Enhancement of Strength and Durability Characteristic of Ternary Blended Concrete

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Abstract:- Concrete is one of a brittle material which has low strain and strength capacity when load applied. In order to make the concrete strong in tension, they are supplemented with reinforcement. Both materials are structural in levels; fibers used in this project can improve the strength level, load carrying capacity and ductility of concrete by changing the percentage and aspect ratio in fibers. When a large portion of short fibers are mixed they control micro-cracks. This concept has been used for hybrid fiber reinforcement. Supplementary Cementations Material (SCM) like Silica Fume (SF), Rice Husk Ash (RHA) are generally in use as cement replacement materials which present a possible solution for sustainable development united with multiple benefits of savings in cost as well as energy. The different types of fibers ware used in this project study are Polypropylene fibers (PEF). The mixture of these fibers in suitable proportion give desired properties. This project is concerned with the strength, durability and flexure investigation of a new innovative concrete named as Fiber Reinforced Blended Concrete (FRBC) in M20, M25 grade of concrete. FRBC is a concrete made up of PEF in mono form and in hybrid form gained thorugh partial replacement of SF and RHA as binary and ternary blend. To enhance the material properties numerous test such as cube compressive strength, cylindrical split tensile strength, modulus of elastic and impact strength.

Keywords:- *SCM, SF, RHA, PEF, FRBC.*

I. INTRODUCTION

Concrete is an artificial construction material used worldwide. It is acquired by incorporation of materials like cement, water, coarse aggregate, fine aggregate and admixtures in necessary proportions. Ordinary Portland Cement (OPC) is one of the major ingredients used for the manufacturing of concrete. FRC is an ordinary cement concrete reinforced with randomly distributed fibers thus improving the concrete properties. Concrete is a material which is brittle and has low strength and strain character under tension. In order to make the concrete strong along with tension they are supplemented with fiber reinforcement. Fibers decrease the volatile propagation, furnish strong bridging and impart resources of strength and ductility.

II. MATERIALS AND METHODS

A. Fiber Reinforced Concrete (FRC)

FRC is an ordinary cement concrete reinforced with randomly distributed fibers thus improving the concrete properties. Fibers decrease the volatile propagation, furnish strong bridging and impart resources of strength and ductility. At both material and structural levels, the use of fibers can increase the strength, load capacity and ductility of concrete with varying their percentage and aspect ratio.

B. Rise Husk Ash (RHA)

The rice husk ash is natural and additive material having several numbers of applications in every aspects. It is also used in water proofing condition and used as an admixture in making concrete to withstand with any type of chemical attacks

C. Silica Fume (SF)

SF is almost a super ultra fine material containing sphere shaped molecule less than has 1 µm in diameter, compare to average that is about 0.15 µm. Which forms the SF approximately 100 times small compare to common cement particle. Where the bulk density of SF be on the degree of dense in silo that has 130 (unidentified) to 600 kg/m^3. The specific gravity of SF is generally ranges from 2.2 to 2.3.

D. Polypropylene Fiber (PPF)

Polypropylene (PP), termed as polypropene, which has state of thermoplastic which is quite perdurable, so that can resist daily tear and wear, along with cracking resistant and stress conditions. PP are used in a different category of construction, including concern like siding, air and moisture barrier membranes, carpet textiles, films and sheets used in construction adhesives and tape, insulating building wraps, and plastic parts which are used in pipe materials

III. REVIEW OF LITERATURE

E Kavitha, K Vidhya (2022) The strength and durability studies on green solid blocks are conducted experimentally. The eco-friendly material olivine sand is used to making the solid blocks[1]. Vidhya K, Shivasakthivadivelan.R A, Kavitha K, Revathi S (2022) conducted an Experimental study on brick using sustainable materials is studied. The industrial by products are used to making greener bricks [2]. Vidhya.K, Kandasamy.K, 2016 zan experimental investigation of the coal-ash brick is conducted. The green building materials is effectively utilized in making greener brick[3]

