Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 5, Issue 7; July-September, 2018, pp. 514-517

http://www.krishisanskriti.org/Publication.html

Experimental Study of Micromechanics ECC Concrete

[1]Mohammad Saif Asad, [2]Niraj Maurya, [3]Nikhil Srivastava, [4]Ankit Kumar and [5]Ankur Kumar

[1,2,3,4]Undergraduate, Buddha Institute Of Technology
[5]Assistant Professor, Buddha Institute Of Technology
E-mail: [1]15ce120@bit.ac.in, [2]ernirajmaurya@gmail.com, [3]nikchhamp001@gmail.com, [4]15ce014@bit.ac.in, [5]ankur495@bit.ac.in

Abstract–*Micromechanic ECC concrete mix design based on Micromechanic design. Micromechanic is generally the analysis of composite or heterogeneous materials on the stage of the single constituent that form the ECC(Engineered Cementitious Composites).ECC does not use coarse aggregate as it effects the ductility of the mix while in normal concrete it is an important component. Their behavior towards strain is also different. This strain hardening behavior of ECC is same to the ductile metal or material as compare to the normal concrete behaves like brittle material. It is also known as Bendable Concrete or Flexible concrete abbreviated as ECC of ultra-ductile fibers reinforced cementations composites, characterized by high ductility and tight crack width control. The aim of this study is increase the strain capacity of more than 3-7% and thus acts more like a ductile metal rather than like brittle glass. The result is to make 37% less expansive, 40% consume less energy and produce 39% less carbon dioxide than regular concrete. It reduced the quantity of water 0.56 and the low volume fraction of fibers (< 2%) resultant extensive strain hardening.*

1. INTRODUCTION

Concrete is widely used in today's construction industry. It has good load bearing capacity. It can take the compressive load very effectively. But the main problem with the traditional concrete is that it cannot take much tensile stresses. It fails under the tensile load. The flexible or Micromechanic ECC concrete is a good substitute for this problem. Conventional concretes are almost unbendable and have a strain capacity of only 0.1% making them highly brittle and rigid. This lack of bend ability is a major cause of failure under strain and has been a pushing factor in the development of an elegant material namely, bendable concrete also known as Engineered Cementations Composites abbreviated as ECC. This material is capable to exhibit considerably enhanced flexibility. A bendable concrete is reinforced with micromechanically designed polymer fibres.

ECC is made from the same basic ingredients as conventional concrete but with the addition of High-Range Water Reducing (HRWR) agent is required to impart good workability. However, coarse aggregates are not used in ECCs (hence it is a mortar rather than concrete). The powder content of ECC is relatively high. Cementations materials, such as fly ash, silica fume, blast furnace slag, silica fume, etc., may be used in addition to cement to increase the paste content. Additionally, ECC uses low amounts, typically 2% by volume, of short, discontinuous fibres. ECC incorporates super fine silica sand and tiny Polyvinyl Alcohol-fibres covered with a very thin (nanometer thick), slick coating. Four-point bending tests was used to pre crack ECC beams at different age, followed by different curing conditions, including air curing, 3% CO2 concentration curing, cyclic wet/dry (dry under 3% CO2 concentration) curing and water curing.

OBJECTIVES

- To check the behaviour of Micromechanic ECC-bendable concrete under compression, Split Tensile Test & Flexure Test.
- •To determine the deflection of ECC beams.
- •To increase the straining capacity.

2. INGREDIENTS OF ECC CONCRETE:

Engineered cementations composite is composed of cement, sand, fly ash, water, small amount of admixtures and an optimal amount of fibers. In the mix coarse aggregates are deliberately not used because property of ECC Concrete is formation of micro cracks with large deflection. Coarse aggregates increases crack width which is contradictory to the property of ECC Concrete.

2.1 CEMENT

Micromechanic ECC can be produced using Ordinary Portland Cement. Compared with conventional concrete, ECC contains considerably higher cement content that is typically two to three times higher than normal concrete. Cement is the major component which binds all the ingredients and contributes to the strength.

