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Experimental Study on Fiber Reinforced Concrete Using PVA Fiber and Glass Powder

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Abstract: ***Concrete consisting of cement, water, fine and coarse aggregates are widely used in civil engineering constructions. Though making concrete is convenient and inexpensive, its brittle behavior upon tensile loading is one of its undesirable characteristics so that leads to the development of fiber reinforced concrete or engineered cementitious composites to improve this deficient.***

The Flexural strength of PVA (polyvinyl alcohol) FRC (fiber reinforced concrete) can be 150-200% greater than for normal concrete.

According to Structural designers the damage tolerance and inherent tight crack width control of PVA FRC is found to be impressive in recent full-scale structural applications. If proper volume fractions are used the compressive strength PVA FRC can be similar to that of conventional concrete. The aim of this research work is to study compressive and tensile strength of FRC consisting PVA fiber & glass powder and studying the effect of glass powder in it. This research also gives rough idea on crack resistance capacity of FRC.

In this paper we studied and provided detailed review on properties of PVA FRC with glass powder and experimentally identified the best ECC mix by analyzing the compressive & the flexural strength at different ratios like 0.5%, 1%, 1.5% of PVA fiber of total dry mix weight and in each case 15% of fine aggregate was replaced by glass powder. By conducting the compressive strength test and flexural strength test the maximum result we get at 28 days is 28.38Mpa and 8.95Mpa respectively which is more durable as compared to conventional concrete by IS 516:1959. So by analysis of results it can be seen that 1% mix is found to be optimum in all aspects.

Keywords: PVA FRC, Polyvinyl Alcohol, Fibre Reinforced Concrete, Glass Powder.

I. INTRODUCTION

Concrete is a material which is widely used in various construction works due to its unique properties. In early times materials were crude cements made by crushing and burning gypsum or limestone. Lime also refers to crushed, burned limestone. When sand and water were added to these cements, they became mortar, which was a plaster-like material used to adhere stones to each other. Over thousands of years, these materials were improved upon, combined with other materials and, ultimately, morphed into modern concrete.

Today's concrete is made using Portland cement, coarse and fine aggregates of stone and sand, and water. Admixtures are chemicals added to the concrete mix to control its setting properties and are used primarily when placing concrete during environmental extremes, such as high or low temperatures, windy conditions, etc.

As we know concrete has excellent compressive strength due to the materials present in it but it leads to low tensile strength and high brittleness that to counter the problem there is development of fiber reinforced concrete or engineered cementitious composites to improve this deficiency of concrete.

Aim of this research was to study properties of PVA FRC with glass powder and to experimentally identify the best FRC mix by analyzing the compressive & the flexural strength at different ratios like 0.5%, 1%, 1.5% of PVA fiber of total dry mix weight and in each case 15% of fine aggregate was replaced by glass powder.

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II. MATERIALS

Table 1: Materials and tests

Material	Property	As per IS	Laboratory work
Coarse aggregate	Sieve analysis	6.9-7.5	7.38
	Flakiness and elongation index	35 %	26.00%
	Impact test	<10% (Exceptionally strong)	3.424 %
	Specific gravity and water absorption	2.5 – 3.0	2.67
Fine aggregate	sieve analysis	2-4	3.126
PPC Cement	Specific gravity	3.08	3.15
	Standard consistency	25-35%	36%
	Initial setting time	30 min	35 min
	Final setting time	600 min	615 min

A. Polyvinyl Alcohol Fiber

PVA Fibbers (polyvinyl alcohol) are high performance reinforcement fibers for concrete and mortar. PVA fibers are well-suited for a wide variety of applications because of their superior crack-fighting properties, high modulus of elasticity, excellent tensile and molecular bond strength, and high resistance to alkali, UV rays, chemicals, fatigue and abrasion. PVA fibers are unique in their ability to create a molecular bond with mortar and concrete that is 300% greater than other fibers. Due to such properties PVA fiber when used in concrete proves to be durable and sustainable.

B. Glass Powder

Million tons of waste glass is being generated annually all over the world. Once the glass becomes a waste it is disposed as landfills, which is unsustainable as this does not decompose in the environment. Also the studies have proven that, while the concrete is in its hardened phase, concrete containing glass powder exhibits better strength. As the percentage of glass powder increases the workability decreases. Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio. Compressive strength increases with increase in percentage of glass powder.