Vijaya Bhaskar Reddy & Rao (2016) carried out the investigation in the optimization of ternary blend cementations system incorporating OPC, GGBS and MicroSilica are used for the alteration in ternary blend concrete. Use of industrial waste materials in ternary blended concrete mixes played an excellent performance and can make environment more sustainable[4]. Sonu Pal & Mishra (2016) investigated the effects of alkaline water on polyester fiber reinforced concrete. The polyester fiber was added as0%, 0.20%, 0.225%, 0.25%, 0.275% & 0.30% by cement weight in M25grade of concrete mix. Strength of FRC improves by 8.75% at 0.25%additionof fiber[5]. Shah & Sheth (2014) analysed the effects of fibers and mineral admixtures in the mechanical properties of HSC and concluded that when the percentages of FA, GGBS, and SF were kept constant and the part of fibers varied from 0 to 2.5, maximum strength was attained at 1.5% addition of steel fibers [6]. Utilization of sustainable materials fly ash and pond ash in self-compacting concrete is discussed. The pond ash and fly material is reduced the weight density of the concrete[7]

Akekeetal.(2013)studied about the structural integrity and properties in concrete with RHA as average replacement with OPC. The study indicated that the compressive strength and workability test pointed no significant change when RHA was exchanged for 25% of OPC in the production of concrete. Also, it was stated that the addition of RHA did not have any sizeable impact in the increase of tensile strength[8]. Karimetal. (2012)conducted are view which was the consolidation of various literatures relating to the uses of RHA in concrete. The summation list salengthy inventory of advantages and also a few disadvantages in use with RHA as a average replacement in OPC. It was stated that RHA improved compressive, flexural and tensile strength and showed good bond strength[9].

Pawade et al. (2011) studied the consequence of SF with and without steel fiber concrete. With the incorporation of bend steel fiber, SF and PPC produced a strong mix of composite with crack formations, better ductility and strength action. The increase in compressive strength was modestly superior in the addition of SF rather than that of steel fiber but the converse is true in the state of flexural strength. The optimum dosage of replacement of SF in the concrete was estimatedas8%[10]. Sumrerng et al. (2009).The base materials included four diverse RHA samples of assorted fineness and replacement of 20% OPC by weight of binder. Fine RHA surpasses coarse RHA in improving the strength and minimizing the water to binder ratio[11].

IV. MIX PROPOTION

A. Mix Design Of The Concrete

Mix proportion is done according the stipulations given in IS: 10262 (1982). Table I shows the concrete mix for used control concrete.

TABLE I. MIX PROPORTION FOR CONTROL CONCRETE

Materials Required Perm^3 of Concrete					
Concrete Grade	**Cement (Kg)**	**Fine Aggregate (Kg)**	**Coarse Aggregate (Kg)**	**w/c Ratio**	**Water (litre)**
M20	384	567	1272	0.52	190
M25	443	551	1248	0.42	190

B. Percentage Of Polypropylene Fiber Required

The percentage of PPF taken per m3 for blended concrete is shown in Table II. The PPF is added in percentage to the cement weight per m3 of Concrete.

TABLE II. PERCENTAGE OF POLYPROPYLENE FIBER REQUIRED FOR BLENDED CONCRETE

Polypropylene Fiber (%)	**Fibre Required Per m^3 of Concrete**	
	M20	**M25**
0.2	0.76	0.86
0.4	1.52	1.76

C. Mix Proportions For Binary And Ternary Blende

The percentage of PPF needed per m3 for blended concrete is shown in Table III. The PPF is added in percentage to the cement weight per m3 of Concrete.