2.2 SAND [FINEAGGREGATE]

Fine aggregate / natural sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. The most useful commercially are silica sands, often above 98% pure. Sand is used for making mortar and concrete and for polishing and sandblasting. Sands containing a little clay are used for making molds in foundries. The sand passed through of 4.75 mm sieve isused which was available locally.The specific gravity of sand is 2.60 and water absorption rate of 1.23%.

2.3 FLY ASH

Fly ash used was pozzocrete dirk 60.And specifications provided in Table 1.below. In RCC construction use of fly ash has been successful in reducing heat generation without loss of strength, increasing ultimate strength beyond 180 days, and providing additional fines for compaction. Replacement levels of primary class fly ash have ranged from 30-75% by solid volume of cementations material. Class F fly ash is utilized so the acquisition cost is reduced. Only transportation cost is estimated. The properties of Fly ash are shown in Table1.

Two different types of fly ash are used for preparation of different ECC mixes, they are known as CLASS F and CLASS C, both containing $SiO_{2,}$ Al_2O_3, Fe_2O_3.

Table 1: Properties of Fly Ash.

S. No.	Characteristics	Proportion
1.	ROS45micronsieve(max)	18
2.	Lossonignition	2.5
3.	Water requirement	95%
4.	Moisture content(max)	0.5
5.	Lime reactivity(min)	5
6.	SiO2+Al2O3+Fe2O3	90min
7.	SiO2	50min
8.	CaO	5max
9.	MgO	4max
10.	SO3	2max
11.	Na2O	1.5max

2.4 PVA FIBER (POLYVINYL ALCOHOL)

PVA Fibers (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, 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.

These are monofilament fibers that are available in 3 different deniers (diameter of the fiber)- 7, 15, and 100. The fiber lengths are 1/4” (PVA7), 5/16” (PVA15), and 1/2” (PVA100). Due to the fine nature of these fibers, and the fact that they disperse into monofilament fibers, they are less likely to be visible in finished surface. How visible they are in relation to each other is in direct proportion to their various diameters (7 is least visible, 100 is most visible). Equally true, the small the fiber, the more fibers there are for any given unit of measure, the more likely they are to choke mixes at higher dosage rates. This is why the PVA100 are dosed at higher rates in the more flowable mixes than are the PVA15.

Fig. 1: PVA Fiber (Polyvinyl Alcohol)

2.5 WATER

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened.

3. ECCMIXDESIGN

Micromechanics are a branch of mechanics applied at the material constituent level that captures the mechanical interactions among the fiber, mortar matrix, and fiber–matrix interface. Typically, fibers are of the order of millimeters in length and tens of microns in diameter, and they may have a surface coating on the nanometer scale. Matrix heterogeneities in ECC, including defects, sand particles, cement grains, and mineral admixture particles, have size ranges from nano to millimeter scale.

The mix design for ECC concrete is based on Micromechanics design basis. It captures the mechanical interactions among the fiber.

Micromechanic is the analysis of composite or heterogeneous material on the level of the individual constitutions that form these materials.

3.1 PROPORTION OF ECC CONCRETE

S.NO.	Mix Designation	M45
1.	Cement	1.0
2.	Fly Ash	1.2
3.	Sand	0.8
4.	Water	0.56
5.	PVA Fiber (Vol %)	0.02

3.2 CASTING AND CURING

Finally we have to choose the mix proportion was 1:0.5:2, AR Glass fiber 1%, 1.5%, 2% and PVA fibers and water to cementations material ratio was 0.40. The casting was done according to IS: 516 for mixing, mixed material was taken and filled into cubes, beams and cylinders for different testing. Specimens were taken out after 24 hours and put for curing for durations of 7,14, 28days.

3.3 SPECIMEN PREPARATION

Add sand, cement, 50% of fly ash & 50% water & super plasticizer PVA Fibers. Add slowly remaining quantity of fly ash, water & super plasticizer. Once the homogenous mixture is formed, add the AR glass fibers slowly. Mix all the constituents till the fibers are homogenously mixed in the matrix. Additionally, slight adjustment in the amount of HRWR is performed to achieve consistent rheological properties for better fiber distribution and workability. The mixtures are then cast into molds and demoded after 24 hr. After being demoded, ECC specimens are cured in curing room where the temperature is 25°C for 7 and 28 days respectively.

