Experimental Investigation on Bendable Concrete Using Natural and Artificial Fibres (Jute and Nylon)

Brinila Bright B N[1],Beer Mohamed Sareef S H[2], Basith P A[3],Harish Priyadharshan T[4]

[1]*Assistant Professor, Department of Civil Engineering, Sethu Institute of Technology, Viruthunagar-626115, Tamil Nadu, India.*
[2], [3], [4] *Final Year Students, Department of Civil Engineering, Sethu Institute of Technology, Viruthunagar-626115, Tamil Nadu, India.*

---***---

ABSTRACT-*Engineering cementitious composite (ECC), also called strain hardening cement-based composites (SHCC) or more popularly as bendable concrete. It is special type of concrete that can take the bending stresses. It consists of special type of materials that makes it flexible. Normal concrete is brittle in nature while ECC is ductile in nature due to this property. It has wide applications and wide future scope in various fields. Fly ash is also known as pulverized fuel ash. It is a fine powder which is a byproduct from burning pulverized coal in electric generation power plants. Ductile property of normal concrete can be improved by using natural and artificial fibers like jute fiber and nylon fiber in place of coarse aggregate and cement partially replaced by fly ash. Two fiber volume fractions 0%,0.5%,1% and 1.5% were considered. For these purpose concrete cubes, cylinders, and prisms are experimentally investigated.*

Key words: Nylon and jute fibers, Fly ash, Super plasticizer, ECC concrete.

1. INTRODUCTION

The flexible concrete is three times more expensive than the ordinary concrete. unlike regular concrete, ECC has a strain capacity in the range of 3-7% compared to 0.01% for ordinary Portland cement (opc) paste, mortar or concrete. Therefore the ECC acts more like a ductile material. Now we are improving the ductile property of normal concrete by using natural and artificial fibres like jute fibre and nylon fibre in place of coarse aggregate and cement partially replaced by fly ash. Experimental Study on Bendable Concrete by Using Admixture and Fibre, this paper 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 with strain capacity of about 3 to 5% compared to 0.01% of normal concrete. The result is a moderately low fiber volume fraction (<2%) composite which shows extensive strain-hardening. Ductile property of normal concrete can be improved by using PVA fibers in place of coarse aggregate and cement partially replaced by fly ash. For these purpose concrete cubes, cylinders, beams and slabs are experimentally investigated. This paper also focuses on significant pattern of cracks developed during testing of specimens [1]. ECC has fiber, mineral admixture and chemical admixtures along with the basic constituents (i.e,) cement, fine aggregate and water. No coarse aggregate is used in ECC, to avoid brittle failure. PVA fibers are known for their low modulus of elasticity, ductility, tensile strength and bonding strength, whereas, Steel fiber increases the flexural, impact and fatigue strength of composite. Hence a combination of these two fibers is used in this work. Fly ash is a material that was proved to be a good replacement for cement, from the previous studies. It occupies the void space in the matrix which would otherwise be occupied by water. GGBS consists of silicates and aluminates of calcium and it can be used as a good substitute material for cement. These two mineral admixtures (Fly ash, GGBS) are used for the experimental studies. In this research, series of investigations were carried out to employ hybrid ductile fibers (PVA and steel fibers) in ECC with high volume of mineral admixture (fly ash) which replaces cement. The amount of mineral admixtures is again replaced by 10%, 20%, 30% and 40% of GGBS and the performance of the resulting composite is studied [2]. And another research study is to investigate the hardened property (i.e. Flexural Test) of ECC by addition of AR Glass fibers in different proportion. The result is a moderately low fiber volume fraction (<2%) composite which shows extensive strain-hardening [3]. Traditional concrete is considered as brittle and rigid, also conventional concrete is not highly durable. The lack of durability of concrete is on account of the presence of calcium hydroxide and the transition zone, which represents the interfacial region between the particles of coarse aggregate and the hardened cement paste. Coir bars are used in concrete members to keep cracks as small as possible. But they are not small enough to heal, so water and deicing salts can penetrate to the coir, causing corrosion that further weakens the structure by affecting the durability. This result is development of engineered cementitious composites. The purpose of this project is to study the Durability properties of Engineered Cementitious Composites. To verify that, in this project Coir fiber and polyvinyl alcohol fiber with various proportions of mineral admixtures such as rice husk ash and silica fume has been used in ECC to study its structural performance and durable properties [4]. In ECC coarse aggregates are not used as they tend to adversely affect the unique ductile behavior of the composite. Polypropylene fibers have advantageous characteristics, the weak bond with the cement matrix as a result of their smooth surface and chemical inertness remains a large limitation. It has been demonstrated that the fiber-matrix bond strongly affects the ability of fibers to stabilize crack propagation in the matrix. As the bond between fiber and matrix is mainly mechanical, it seems that incorporating silica fume into fiber reinforced cement composites provides a better bond with the matrix through pore refinement and better distribution of the hydration products. Hence, in this project an effort was made to study the effect of PP fibers on the mechanical properties of mortars incorporating silica fume. Six fiber volume fractions 0%, 0.1%, 0.2%, 0.3%, 0.4% and 0.5% were considered. The experimental study is to present the behaviour of prism with optimum percent of fibers under two point loading [5]. Therefore the nylon, jute fibers and fly ash is used for the purpose of ductility and property enhancement.

