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To Analyse The Behaviour of Concrete using Innovative Material: An Experimental Study

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Abstract

Concrete is most widely used construction material in the world. It is fundamentally a mixture of aggregate and cements paste. This traditional concrete may be strong initially, but it tends to crack easily under the action of varying mechanical and environmental loads. Structures which are using this kind of concrete cannot resist the earth quake load without major damage or collapse. For this reason it is necessary to find out best an option which possesses higher compressive strength as well as good in tensile strength. In seismic region higher ductility in concrete can make a significant difference in the seismic response of the structure. This paper will perform experiments to test tensile strength as well as compressive resistance of the innovative material to be used in place of concrete. It will also explode the benefits of application to society and economic advantages while also taking into account environmental impact and cost by using such an innovative material.
Keyword- Ductility, Seismic behaviour, Innovative Material, Tensile Strength

I. INTRODUCTION

Concrete is a mixture of cement (usually Portland cement) and stone aggregate .When mixed with a small amount of water, the cement hydrates lock the aggregate into its rigid structure. Typical concrete mixes have high resistances to compressive stresses however, any appreciable tension (e.g. due to bending) will break the microscopic rigid lattice resulting in cracking and separation of the concrete. For this reason, typical non reinforced concrete must be well supported to prevent development of tension. Concrete possesses very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to the propagation of such micro cracks eventually leading to brittle fracture of the concrete. Nowadays, fibers are used as a reinforcing material in place of steel in concrete. These fibers could prevent cracking and substantially improve the tensile strength, impact strength wear and tear, fatigue resistance and ductility of concrete. Since concrete is weak in tension hence measures must be adopted to overcome this deficiency. Hence fibers of different material can be utilized in the making of concrete which provide adequate tensile strength.

A. *Aim of the Study*

To Analyze The Behavior Of Concrete Using Innovative Materials: An Experimental Study.

B. *Objective of Study*

The objectives of our project are as follows:
- To provide an economical construction material.
- Addition of fibers in concrete to increase tensile strength.
- To check the ductile behavior of the concrete.
- To check the behavior of ECC-bendable concrete under Compression Split Tensile Test & Flexure.
- To investigate the effect of sand, super plasticizer & Polypropylene fibers on the behavior of ECC Bendable concrete.

II. INTRODUCTION

Engineered Cementitious Composite (ECC, also known as “ECC Concrete”), developed in the last decade, may contribute to safer, more durable, and sustainable concrete infra-structure that is cost-effective and constructed with conventional construction equipment. With two percent by volume of short fibers, ECC has been prepared in ready-mix plants and transported to construction sites using conventional ready-mix trucks. The mix can be placed with-out the need for vibration due to its self-consolidating characteristics. The moderately low fiber content has also made shotcreting ECC viable. Furthermore, the most expensive component of the composite, fibers, is minimized resulting in ECC that is more acceptable to the highly cost sensitive construction industry.

ECC is ductile in nature. Under flexure, normal concrete fractures in a brittle manner. In contrast, very high curvature can be achieved for ECC at increasingly higher loads, much like a ductile metal plate yielding. Extensive inelastic deformation in ECC is achieved via multiple micro human hair. This inelastic deformation, although different from dislocation movement, is analogous to plastic yielding in ductile metals such that the material undergoes distributed damage throughout the yield zone. The tensile strain capacity of ECC can reach 3-5%, compared to 0.01% for normal concrete. Structural designers have found the damage tolerance and inherent tight crack width control of ECC attractive in recent full-scale structural applications. The compressive strength of ECC is similar to that of normal to high strength concrete The aim of research work is to study ductile behavior of concrete, crack resistance capacity & concrete should give warning before its failure. Normal concrete is brittle in nature while ECC is ductile in nature, due to this property; it has wide applications & wide future scope in various fields.

A. Effect of Fibres in Concrete

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of concrete. Some types of fibers do not increase the flexural strength of concrete, so it can't replace moment resisting or structural steel reinforcement. Some fibers also reduce the strength of concrete.

