International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 06, June-2015

Evaluation of Engineering Cementitious Composites (ECC) With Different Percentage of Fibers

Bhaumik Merchant
U.G. Student, Dept. of Civil Engg.
PanditDeendayal Petroleum University
Gandhinagar, India

Ajay Gelot
U.G. Student, Dept. of Civil Engg,
PanditDeendayal Petroleum University
Gandhinagar, India.

***Abstract*— Concrete is good in compression but if any type of strain applied to it, it starts to fail. Where the steel is good tension. It can bear the deflection up to its elastic limits. This project is based on behavior of engineered cementitious composited (ECC) when it is replaced with the different amount of Polyvinyl Alcohol (PVA) Fibers. As for research, PVA fibers is used with cementitious up to 2% to evaluate the optimum amount of fiber on which we can find the maximum compressive, tensile and flexural strength. PVA is basically an adhesive which is used to formulate glue [1]. Generally due to excessive loading, cracks develops which concludes to successive damage to the structural component. In research plasticizer is used to increase workability. With the help of optimum amount of PVA fibers, it can limit the crack widths up to 60µm to 100µm [2]. Also can be used to reduce resources and funds for rehabilitation of structure. At the starting this fiber concrete can be double the cost as compare to conventional concrete but as it can amplify the duration of structure, it will be less costlier than the conventional concrete.**

Keywords—Engineered Cementitious Composites, Polyvinyl Alcohol fibers, Compressive and Flexural strength, Rehabilitation

I. INTRODUCTION

Development of cracks are unavoidable during the lifespan of concrete. Crack can be occurred due to concrete shrinkage, excessive loading, severe environment, and poor construction procedure or design error. Durability of the concrete is greatly affected by development of cracks, and these cracks create pathway to harmful agents to penetrate into the concrete and this can deteriorate the reinforcement in the concrete. Experimental investigation and practical experience have demonstrated that cracks in cementitious material have the ability to seal themselves, e.g. water flowing through cracked concrete slows over time. In extreme cases, these cracks can be sealed completely [3].

Engineered cementitious composites are designed to produce a strong and flexible material that can be used in numerous applications where fiber reinforced concrete may not be suitable. This is a recent development, and further studies are still in progress. The material ingredients of engineered cementitious composite are similar to that of fiber reinforced concrete, including cement, sand, water, fiber, and

a few chemical additives. Unlike the fiber reinforced concrete, the engineered cementitious composites do not include large volume of fiber. The mixing procedure of ECC is similar to that employed for the normal concrete. The ECC are economical by a reduction in the usage of fiber while maintaining the desired characteristics of strength and ductility. The basic difference in the properties of ECC and fiber reinforced concrete is that after cracking the ECC strain hardens while the fiber reinforced concrete does not exhibit such a behavior. In fiber reinforced concrete, the crack develops with the rupture of the fibers due to which the stress bearing capability is decreased. ECC has higher amount of cement due to the absence of coarse aggregate in the mix proportion than fiber reinforced concrete. ECC can maintain very tight cracks width, shown to be on the order of 60μm to 80μm on average [4]. Interaction between fiber and matrix lead to development of high tensile strength, which can exceed 3%. Coarse aggregate is not used in ECC because it can increase the crack widths which is contradictory to the property of ECC concrete.

II. MATERIALS AND METHODS

This includes materials and specifications the tests performed on ECC as per relevant standards and details of making and testing of ECC. We also have replaced cement with 30% of fly ash. We have taken four different percentage of fibers to evaluate and to optimize the exact range of PVA fibers which is feasible for concrete, economically as well as strength wise. On the basis of literature reviews and trajectories experimental program was derived. It specifies the materials, mix proportions, tests to be performed, period of testing. The materials used for preparing PVA mixed ECC concrete are fly ash, aggregate – maximum size of 10mm, river sand, plasticizer as glenium, PVA fibers with range of 0.5% to 2% and water. Density of the fiber is 1260 kg/m^3. Mixture proportions and properties of concrete used in test are given in Table 1.