2. MATERIALS USED

2.1 Jute (Natural fiber): Jute is a kind of fibre obtained from plants known as white corchorus capsularis. The manufacturing process of jute fiber involves hand harvesting of the source plant, drying in the field for defoliation, retting for periods up to a month, stripping and sun drying in the field for defoliation, retting for periods up to a month, stripping and sun drying. The Length of jute fibre used in this project is 12mm.

Fig-1: jute Fiber

2.2 Nylon (Artificial fiber): Nylon is generic name that identifies a family of polymers. Nylon fibres are impacted by the base polymer type, addition of different levels of additive, manufacturing condition and fibre dimensions. Nylon is particularly effective imparting impact resistance and flexural toughness and sustaining and increasing the load carrying capacity of concrete .The length of nylon fiber used in this project is 12mm.

Fig-2: Nylon Fiber

2.3 Fly ash: In RCC construction use of fly ash has been successful in reducing heat generation without loss of strength; increasing ultimate strength beyond 180days.The huge amount of fly ash is produce in the thermal power station. Class F fly ash is utilized so the acquisition cost is reduced. Only transportation cost is estimated.

2.4 Cement: In manufacturing of paver blocks, OPC – 43 was used .The word "cement" can be traced back to the Roman term opus cementicium, used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder.

2.5 Fine Aggregate: Fine aggregate is basically sand obtained from the land or the marine environment. fine aggregate generally consist of natural sand or crushed stone as per IS383-1970 fine aggregate are aggregate which passes through 4.75mm IS sieve. And coarse aggregate are aggregates most of which are retained in 4.75mm IS sieve. The fine aggregates confirm to zone II.

2.6 Water: Water that is clean and free from injurious amounts of oils, acids, alkalis, salt, sugar, organic material or other substance that may be deleterious to concrete is used.

2.7 Super plasticizer: Super plasticizer used is modified sulphonated naphthalene formaldehyde. This is used to control rheological properties of fresh concrete. Typically super plasticizers increase slump from say 5cm to about 18-20cm without addition of water. When used to achieve reduction in mixing water they can reduce water up to 15-20% and hence decrease W/C ratio by same amount.

Table-1: Physical properties of jute fiber

S. No	Property	Jute
1	Specific gravity	1.50
2	Water Absorption	13.5%

Table-2: Physical properties of nylon fiber

S. No	Property	Jute
1	Specific gravity	1.14
2	water absorption	3.5%

Table-3: Physical properties of fine aggregates

S. No	Property	Fine Aggregate
1	Specific gravity	2.78
2	fineness modulus	3.50
3	bulk density	1686kg/m^3
4	water absorption	2.83%

3. ECC-MIX DESIGN

3.1 Concrete mix design

The mix design of grade M30 was used. The mix design for ECC Concrete is basically based on Micromechanics design basis. 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 millimetre scale. Hence the ideal mix proportion given in the literature of ECC-ECC Concrete was used as the guidelines to determine the proportion of various constituents in the concrete. The volume fraction of using jute and nylon fiber was varied as 0%, 0.5%, 1.0%, 1.5%, added in total volume of concrete mix. The ideal Mix proportion which was taken as reference is given below:

Table- 4: Mix- proportions

Mix Designa -tion	Cement (Kg/m^3)	Fly Ash (Kg/m^3)	Fine Aggregate (Kg/m^3)	W/C Ratio
M30	320	96	2226	0.45