B. Advantages of ECC

Inherently good corrosion more flexible than traditional concrete, ECC acts more like metal than glass. Traditional concrete is considered a ceramic, brittle and rigid. It can suffer catastrophic failure when strained in an earthquake or by routine overuse. It is studded with specially-coated reinforcing fibers that hold it together. ECC remains intact and safe to use at tensile strains up to 5%. Traditional concrete fractures and can't carry a load at 0.01 % tensile strain. Today, builders reinforce concrete structures with steel bars to keep cracks as small as possible. But they're not small enough to heal, so water and deicing salts can penetrate to the steel, causing corrosion that further weakens the structure. Li's self-healing concrete needs no steel reinforcement to keep crack width tight, so it eliminates corrosion.

- Resistance.
- Reduced life cycle costs (for reinforced concrete).
- Can withstand shipping, handling and fabrication.
- Effectively use as Structural Elements
- Durable effect against various Environment Conditions
- Durability against Transportation

C. ECC Mix Design: Methodology

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 millimeter scale. However the micromechanics based mix design requires pull test to be carried on the PVA fibers, which is not possible in the laboratory. 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 ideal Mix proportion which was taken as reference is given below:

Fig. 1 & 2: ECC Mix Design: Methodology

D. Proportioning Of Concrete

Mix proportion was 1:1:1 and PVA fiber 1.2%, super plasticizer dosage was reduced to 600ml/bag and water to cementitious material ratio was 0.33. To achieve workability various trials were taken. However in order to increase the workability of concrete the water to cementitious ratio was increased to 0.45.

E. Casting Procedure of ECC- Concrete

The performance of the ECC Concrete was influenced by the mixing. This means that a proper & good practice of mixing can lead to better performance & quality of the ECC Concrete. The quality of the concrete is also influenced by the homogeneity of the mix material Flexural Test on Slab during the mixing & after the placement of fresh concrete. A proper mix of concrete is encouraged to the strength of concrete & better bonding of cement with the PVA fibers. Once the concrete mix design was finalized, the mixing was carried out. The mixing of ECC Concrete was carried out by using hand mixing. The procedure of hand mixing was as follows:- Add sand, cement, 50% of fly ash & 50% water &super plasticizer. Add slowly remaining quantity of fly ash, water &super plasticizer. Once the homogenous mixture is formed, add the PVA fibers slowly. Mix all the constituents till the fibers are homogenously mixed in the matrix.

F. Placing, Compaction & Casting of Concrete Specimens

Before placing of concrete, the concrete mould must be oiled for the ease of concrete specimens stripping. The oil used is a mixture of diesel & kerosene. Special care was taken during the oiling of the moulds, so that there are no concrete stains left on the moulds. Once the workability test of ECC Concrete was done, the fresh concrete must be placed into the concrete moulds for hardened properties tests. During the placing of fresh concrete into the moulds, tamping was done using Tamping rod in order to reduce the honeycombing. After placing the concrete into the moulds, vibrations were done using a table vibrator. The vibration of concrete allows full compaction of the fresh concrete to release any entrained air voids contained in the concrete. If the concrete were not compacted to a proper manner, the maximum strength of the concrete cannot be achieved. 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 & compacted. After the leveling of the fresh concrete was done, the concrete in the mould was left overnight to allow the fresh concrete to set.

G. Curing of Concrete Specimen

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. Some of the cubes were cured in the Accelerated Curing Tank due to time limit. 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.

H. Testing Of Concrete

This deals with Tests and testing procedure for fresh & hardened concrete specimen. Investigations are carried out by testing beams 28 days. Beams were tested on Universal Testing Machine.


Fig. 3 & 4: Testing Of Concrete

I. Flexure Test- [Test on Beams]

Concrete is quite strong in compression and weak in tension. Hence in most of the design of concrete structures its tensile strength is ignored. However at certain situations like water retaining and pre stressed concrete structures the tensile strength of concrete is essential requirement. A direct application of pure tensile stress is difficult. An indirect way is adopted by measuring the flexure strength of beam. Three specimens shall be tested each at the end of 28 days. The dimension of each specimen should be noted before the testing. The specimen shall then be placed in a machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould. The load shall be increased until the specimen fails and the maximum load applied to the specimen during the test shall be recorded. If the line of rupture occurs in the middle third, the modulus of rupture is given by equation. F= PL/bd2. In case line of rupture lies outside the middle third at a distance ‘a’ from the support up then modulus of rupture is given by F=3Pxa/bd2.

