compared to conventional concrete.
6. The RCPT values conclude the HSC with MK has very low chloride ion penetration.
7. The sorptivity and water absorption tests indicate that HSC with MK have less voids and has low surface water absorption.

REFERENCES:

[1] SANJAY N.PATIL,ANIL K.GUPTA,SUBHASH S.DESHPANDE METAKAOLIN-POZZOLANIC MATERIAL FOR CEMENT IN HIGH STRENGTH CONCRETE

[2] D.VISWANADHA VARMA,G.V.RAMA RAO INFLUENCE OF METAKAOLIN IN HIGH STRENGTH CONCRETE OFM70 GRADE FOR VARIOUS TEMPARATURES AND ACIDIC MEDIUM

[3] HAMDY K.SHEHAB EL-DIN,AHMED S.EISA ,BALIGH H.ABDEL AZIZ ,AHMED IBRAHIM MECHANICAL PROPERTIES FROM HIGH STRENGTH CONCRETE MADE FROM HIGH VOLUME OF METAKAOLIN AND HYBRID FIBERS

[4] VAHID AFROUGHSHBET,TOGAY OZBAKKALOLGLU MECHANICAL AND DURABILITY PROPERTIES OF HIGH STRENGTH CONCRETE CONTAINING STEEL AND POLYPROPYLENE FIBERS

[5] AHMED MOHMAMED KORANY,AHMED ABD EL-AZIM AHMED, MAGDY ALI ABD EL-AZIZ THE EFFECT OF STEEL AND POLYPROPYLENE FIBERS ON PROPERTIES OF HIGH STRENGTH CONCRETE