3.2 Placing, compaction and casting of concrete Specimens

Once the mix design was finalized, the mixing was carried out. The mixing of bendable concrete was carried out by using hand mixing. Add sand, cement, 50% of fly ash & 50% water and super plasticizer. Add slowly remaining quantity of fly Ash, water and super plasticizer. Once the homogenous mixture is formed, add the fibers (jute and nylon) slowly. Mix all the constituents till the fibers are homogenously mixed in the matrix. During the placing of fresh concrete into the moulds, tamping was done using Tamping rod. After placing the concrete into the moulds, vibrations were done using a table vibrator. After vibration operation, the leveling of concrete was done on the surface of the concrete. Leveling is the initial operation carried out after the concrete has been placed and compacted.About samples were prepared as shown in Fig.1 in order to determine various properties such as , compressive strength, split tensile strength, flexural strength.

Fig - 3. Concrete specimens

3.3 Curing of concrete specimens

After leaving the fresh concrete in the moulds to set overnight, the concrete specimens in the moulds were stripping. The identification of concrete specimens was done. After 24 hours, all the concrete specimens were placed into the curing tank with a controlled temperature of 25 0C in further for 28 days for the hardened properties test of concrete. Curing is an important process to prevent the concrete specimens from losing of moisture while it is gaining its required strength. Lack of curing will lead to improper gain in the strength. After 28 days of curing, the concrete specimens were removed from the curing tank to conduct hardened properties test of ECC Concrete.

4. TESTING OF CONCRETE

4.1 Testing on hardened concrete

This deals with Tests and testing procedure for hardened concrete specimen. Investigations are carried out by testing cubes, beams and cylinders for 7, 28 days. Cubes and cylinders were tested on Compression Testing Machine (CTM) and beams were tested on Universal Testing Machine (UTM).

4.1.1 Compressive strength test (test on cubes)

The 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. Align carefully and load is applied, till the specimen breaks. The formula used for calculation: Compressive Strength = Total Failure Load/Area of the Cube

Fig- 4: compressive strength test

4.1.2Split tensile strength test (test on cylinders)

Split tensile strength test is an indirect test to determine the tensile strength of cylindrical specimens. Splitting tensile strength tests were carried out on cylindrical specimens of size 150 mm diameter and 300 mm length at the age of 7, 28 days curing. The load was applied gradually till the specimens split and readings were noted. The procedure for test, apparatus required and loading condition was followed as per IS 516: 1959. The formula used for calculation:

Split tensile Strength =2P/π*D*L

Fig- 5: Split tensile strength test

4.1.3 Flexural strength test (test on beams)

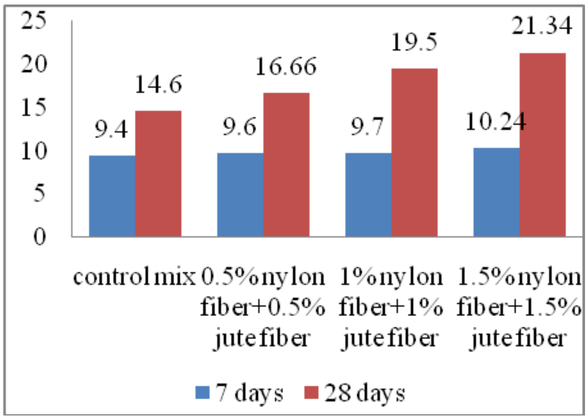
The test is carried out to find the flexural strength of the prism of dimension 100 x 100 x 500 mm. The prism is then placed in the machine in such manner that the load is applied to the uppermost surface as cast in the mould. Point loading adopted on an effective span of 400 mm while testing the prism. The load is applied until the failure of the prism. By using the failure load of prism Flexural Strength = Pl/bd^2.Where P – Failure load of the prism, l – Length of the prism, b – Breadth of the prism, d – Depth of the prism.

Fig- 6: Flexural strength test

5. RESULT AND DISCUSSION

5.1 Compressive strength

The tests were conducted on the cube specimens after 7 and 28 days curing. Figure 7 shows the comparison of average compressive strength of various % fiber mixes.