TABLE III. MIX CEMENTATIONS MATERIAL COMBINATIONS FOR BINARY AND TERNARY BLEND POLYPROPYLENE FIBER REINFORCED CONCRETE

Mix ID	**Cement Content(kg/m³)**		**Mineral Admixture Content (kg/m³)**			
			SF (7.5%)		**RHA (15%)**	
	M20	M25	M20	M25	M20	M25
CPP	384	483	-	-	-	-
CPPS	352	410	28	32	-	-
CPPR	325	376	-	-	57	66
CPPSR	298	344	28	32	57	66

V. TESTING, RESULTS AND DISCUSSION

Tests results are evaluated and discussed in the following section. These materials undergoes some test for various properties like fineness of cement, initial and final setting time of cement, standard consistency, specific gravity and fineness modulus of coarse & fine aggregate, tensile strength.

A. General

The properties like cube compressive strength, split tensile strength, flexural strength, modulus of elasticity at the age of 28 days.

TABLE IV. COMPRESSIVE STRENGTH, SPLIT TENSILE STRENGTH, FLEXURAL STRENGTH AT 28 DAYS

S. No	**Grade of Concrete**	**Cube Compressive Strength (MPa)**	**Splitting Tensile Strength (MPa)**	**Flexural Strength (MPa)**	**Modulus of Elasticity (MPa)**
1	M20	26.80	2.19	3.68	26887
2	M25	34.51	2.55	4.11	29886

B. Compressive Strength

The compressive strength test along with different percentage of RHA and SF mixed concrete and its compressive strength for varying percentage of PPFRBC is carried out on the cube of 150mm x150mm x 150mm size. Casting is done for 24 timing hours the cube samples is then remould properly and placed inside a tank of water to further curing.

TABLE V. CUBE COMPRESSIVE STRENGTH OF POLYPROPYLENE FIBER REINFORCED CONCRETE

S. No	**Mix Id**	**Grade of Concrete**	**Cube Compressive Strength (MPa)**
1	PP0R0S0	M20	4.22
2	PP.2R0S0	M20	4.27
3	PP.4R0S0	M20	4.41
4	PP.2R15S0	M20	4.52
5	PP.4R15S0	M20	4.58
6	PP.2R0S7.5	M20	4.55
7	PP.4R0S7.5	M20	4.67
8	PP.2R15S7.5	M20	4.78
9	PP.4R15S7.5	M20	4.92
10	PP0R0S0	M25	5.21
11	PP.2R0S0	M25	5.33
12	PP.4R0S0	M25	5.42
13	PP.2R15S0	M25	5.62
14	PP.4R15S0	M25	5.68
15	PP.2R0S7.5	M25	5.84
16	PP.4R0S7.5	M25	5.89
17	PP.2R15S7.5	M25	6.02
18	PP.4R15S7.5	M25	6.12

C. Split Tensile Strength

STS is opposite to direct test helps in finding concrete strength. Split tensile strength experiments are done at a condition of 28 counted days for the concrete cylinder specimen of size 0.15m diameter and 0.30m length using 2000K N electrically operated using CTM.

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TABLE VI. TENSILE STRENGTH OF POLYPROPYLENE FIBER REINFORCED CONCRET

S.No	Mix Id	Grade of Concrete	Split Tensile Strength (MPa)
1	PP0R0S0	M20	2.22
2	PP.2R0S0	M20	2.45
3	PP.4R0S0	M20	2.5
4	PP.2R15S0	M20	2.75
6	PP.2R0S7.5	M20	3.05
7	PP.4R0S7.5	M20	3.12
8	PP.2R15S7.5	M20	3.33
9	PP.4R15S7.5	M20	3.5
10	PP0R0S0	M25	3.22
11	PP.2R0S0	M25	3.35
12	PP.4R0S0	M25	3.44
13	PP.2R15S0	M25	3.54
14	PP.4R15S0	M25	3.59
15	PP.2R0S7.5	M25	3.67
16	PP.4R0S7.5	M25	3.74
17	PP.2R15S7.5	M25	3.82
18	PP.4R15S7.5	M25	3.95

D. Flexural Strength

Flexural strength test is done at 28 days on 750 mm x150 mm x 150mm size prism specimen using 1000 kN capacity universal testing machine by subjecting the specimen to two point loading.