From each mixture of 0.5%, 1%, 1.5% and 2% fiber volume fraction, the following specimens are casted: four cubes (150x150x150mm), three cylinders (150mm dia. and 300mm height), and three beams (150x150x700mm). Specimens are tested at 7 and 28 days.

TABLE I
PROPERTY OF FLY ASH

Type	**Class F**
Specific gravity	2.23
SiO_2	51.1%
Al_2O_3	22.9%
FE_2O_3	12.2%
SiO_3	5%

TABLE II
PROPERTY OF FIBER

Type	**PVA**
Density (g/cm^2)	1.26
Length (mm)	12
Modulus of Elasticity	42.8
Reduction in water	<2
Breaking Elongation	<7-15
Nominal strength (MPa)	1620
Apparent Strength (MPa)	1092

TABLE III
SIEVE ANALYSIS FOR FINE AGGREGATES

IS Sieve Designaction	Weight Retained	Cumulative Weight Retained	Cumulative % Retained	Cumulative% Passing	% Passing Limits as per IS 383 Zone-2
10mm	-	-	-	100	100
4.75mm	10	10	2	98	90-100
2.36mm	45	55	11	89	75-100
1.18mm	52	107	21.4	78.6	55-90
600micron	105	212	42.4	57.6	35-59
300micron	185	397	79.4	20.6	8-30
150micron	88	485	97	3	0-10
Pan	15	500			
FM	2.53				

TABLE IV
MIXTURE PROPORTION

Mix Ingredients	**Quantity**
Cement	296.13 kg/ m^3
Water	186 lit/ m^3
Fly Ash	150 kg/ m^3
Sand	572.7 kg/ m^3
Grit (10mm to 4.75mm)	1017 kg/ m^3
w/c	0.43
HRWRA (Glenium)	1.25 lit/m^3

III. RESULTS AND DISCUSSIONS

A. Proportion of Fresh Concrete

As percentage of fiber increase, workability decreases compared to initial amount used. Due to addition of more fibers, entrapped air voids increases and therefore these air voids reduces the workability. It becomes difficult to mix as the amount of fiber increases which also leads to cause a finishing problem.

B. Compressive Strength

Generally, small amount of replacement of any cementitious material will increase the compressive strength of cube. Same as we replace small quantity of fiber as 0.5%, it will enhance the strength. Enhancement of Polyvinyl Alcohol fibers to the mix increased the 28 day's compressive strength of the mix with the amount of 1% by 27% due to limitation provided by fibers. The compressive strength at 1% is higher than 2% replacement. Fiber bonding characteristics of concrete increases.

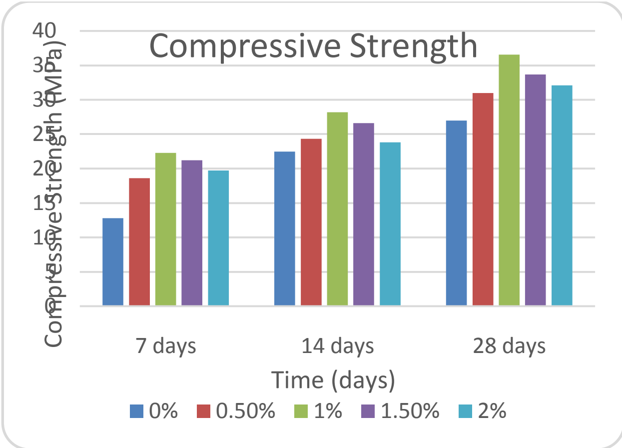

Fig. 1 Compressive Strength at Different Fiber Content

C. Tensile Strength

In split tensile strength, it escalate due to Polyvinyl Alcohol fibers at 28 days is approximately 50% higher than 7 day's strength. It varies from 1.68 MPa to 3.42 MPa for 7 days and 4.38 MPa to 6.98 MPa for 28 days. Tests shows maximum 40% increases in split tensile strength at 28 days. Split tensile test give perfect estimation about direct tensile strength due to mixed stress field and fiber orientation but its failure pattern gives good idea about ductility of the material. Failure patterns of splitting tensile test indicate that specimens after first cracking do not separate unlike the concrete failure. Large damage zone is produced due to closely spaced micro cracks surrounding a splitting plane.