C. Super Plasticizer

UltraTech Seal & Dry ILW+ is specially formulated Integral waterproofing liquid system which will improve the performance properties of plaster, mortar and concrete. It makes plaster, mortar and Concrete cohesive and enhances the yield, compressive strength and water tightness. I also does the work of super plasticizer in fiber reinforced concrete.

III. PREVIOUS RESEARCH WORK

A. Use of Slag to Improve Mechanical Properties of Engineered Cementitious Composites (ECCs)

A series of investigations was carried out to evaluate mechanical properties and drying shrinkage of ECC with 70% combination mineral admixtures of FA and ground granulated blast furnace slag(SL).Four ECC mixtures with constant W/B of 0.25 are prepared with combined inclusion of FA and SL as constant cement replacement level of 70%. The experimental results show that ECC with combination mineral admixtures can achieve strain hardening behavior, tensile capacity of ECC can bemorethan2.5%at90days.Meanwhile,compared to ECC only with fly ash, slag and fly ashcan effectively increase compressive strength of ECC, especially at early age. Incorporating SL into matrix can slightly increase drying shrinkage of ECC. However ,among four ECC mixtures ,ECC with 30% SL and 40% FA presents the lowest drying shrinkage.

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B. Experimental Study on Bendable Concrete

Carried out experimental study to prepare different nominal mixproportions by replacing cement with fly ash and by incorporating different volume of fibers. They used a constant water/cement percentage for finding out better proportion for workability, while keeping the recron fiber volume fraction as 2%-3%, Super plasticizer as 2% and water/cement ratio fixed out as 0.5, and replacement of fly ash with cement was 20%-30%.The experimental results show that the Compressive strength of M30 PVA FRC with glass powder is 16.4% greater in compressive strength than compared to M30 Nominal Concrete, The maximum Flexural strength in PVA FRC with glass powder having 40% replacement of cement with fly ash and having 3% volume of fibers is 7 MPa and The maximum Splitting Tensile strength in PVA FRC with glass powder having 40% replacement of cement with fly ash and having 3% volume of fibers is around 5 MPa.

C. Experimental Study Of Bendable Concrete By Using Admixture And Fiber

In their paper they explained the need for developing a new class of FRCs which has the strain-hardening property but which can be processed with conventional equipment. Ductile property of normal concrete can be improved by using PVA fibers in place of coarse aggregate and cement partially replaced by fly ash. In their experiment they used M40 grade concrete with 4.6% super plasticizer and 0.5-1.5% fiber with 0.36 water cement ratio. They have tested cubes of size 150 x 150 x 150 mm are placed in the machine such that load is applied on the opposite side of the cubes as casted. They carried test to find the flexural strength of the prism of dimension 100 x 100 x 500 mm. Two points loading adopted on an effective span of 400 mm while testing the prism. The load is applied until the failure of the prism. By using the failure load of prism. Conventional concrete is brittle in nature where as ECC has an appreciable ductility. Flexural strength of ECC is 60% more than convention concrete, though compressive strength of ECC and convention concrete is nearly same.

D. Mechanical Properties of PVA and Polyester Fibers Based Engineered Cementitious Composites

In their research they studied and explained Mechanical Properties of Polyvinyl Alcohol Fibers and Polyester Fibers Based Engineered Cementitious Composites. Five cylindrical specimens (150 300 mm) and ten cube (150 150 150 mm and 70.7 70.7 70.7 mm) specimens were tested in Compression Testing Machine (CTM) of capacity 2000 kN after 28 days. The split tensile strength of ECC was measured through testing of five cylindrical specimens (100 200 mm). The compressive strengths of cylinder specimens and small cube specimens are found to be 0.833 and 1.20 times of the compressive strength of standard cube(150 mm size). The compressive, tensile, and flexural strength of PVA-ECC are respectively found to be 1.14, 2, and 1.11 times of compressive, tensile, and flexural strength of Poly-ECC.