TABLE VII. FLEXURAL STRENGTH OF POLYPROPYLENE FIBER REINFORCED CONCRET

S. No	Mix Id	Grade of Concrete	Flexural Strength Strength (MPa)
1	PP0R0S0	M20	4.22
2	PP.2R0S0	M20	4.27
3	PP.4R0S0	M20	4.41
4	PP.2R15S0	M20	4.52
5	PP.4R15S0	M20	4.58
6	PP.2R0S7.5	M20	4.55
7	PP.4R0S7.5	M20	4.67
8	PP.2R15S7.5	M20	4.78
9	PP.4R15S7.5	M20	4.92
10	PP0R0S0	M25	5.21
11	PP.2R0S0	M25	5.33
12	PP.4R0S0	M25	5.42
13	PP.2R15S0	M25	5.62
14	PP.4R15S0	M25	5.68
15	PP.2R0S7.5	M25	5.84
16	PP.4R0S7.5	M25	5.89
17	PP.2R15S7.5	M25	6.02
18	PP.4R15S7.5	M25	6.12

E. Maximum Cube Compressive Strength Attained At 28 Days

TABLE VIII. COMPRESSIVE STRENGTH ATTAINED AT 28 DAYS

S. No	Grade of concrete	Mix ID	Maximum Compressive Strength(MPa)
1	M20	PP	27.68
		PPR	29.8
		PPS	32.18
		PPRS	34
2	M25	PP	34.8
		PPR	37.8
		PPS	38.34
		PPRS	42

F. Maximum Cylinder Split Tensile Strength Attained At 28 Days

TABLE IX. SPLIT TENSILE STRENGTH ATTAINED AT 28 DAYS

S. No	Grade of concrete	Mix ID	Maximum Split Tensile Strength(MPa)
1	M20	PP	2.5
		PPR	2.9
		PPS	3.12
		PPRS	3.5
2	M25	PP	3.44
		PPR	3.59
		PPS	3.74
		PPRS	3.95

G. Maximum Prism Flexural Strength Attained At 28 Days

TABLE X. FLEXURAL STRENGTH ATTAINED AT 28 DAYS

S.No	Grade of concrete	Mix ID	Maximum Flexural Strength (MPa)
1	M20	PP	4.41
		PPR	4.58
		PPS	4.67
		PPRS	4.92
2	M25	PP	5.42
		PPR	5.68
		PPS	5.89
		PPRS	6.12

H. Water Absorption Test

TABLE XI. THE SATURATED WATER ABSORPTION TEST RESULT

Mix ID	Water Absorption (%) at 28 days	
	M20	M25
CC	1.21	1.12
PPR	0.986	0.89
PPS	0.975	0.88
PPRS	0.898	0.82

VI. CONCLUSION

The Binary and ternary mixed concrete mixes decreases the value of slump when in order with the control mix of concrete, where the slump value varies from 49 to 75mm was maintained for all mixes by adjusting the super plasticizers dosage. The compressive strength values of RHA blend concrete at 28 days decreases for both the concrete grades. From the desire amount of RHA and SF for cement replacement for developing M20, M25 grade is arrived as 7.5 and 15% on condition. The split tensile strength of polypropylene FR binary and ternary mix concrete is greater compared to control concrete in both the grade of concrete mix. The maximum tensile strength is achieved with 0.4% of polypropylene fibre reinforced ternary mixed concrete. The combination of SF and RHA in fibre reinforced concrete reduces the water absorption compared to the concrete without the admixtures. The effective porosity of 28 days cured SF / RHA based binary blend fibre reinforced concrete showed lower porosity values than the control concrete. Maximum reduction of porosity at the 28 days has been determined in ternary blend concrete mix about 31.66% which is significantly reduced compared to CC mix. The load deflection behaviour of FR mixed concrete beams during the first crack and at ultimate failure is improved by the addition of SF and RHA. The addition of fibers improves the stiffness of the beam. Fibrous concrete beams are capable of lesser damage at under loading condition compared with normal concrete beam.