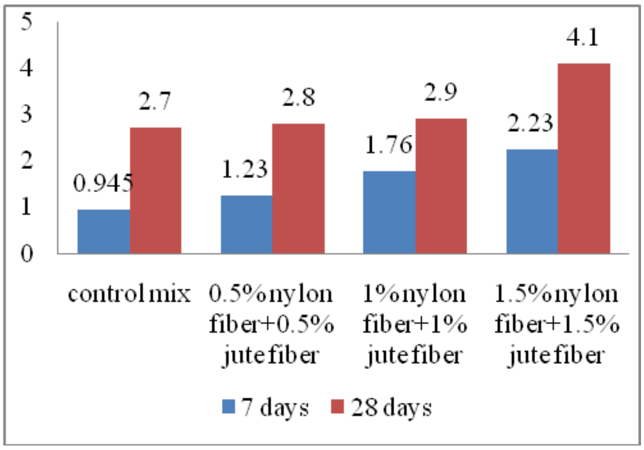


X axis- Addition of materials
Y axis-Compressive strength (N/mm^2)

Chart-1: Comparison of compressive strength (7 and 28 days)

5.2 Split tensile strength

The tests were conducted for the cylinder specimens after 7 and 28 days curing. Figure 8 shows the comparison of average split tensile strength of various % fiber mixes. Both 7 days and 28 days test results explains that the variation increased in steady state manner.

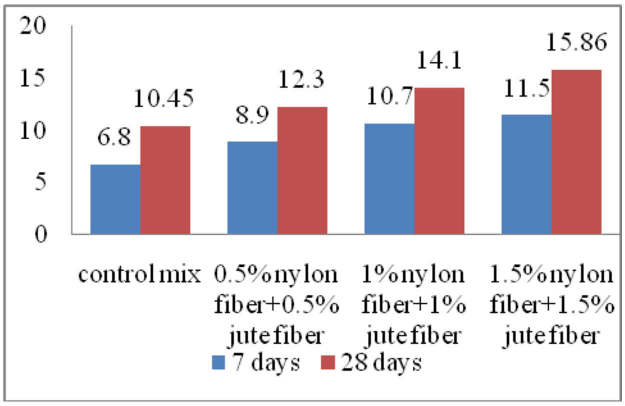


X axis- Addition of materials
Y axis-Split tensile strength (N/mm^2)

Chart-2: Comparison of Split tensile strength (7 and 28 days)

5.3 Flexural strength

The flexural strength test was conducted on the prism specimens after 7 and 28 days curing. Figure 9 shows the comparison of average flexural strength of various % fiber mixes and Figure 10 shows the graph between load and deflection 7 and 28 days.



X axis- Addition of materials
Y axis-Flexural strength (N/mm^2)

Chart-3: Comparison of flexural strength (7 and 28 days)

6. CONCLUSIONS

Based on the experimental investigations carried out the following conclusions are arrived at:

- 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 have numerous potential applications.
- In this paper the compression and flexural strength of bendable concrete is done the values are compared with conventional cubes and prism.

Therefore it is proved that the bendable concrete is more strength than the conventional concrete and it is more flexible so that is resist cracks and acts as more efficiency in seismic regions.

- It was found that addition of nylon (1.5%) and jute fibers (1.5%) has improved the flexural behavior of ECC specimens.

- The cost of ECC is currently about three times that of normal concrete per cubic yard compared to plain concrete, fiber reinforced concrete is much tougher and more resistant to impact.

- On comparing the 7 days and 28 days test, better results was obtained in the 28 days strength.

REFERENCES

[1].Ganesh S. Ghodke, Nilesh S Daphal, Yogesh S.Bandgar, Dattatray S.Gadekar. “Bendable Concrete by Using Admixture and Fiber” International Journal for Technological Research in engineering (May-2017).

[2].Sharmila.s “Behavior of Hybrid Fiber Engineered Cementitious Composites”. International Journal of science, Environment and technology (Vol. 5, No 5, 2016, 3539 – 3545).

[3].Satheesh V S, Yuvaraja N,Vinoth V, Balaji P, Abhinav Gurung.“Flexural behavior of bendable concrete”.International journal of scientific engineering and applied science (may-2017).

[4].R.Sathishkumar , S.Ranjith “Effect Of Coir Fiber And Polyvinyl Alcohol Fiber On Durability Properties of Engineered Cementitious Composites ”. International Research Journal of Engineering And Technology (IRJET) Volume: 04 Issue: 04 Apr -2017.

[5].Ms.E.Ramya,Ms.S.Nalini,Mrs.S.Sivaranjini,Mr.R.M.Saravanakumar “Experimental Investigation Of Polypropylene Fiber In Engineered Cementitious Composites.” International Journal of Civil and Structural Engineering Research .Vol. 2, Issue 2, pp: (40-46), Month: October 2014 - March 2015