E. Durability Studies on Polyvinyl Alcohol FiberReinforced Concrete

In their research they have done durability Studies on Polyvinyl Alcohol Fiber Reinforced Concrete. This report will present data to support the argument that polyvinyl alcohol fiber reinforced concrete is an ideal material for achieving these goals. The report also discusses poly vinyl alcohol fiber reinforced concrete materials properties and mix design. The PVA fiber will be added to the conventional concrete 0%, 0.1%, 0.2%, 0.3% and 0.4% by its cement weight. The Compressive strength, Split tensile strength and Modulus of rupture of concrete was found and with comparison of concrete strengths the optimum level of PVA fiber was found. They concluded that the addition of poly vinyl alcohol fibers leads to increase in compressive strength, split tensile strength and modulus of rupture with age and with the increase of poly vinyl alcohol fiber content up to 0.3% compared to control concrete at 28 day. Compared to conventional concrete poly vinyl alcohol fiber reinforced concrete specimens attains 48.5% higher compressive strength, 50.4% higher split tensile strength, 21.4% higher modulus of rupture.

F. Engineered Cementitious Composites for Structural Applications

This research work suggests the need for developing a new class of FRCs which has the strain-hardening property but which can be processed with conventional equipment. It is demonstrated that such a material, termed engineered cementitious composites or ECCs, can be designed based on micromechanical principles. The result is a moderately low fiber volume fraction (<2%) composite which shows extensive strain-hardening, with strain capacity of about 3 to 5% compared to 0.01% of normal concrete. According to test results, the beam is withstanding high load and a large deformation without succumbing to the brittle fracture typical of normal concrete, even without the use of steel reinforcement. The significant properties of ECC Concrete are ductility, durability, compressive strength, and self-consolidation.

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The cost of ECC is currently about three times that of normal concrete per cubic yard. However initial construction cost saving can be achieved through smaller structural member size, reduced or eliminated reinforcement elimination of other structural protective systems, and/or faster construction offered by the unique fresh and hardened properties of ECC. When long term cost and environmental impacts are accounted for, as suggested by the life cycle cost/impact analyses for the ECC bridge deck highlighted above, the advantages offered by ECC over conventional concrete become even more compelling.

IV. METHODOLOGY

1) Literature Review & Selection of topic
2) Setting out the objectives
3) Preliminary tests of materials
4) Mix design and batching
5) Mixing, Casting and Curing
6) Concrete Testing for compressive & flexural strength
7) Analysis of test results of conventional conc., conc. with glass powder & PVA FRC with glass powder
8) Comparative study between results of PVA FRC & conventional concrete
9) Conclusions

A. Mix Design

M20 grade is used for mix design – 1:1.5:3
Water-cement ratio – 0.60

1) According to the mix 1 part of Cement, 1.5 part of fine aggregate, 3 part of coarse aggregate were taken
2) By analyzing the different research papers based on use of glass powder in concrete it can be seen that 15% replacement of fine aggregate by glass powder is found to be optimum
3) Similarly PVA fiber was added as 0.5%, 1% and 1.5% of total dry mix weight of concrete.
4) Super plasticizer was added as 6ml per kg of cement. (as directed on plasticizer company)

Table 2: Mix proportions for concrete blocks 150mm^3

Sr No.	Mix Name	Cement(kg)	Fine Aggregate(kg)	Course aggregate(kg)	Glass powder(kg)	PVA (gm)	Plastici-zer(ml)
1	Conventional concrete (M1)	1.36	2.04	4.08	-	-	-
2	Concrete with Glass Powder (M2)	1.36	1.734	4.08	0.306	-	-
3	PVA (0.5%) FRC with glass powder (M3)	1.36	1.734	4.08	0.306	37.4	8.16
4	PVA (1%) FRC with glass powder (M4)	1.36	1.734	4.08	0.306	74.8	8.16
5	PVA (1.5%) FRC with glass powder (M5)	1.36	1.734	4.08	0.306	112.65	8.16

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Table 3: Mix proportions for concrete beams 500x100x100mm^3