REFERENCES

[1]. E Kavitha, K Vidhya (2022) "Strength and Durability studies on sustainable eco-friendly green solid blocks", International Journal of Coal Preparation and Utilization, January 2022.

[2]. Vidhya K, Shivasakthivadivelan.R A, Kavitha K, Revathi S, "Experimental Study on Greener Brick Using Sustainable Materials" Emperor Journal of Applied Scientific Research, Vol. 2, Issure.08, 2020.

[3]. N. Sudharsan, T. Palanisamy, S. C. Yaragal, "Environmental sustainability of waste glass as a valuable construction material - A critical review" Ecology, Environment and Conservation, Vol 24, pp. S331–S338,2018.

[4]. Sudharsan, N., & Palanisamy, T, "A comprehensive study on potential use of waste materials in brick forsustainable development", Ecology, Environment and Conservation, 24, S339–S343, 2018.
[5]. Vidhya.K, Kandasamy.K, "Experimental investigations on the properties of coal-ash brick units as green building materials" International Journal of Coal Preparation and Utilization" Vol. 36, Issure.6, pp. 318-325, 2016.
[6]. VijayaBhaskar Reddy, S & Rao, S, 'Research Papers Effect of Mineral Admixtures (Micro Silica and Ggbs) on Compressive Strength of Ternary Blended Concrete', vol. 5, no. 1, pp. 688-694, 2016
[7]. Sonu Pal, MK & Mishra, VP, 'Effects of Alkaline Curing On The Properties of Polyester Fibre Reinforced Concrete', International Journal of Civil Engineering and Technology, vol. 7, no. 4, pp. 506512, 2016.
[8]. Shah, J &Sheth, A, 'Studying the effects of Fibres and Mineral admixtures on high strength concrete', International Journal of Innovative Research in Advanced Engineering (IJIRAE), vol. 1, no. 4, pp. 202-205, 2014.
[9]. Vidhya K. & Swernalatha S, "Utilization of fly ash and pond ash in self-compacting concrete" International Journal of innovative research & Development, Vol. 2, Issure.5, pp. 1672-1680, 2013.
[10]. Akeke, GA, Ephraim, ME &Ukpata, JO, 'Structural properties of rice husk ash concrete', International Journal of Engineering and Applied Sciences, vol. 3, no. 3, pp. 57-62, 2013.
[11]. Vidhya.K, Kandasamy.K, Sanjana Malaimagal U, Karthikeyan S.R, SathickBasha.G, Tariq Junaid.H, "Experimental studies on pond ash brick" J. Eng. Res. Develop, Vol. 6, Issure.5, pp. 6-11, 2013
[12]. Karim, MR, Zain, MFM & Jamil, M, 'Strength of mortar and concrete as influenced by rice husk ash: A review', World Applied Sciences Journal, vol. 19, no. 10, pp. 1501-1513, 2012.
[13]. Pawade, PY, Pande, AM &Nagarnaik, PB, 'Effect of Steel Fibres on Modulus of Elasticity of Concrete', International Journal of Advanced Engineering Sciences and Technologies, vol. 7, no. 2, pp. 169-177, 2011.
[14]. Sumrerng, R, Prinya, C &Rattana, M, 'Effect of grinding on chemical and physical properties of rice husk ash', International Journal of Minerals, Metallurgy and Materials, vol. 16, no. 2, pp. 242-247, 2009.
[15]. Khedr, SA &Abou-Zeid, MN, 'Characteristics of silica-fume concrete', Journal of Materials in Civil Engineering, vol. 6, no. 3, pp. 357-375, 1994.
[16]. Murthi, P &Sivakumar, V, 'Studies on Acid Resistance of Ternary Blended Concrete', Asian Journal of Civil Engineering (Building and Housing), vol. 9, no. 5, pp. 473-486, 2008.