Fig. 2: ECC SPECIMEN

4. RESULT AND DISCUSSION

4.1 SLUMPTEST

Slump test is used to determine the workability of fresh concrete. Due to a huge slump may obtain if there is any disturbance in the process. It also mentioned that a slump more than 225mm will indicate a very runny concrete. The apparatus & equipment used for the slump test & the procedure of the test according to IS7320-1974.

4.2 COMPRESSION TEST RESULT

According to IS: 509-1959, the testing for the specimens should be carried out as soon as possible after taking out from the curing rank. The specimen needs to get measurement before testing. The length and height of specimen is measured and recorded. The axis of specimen is aligned with the centre of thrust of the seated plate. Plate is lowered until the uniform bearing is obtained. The force is applied and increased continuously at a rate equivalent to 20MPa compressive stresses per minute until the specimen failed. Record them maximum force from the testing machine. The observation from our results shows that the increase in compressive strengthisupto28% increase of adding 1%, 1.5% and2% fiber content in comparison of conventional concrete. It shows that variation in compressive strength by adding fiber.

The compressive strength of ECC mortar was compound as an average value of three cylinder specimens. The compressive test were performed at 7 days and 28 days under moist curing. After 24 hours of casting, all the specimens were demoulded and moisture cured in plastic bag with a controlled temperature of 25^0C.

Fig. 3: Test on Cube

4.3 SPLIT TENSILE RESULT

Normally concrete is very strong in compression but weak in tension. Indirect tensile test is used to indicate the brittle nature of specimens. Concrete is not elastic material. The stress strain behavior of concrete is straight line upto10-15% if it's ultimate strength. Split tensile test was performed on cylinder of size on universal testing machine according to IS: 5816-1999. The failure load to each cylinder was noted for finding split tensile strength.

Fig. 4: Split tensile test

4.4 FLEXURAL TEST

The beam mould of size 100 X 15 X 10 cm (when size of aggregate is less than 40mm). The specimen shall be supported on 38mm diameter roller with 1000mm span for 150mm size specimen. The load shall be applied through two similar rollers mounted at the two points of the supporting span that is spaced at 40mm. The load is applied without shock at a rate of 4KN/minute for 150mm specimen. The load shall be increased until the specimen fails and the maximum load applied to the specimen during the test. The flexural test was performed on beams on universal testing machine according to IS: 516-1959. The failure load to each beam was noted for finding flexural strength. Table 2 shows the results on flexural testing.

Flexural strength of beam can be calculated by following formula,

$$f_b = PL / bd^2$$

Where,

P = Maximum load in kN applied to the specimen

L = length of the specimen in mm

d = depth measured in cm of the specimen at the point of failure

b = measured width of the specimen in mm

Fig. 5: Flexural strength

5. CONCLUSION

According to test results, the beam is with standing 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. Although the cost procured for the designing of ECC is normally higher than that of the normal concrete but it has numerous potential application.

The percentage increase of compressive strength of various grades of AR glass fibre concrete mixes compared with 28 days compressive strength is observed 37%.

The percentage increase of flexure strength of various grades of AR glass fibre concrete mixes compared with 28 days compressive strength is observed 5.19%.

In failure pattern it is observed that the CC fails into two parts where as in ECC only crack is developed which reflects its ductile behavior.

The result is a moderately low fiber volume fraction (<2%).

REFERENCES

[1] Alberti M G, Enfedaque A, Galvez J C, Canovas M F and Osorio I R (2014), "Polyolefin fibre reinforced concrete enhanced with steelhooked fibres in lowproportions", Journalof Materialsand Design, Vol. 60, pp. 57–65.

[2] SHACKLOCK BW., "Concrete constituents and Mix proportions": by Cement and concrete Association UK 1974.

[3] Soutsos M T, Le T T and Lampropoulos A P (2012), "Flexural performance of fibre reinforced concrete made with steel and synthetic fibres", Journal of Construction and Building Materials, Vol.36,pp.704-710.

[4] M.S.SHETTY., "Concrete Technology": Theory and Practice for concrete S.CHAND& COMPANY LTD., First Edition1982.