Sr No.	Mix Name	Cement(kg)	Fine Aggregate(kg)	Course aggregate(kg)	Glass powder(kg)	PVA (gm)	Plastici-zer(ml)
1	Conventional concrete(M1)	2.016	3.03	6.048	-	-	-
2	Concrete with Glass Powder (M2)	2.016	2.570	6.048	0.460	-	-
3	PVA(0.5%) FRC with glass powder (M3)	2.016	2.570	6.048	0.460	55.44	12.1
4	PVA(1%) FRC with glass powder (M4)	2.016	2.570	6.048	0.460	110.88	12.1
5	PVA(1.5%) FRC with glass powder	2.016	2.570	6.048	0.460	165.60	12.1

V. RESULT AND DISCUSSION

Table 4: Compressive Strength Test Result

MIX	Compressive Strength after 7 days		Compressive Strength after 14 days		Compressive Strength after 28 days	
M1	13.80	15.11	18.20	18.27	20.40	20.30
M2	19.09	19.03	26.54	26.39	29.29	29.38
M3	16.51	16.27	23.40	23.40	26.45	26.10
M4	17.00	16.86	25.24	25.49	28.05	28.31
M5	16.75	16.56	24.32	24.48	27.25	27.20

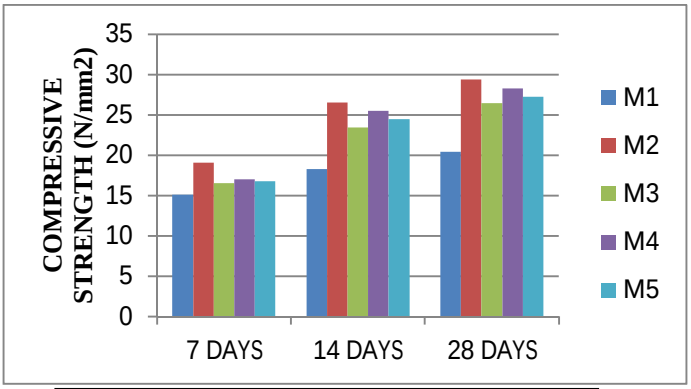


Fig. 1 : Compressive Strength Test Analysis

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Table 5: Flexural Strength Test Result

MIX	Flexural Strength after 7 days		Flexural Strength after 14 days		Flexural Strength after 28 days	
B1	2.60	2.72	2.98	2.99	3.16	3.15
B2	2.74	2.67	3.05	3.02	3.20	3.27
B3	2.99	3.06	4.14	4.24	4.60	4.72
B4	4.38	4.48	6.07	6.21	6.75	6.90
B5	5.63	5.81	7.80	8.05	8.67	8.95

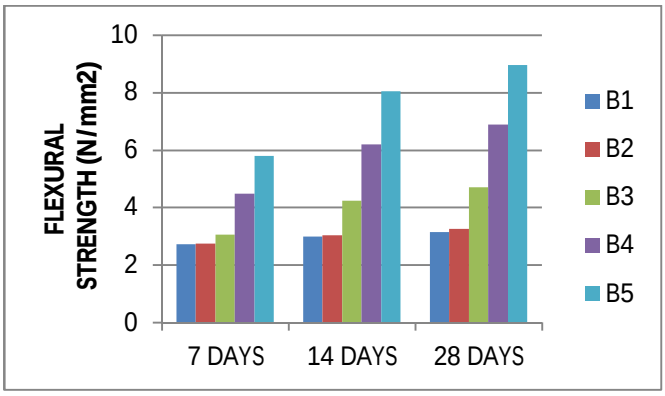


Fig. 2 : Flexural Strength Test Analysis

VI. DISCUSSION ON RESULTS

A. *Compressive Strength Test*

As we know that from previous results that addition of glass powder significantly increases compressive strength of concrete. It can be seen in above graph that mixes consisting glass powder show higher compressive strength; this increase in compressive strength is due to chemical properties of glass powder. This shows the significance of use of glass powder in PVA FRC. By analysis of different papers on FRC it can be seen that after some limit increase in fiber percentage decreases the compressive strength of concrete to some extent. This result of compressive strength can be manipulated with change in volume fraction of fibers in concrete. From above graph we can see that concrete mix containing 1% PVA fiber shows higher compressive strength as compared to other mixes containing fibers.