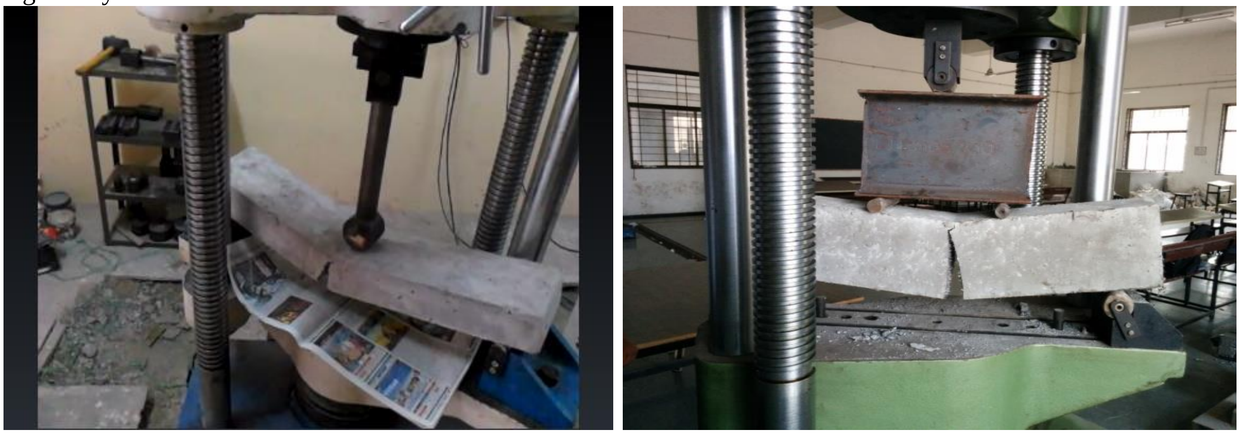

Fig. 5 & 6: Flexure Test- [Test on Beams]

III. RESULT AND DISCUSSION

Grade: M-20

Sr. No.	*Dimension L x B x H in cms*	*Load (kN)*		*Flexural Strength in N/mm²*	*Deflection in mm*
Sample 1	*75 x 15 x 15*	*Initial*	*9.59*	*1.96*	*16.55*
		Final	*13.71*	*2.84*	*47.84*
Sample 2	*75 x 15 x 15*	*Initial*	*7.21*	*1.49*	*13.32*
		Final	*10.39*	*2.15*	*51.73*
Sample 3	*75 x 15 x 7.5*	*Initial*	*2.39*	*1.96*	*20.31*
		Final	*4.42*	*3.62*	*51.48*

Table 1: Test Result (For Fibre Content 0.020% Of Volume)

Sr. No.	*Dimension L x B x H in cms*	*Load (kN)*		*Flexural Strength in N/mm²*	*Deflection in mm*
Sample 1	*75 x 15 x 15*	*Initial*	*8.50*	*1.76*	*7.50*
		Final	*26.00*	*5.39*	*12.00*
Sample 2	*75 x 15 x 9.3*	*Initial*	*8.50*	*4.59*	*1.60*
		Final	*15.00*	*8.09*	*7.30*

Table 2: Test Result (For Fibre Content 0.015% Of Volume)

Sr.No.	*Dimension L x B x H in cms*	*Load (kN)*		*Flexural Strength in N/mm²*	*Deflection in mm*
Sample 1	*75 x 15 x 15*	*Initial*	*9.00*	*1.87*	*1.80*
		Final	*20.79*	*4.31*	*7.00*
Sample 2	*75 x 15 x 15*	*Initial*	*8.80*	*1.83*	*2.70*
		Final	*20.19*	*4.19*	*5.80*
Sample 3	*75 x 15 x 8.4*	*Initial*	*8.70*	*5.75*	*2.90*
		Final	*13.32*	*8.81*	*24.30*
Sample 4	*75 x 15 x 8.4*	*Initial*	*8.70*	*5.75*	*2.80*
		Final	*10.56*	*6.98*	*21.90*
Sample 5	*75 x 15 x 8.4*	*Initial*	*3.00*	*1.98*	*3.60*
		Final	*12.30*	*8.13*	*20.10*