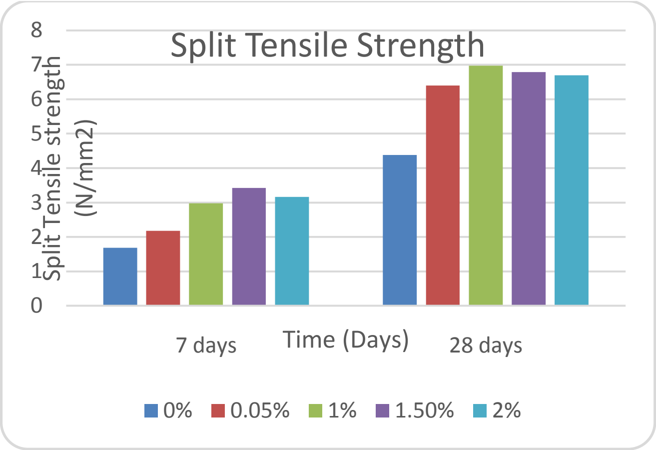

Fig 2. Split Tensile Strength at Different Fiber Content

D.Flexural Strength

Flexural strength also increases as fiber content increases. During the test, it was perceived that PVA-ECC specimen has greater crack control as demonstrated by reduction in crack widths and crack spacing. Nominal increases remains for all amount of fibers compared to normal mixes.