B. *Flexural Strength Test*

From results and from the above graph it is clear that addition of glass powder does not show a noticeable change in the flexural strength of the concrete. Furthermore we can see that with increase in volume fraction of fiber in concrete the flexural strength of the concrete also increases. The mix B5 with 1.5% PVA fiber shows the highest flexural strength amongst others but due to this increase in volume fraction of fiber the concrete the compressive strength of concrete decreases also it affects the economy.

C. *Post Failure Comparison Of Conventional Concrete And PVA FRC*

When we compare conventional concrete with the PVA FRC & glass powder it can be seen clearly that PVA FRC with glass powder performs better than conventional concrete in all major aspects.

1) The PVA FRC with glass powder sustains more load than the conventional concrete.
2) The reason of sustaining more load in PVA FRC is that during application of load unlike the conventional concrete the PVA FRC remains in intact form even after failure, this is due to presence of microfibers present PVA FRC which hold all the ingredients of concrete together.

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3) The glass powder in concrete helps to increase compressive strength in each mixes of PVA FRC due to its chemical properties.
4) Another important advantage of PVA FRC with glass powder over conventional concrete is that it does not fail suddenly and gives indication before failure through various micro cracks and large deflections which gives us time to carryout necessary precautions.
5) As it is clear that PVA FRC with glass powder is tougher than Conventional concrete so it becomes more durable and sustainable than conventional concrete.

VII. CONCLUSIONS

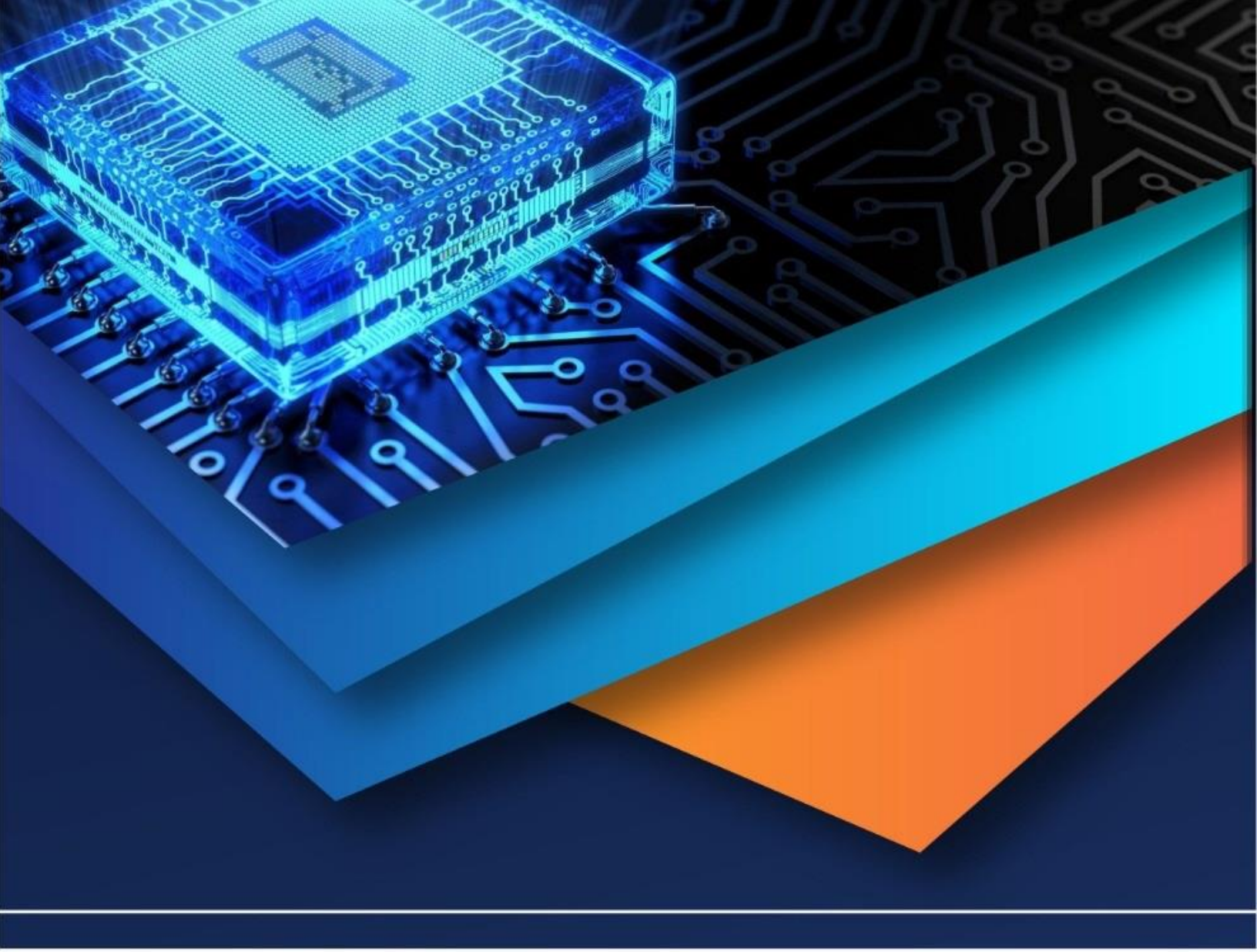
This experimental study focused on behavior of FRC using PVA fiber with glass powder. Based on this discussion, the following conclusion could be drawn:

A. When we compare conventional concrete with the PVA FRC & glass powder it can be seen clearly that PVA FRC with glass powder performs better than conventional concrete in all major aspects. It is found that presence of fibers can increase the alertness of the failure, which mainly occurs due to brittleness of the conventional concrete.
B. Compressive strength increases with increasing fiber content. But when it reaches up to its optimum value (1%), it starts decreasing with the increasing content of fiber.
C. Flexural strength also increases as fiber content increases. I can be seen that the PVA FRC with glass powder shows nearly 150-200% increased flexural strength than normal concrete.
D. During the test, it was perceived that PVA FRC specimen has greater crack control as demonstrated by reduction in crack widths and crack spacing. There is considerable improvement in the post-cracking behavior of concretes containing fibers.
E. Addition of Fibers reduces the w/c ratio which leads to the low workability but appropriate amount of plasticizers can increase workability.
F. Compared to plain concrete, PVA FRC with glass powder is much tougher.
G. The cost of ECC is currently about three times that of normal concrete per 27 cubic feet. However initial construction cost saving can be achieved through smaller structural member size.

REFERENCES

[1] Yu Zhu, Yingzi Yang and Yan Yao(2012) “Use of slag to improve mechanical properties of engineered cementitious composites (ECCs)” Construction and Building Materials 36 (2012) 1076–1081.
[2] KallepalliBinduMadhavi, V Rajesh, Mandala Venugopal, and Kunchepu Suresh (2016) “Experimental Study on Bendable Concrete” ISSN: 2278-0181 IJERTV5IS100400 Vol. 5 Issue 10, October-2016.
[3] Ganesh Ghodke, NileshDaphal, Yogesh Bandgar, DattatrayaGadekar, SagarChavan, Ashwini Waghule (2017) “Experimental Study Of Bendable Concrete By Using Admixture And Fiber” Volume 4, Issue 9, May-2017
[4] Bhaumik Merchant, Ajay Gelot (2015) “Evaluation of Engineering Cementitious Composites (ECC) With Different Percentage of Fibers” ISSN:2278-0181 IJERTV4IS060084, Vol. 4 Issue 06, June-2015
[5] S. B. Singh and Pankaj Munjal (2019) “Mechanical Properties of PVA and Polyester Fibers Based Engineered Cementitious Composites” Springer Nature Singapore Pte Ltd. 2019.
[6] Dr. M. Devi, Mr. M. Ganeshkumar, Mr. L. Kannan, Mr. T. S. Venkatachalam (2018) “Durability Studies on Polyvinyl Alcohol FiberReinforced Concrete” Vol. 7 Issue 02, February-2018
[7] Dr. A. W. Dhawale, Mrs. V. P. Joshi (2013) “Engineered Cementitious Composites for Structural Applications” Volume 2, Issue 4, April 2013 ISSN 2319 – 4847 Volume 2.
[8] Suraj P. Mishra, Kalpana D. Takhur, Vicky N. Gupta (2020) “Partial Replacement Of Fine Aggregate By Glass Powder” ISSN:2278-0181, Volume 9, Issue 02, Feb-2020.

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