Table 3: Test Result (For Fibre Content 0.030% Of Volume)

Sr. No	*Fiber Content % Of Volume*	*Flexural strength (Normal Section)*	*Flexural strength (Reduced Section)*
1	*0.000 %*	*3.12*	*3.12*
2	*0.015%*	*5.39*	*8.09*
3	*0.020%*	*2.495*	*3.62*
4	*0.030%*	*4.25*	*7.97*

Table 4: Test Result (For Different Fiber Content)

All testing are performed as per IS: 516-1959

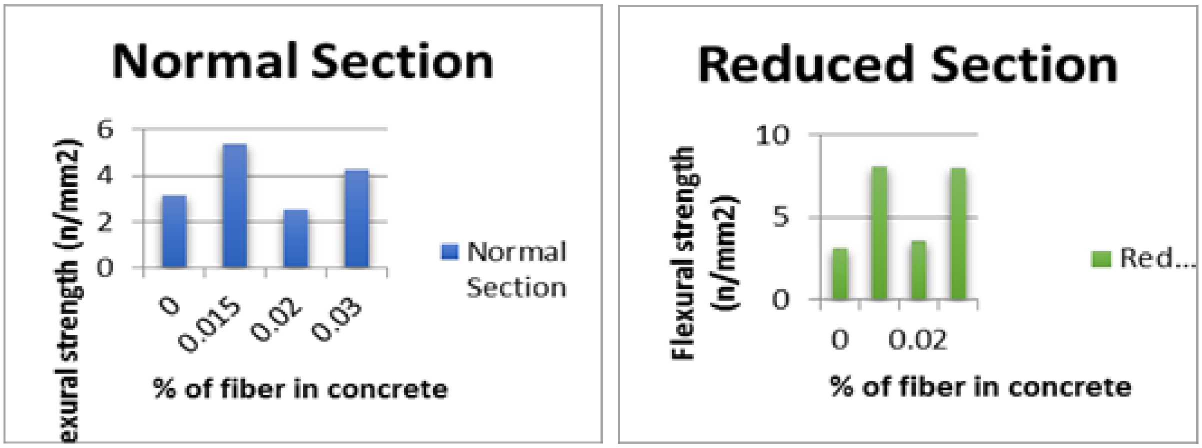

Fig. 7 & 8: Normal & Reduced Section

- The above result shows that 61.58% increase in flexural strength of concrete compare to regular concrete.
- For 0.015% fiber content the flexural strength for normal section is 3.12 and flexural strength for reduced concrete is 3.12
- For 0.020% fiber content the flexural strength for normal section is 2.495and flexural strength for reduced concrete is 3.62
- For 0.030% fiber content the flexural strength for normal section is 4.25 and flexural strength for reduced concrete is 7.97
- The result shows 61.58% increase in strength by adopting reduced section compare to regular section.

IV. FUTURE SCOPE

More investigations and studies required to find out shear resistance of concrete so that the application of concrete in earthquake resistant structures can be tested. More laboratory work to be done to find out the corrosion resistance capacity of concrete. Therefore it is recommended that the testing can be done by casting ECC Concrete beams with steel reinforcing bars.

V. CONCLUSION

- The ductile behavior and increase in tensile strength is achieved by ECC composite.
- Initial manufacturing cost of ECC is higher than conventional concrete but long term financial benefits are with ECC due to reduction in maintenance cost compare to regular concrete.
- As we are getting good results with reduced section we can reduced the dimension of structural elements and thus reduced the cost of construction.
- ECC material gives advantages of both steel and concrete.
- The weight of structure will be reducing by replacing coarse aggregate.
- According to test result the beam is withstanding higher load and undergoes large deformation compare to brittle failure of normal concrete even without use of steel reinforcement.

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