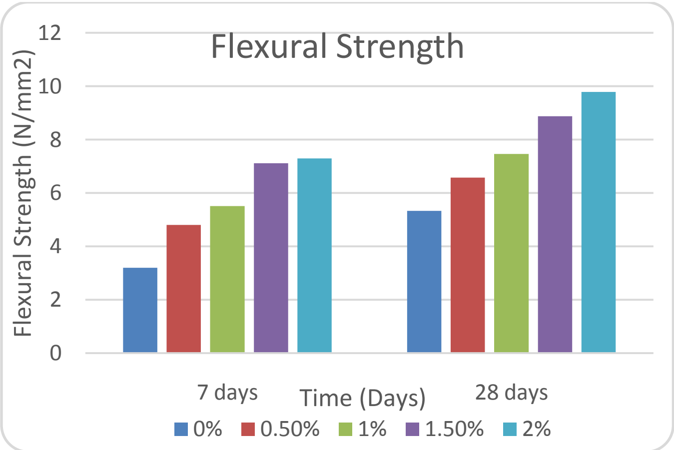

Fig. 3 Flexural Strength at Different Fiber Content

Fig. 4 Comparison of Crack Width with One Rupee Coin

Fig. 5 Fibers Stretched in Split Tensile Test

Fig. 6 Zoomed Photo of Crack Width

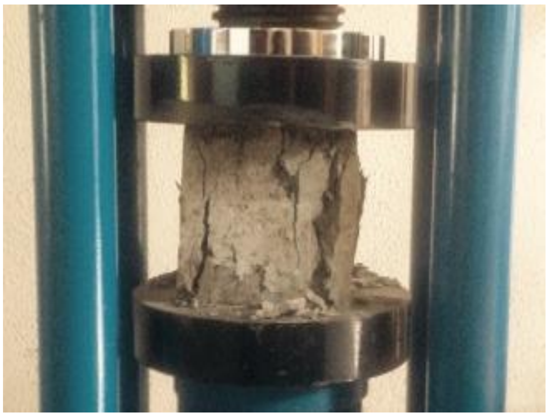

Fig. 7 Behavior of Control Specimen

Fig. 8 Behaviour of Fiber Concrete

IV. CONCLUSIONS

- From this research, there is need of developing a new class of ECC 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 significant properties of ECC-Concrete are ductility, durability, compressive strength, and self-consolidation. Polyvinyl Alcohol fibers dose not disperse properly in the mixing water. Addition of fibers to dry mix was found to be more practical. It is found that presence of fibers can decrease the alertness of the failure, which mainly occurs due to spalling or brittleness of the conventional concrete. Where fiber concrete can be fail due to protruding at the transverse direction.
- Compressive strength increases with increasing fiber content. But when it reaches up to its optimum value, it starts decreasing with the increasing content of fiber.
- In split tensile strength, it escalate due to Polyvinyl Alcohol fibers at 28 days is approximately 50% higher than 7 day's strength.
- Flexural strength also increases as fiber content increases. During the test, it was perceived that PVA-ECC specimen has greater crack control as demonstrated by reduction in crack widths and crack spacing.
- Fibers reduces the w/c ratio which leads to the low workability.
- It is difficult to justify the proper surface but appropriate amount of plasticizers can increase workability so that geographic shapes can be determine easily.
- There is considerable improvement in the post-cracking behavior of concretes containing fibers. Although in the fiber-reinforced concrete the ultimate tensile strengths do not increase appreciably, the tensile strains at rupture do.
- Compared to plain concrete, fiber reinforced concrete is much tougher and more resistant to impact.
- 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.

REFERENCES

[1] Kong, H.J., Bike, S.G., and Li, V.C., 2002, "Con1stitutive rheological control to develop a self-consolidating engineered cementitious composite reinforced with hydrophilic (polyvinyl alcohol) fibers," in press, Cement and Concrete Comp
[2] Dr. A. W. Dhawale, Mrs. V. P. Joshi, "Engineered Cementitious Composites for Structural Applications"
[3] Yingzi Yang, Michael D. Lepech, En-Hua Yang, Victor Li, "autogeneous healing of engineered cementitious composites under wet-dry cycles"
[4] Yingzi Yang, Michael D. Lepech, En-Hua Yang, Victor Li, "Self-healing of engineered cementitious composites under cycle wetting and drying"
[5] Priti A. Patel, Dr. Atul K. Desai and Dr. Jatin A. Desai, "Evaluation of engineering properties for polypropylene fiber reinforced concrete"
[6] Balaguru, P. N., and Shah, S. P., Fiber-Reinforced Cement Composites, Singapore, McGraw-Hill, 1992.
[7] Bentur, A., and Mindess, S., Fiber Reinforced Cementitious Composites, London, Elsevier Applies Science, 1990.
[8] Yang, Y.; Lepech, M.; Victor C. Li. Self -healing of ECC under cyclic wetting and drying. Oct. 2005, pp 231-242
[9] Emily n. Herbert, Victor C. Li. Self-healing of Engineered cementitious composites in the natural environment. RILEM State of the art reports volume 2, 2012, pp 155-162
[10] Gregor Fischer, Victor C. Li. Deformation Behaviour of Fiber Reinforced Polymer reinforced engineered cementitious composite (ECC) flexural Members under Reversed Cyclic loading conditions. ACI Structural Journal, 2003; 100: pp 25-35.
[11] Xiuping Feng, Boyd Clark; Evaluation of the physical and chemical properties of fly ash products for use in portland cement concrete. 2011 World of Coal Ash (WOCA) conference, May 2011, Denver, USA
[12] Keith E. Kesner, Sarah L. Billington, Kyle S. Douglas. Cyclic response of Highly Ductile Fibre-Reinforced Cement-Based Composites. ACI Materials Journal, 2003, 100: pp 381-390.
[13] IS 5816:1999, Splitting Tensile Strength Of Concrete
[14] IS 516:1959 (Eighteenth reprint JUNE 2006) Method Of Tests For Strength Of Concrete
[15] IS 4031 (Part 11):1988; Methods Of Physical Tests For Hydraulic Cement