P.E.S COLLEGE OF ENGINEERING

MANDYA – 571401, KARNATAKA

(An Autonomous Institute Affiliated to VTU, Belagavi)

A PROJECT REPORT ON

"EXPERIMENTAL STUDY ON BENDABLE CONCRTE"

Submitted by

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P.E.S COLLEGE OF ENGINEERING
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DEPARTMENT OF CIVIL ENGINEERING

NBA ACCREDITED

CERTIFICATE

This is to certify that **MANJUNATH T L (4PS18CV060), HEMANTH KUMAR B R (4PS18CV038), NINGARAJU G M (4PS18CV069)** and **DHANYA KUMAR S J (4PS18CV029)** have successfully completed the project work on ***"EXPERIMENTAL STUDY ON BENDABLE CONCRETE"*** in partial fulfilment for the award of Bachelor of Engineering in Civil Engineering of PES College of Engineering, Mandya, affiliated to VTU Belagavi during the year **2021-2022**.The project has been approved as it satisfies the academic requirements in respect of project works prescribed for the degree in Bachelor of Engineering.

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CANDIDATE'S DECLARATION

We, the undersigned students of VIII semester of Civil Engineering PES College of Engineering Mandya, declare that our project work entitled **"*EXPERIMENTAL STUDY ON BENDABLE CONCRETE*",** has been prepared by us under the guidance of **Mrs. LAKSHMI.P.S,** Assistant Professor, Department of Civil Engineering, PESCE Mandya. This work has been submitted for the partial fulfillment of the requirement for the award of **Bachelor of Engineering** in **Civil Engineering Department** by **P.E.S. College of Engineering, Mandya** during the academic year 2021-2022. We also declare that this project was not entitled for submission to any other university in the past and shall remain the only submission made and will not be submitted by us to any other university in the future.

Place: Mandya

Date:

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ABSTRACT

Bendable Concrete commonly known as Engineered Cementitious Composite (ECC) is an ultra-ductile concrete with strain-hardening and multiple-cracking behavior in tension and flexure. Over the last decade, enormous strides have been made in creating Bendable Concrete with extreme tensile ductility. In the present project strength characteristics of different Bendable concrete mixtures are evaluated by incorporating supplementary cementitious materials such as Sugarcane Bagasse ash and Polypropylene fiber. In flexure, concrete is weak bendable concrete shows effective results on flexural values by partial replacing cement with Polypropylene fiber and Sugarcane Bagasse ash is partially replaced with cement by 10% of Cement weight. The mix shows different strength for percentages of Sugarcane Bagasse Ash and dose of Polypropylene fiber in each mix.

Keywords: Bendable Concrete, Engineered Cementitious Composites (ECC), Sugarcane Bagasse Ash (SBA).

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Bendable concrete 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 microcracks with widths limited below 60 μm about half diameter of 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 0.1% 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. 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 [1].

ECC elongates without fracturing, due to the interaction between fibers, sand, and cement working in a matrix that binds everything together within the material. In addition to reinforcing the concrete with fibers that act as ligaments to bond it more tightly. The design of the cement matrix with special ingredients to make it more compatible with the fibers and to increase flexibility. Where ordinary concrete and fiber reinforced concrete are designed to resist cracking, ECC is designed to crack only in a carefully controlled manner. The cracks that appear in ordinary concretes are Griffith-type cracks; they increase in width as they grow longer. The cracks that are formed in ECC are steady state (or flat) cracks. The width of these cracks remains constant regardless of the length [1].

1.2 ADVANTAGES

Fibers are not as efficient in withstanding tensile stresses as compared to conventional steel reinforcement, but fibers are more closely spaced than steel which makes fibers better in controlling cracks and shrinkage. The following advantages of ECC are summarized,

- Increased crack resistance, more energy absorption capacity, increased toughness and long-term ductility.
- Increased impact resistance and shear strength of concrete
- Fibers provides multidirectional reinforcements.
- Ultimate load carrying capacity in flexure is greatly enhanced.
- The weight of flexible concrete is approximately reduced by 20-40%.
- The use of steel reinforcement is reduced.
- It can be used as precast concrete.
- ECC incorporates high volumes of industrial wastes including Bagasse ash, sands and wastes from metal casting processes, wasted cement kiln dust from cement production, which essentially reduces pollution.

1.3 DISADVANTAGES OF BENDABLE CONCRETE

- The initial cost of flexible concrete construction is high.
- The availability of special materials for bendable concrete is difficult to obtain.
- The quality of bendable concrete is dependent on the quality of the materials and the atmospheric conditions it is made.

1.4 APPLICATIONS

- The Mitaka Dam near Hiroshima was repaired using ECC in 2003. The surface of the then 60-year-old dam was severely damaged, showing evidence of cracks, spalling, and some water leakage. A 20 mm-thick layer of ECC was applied by spraying over the 600 m^2 surface.

Fig. 1.1: Repair of Mitaka Dam by spraying water-tight ECC layer (Kunieda and Rokugo, 2006)

Fig. 1.2: Mitaka Dam, Hiroshima

- Also in 2003, an earth retaining wall in Gifu, Japan, was repaired using ECC. Ordinary portland cement could not be used due to the severity of the cracking in the original structure, which would have caused reflective cracking. ECC was intended to minimize this danger; after one year only microcracks of tolerable width were observed.

- The 1 km (0.62 mi) long Mihara Bridge in Hokkaido, Japan was opened to traffic in 2005. The steel-reinforced road bed contains nearly 800 m3 of ECC material. The tensile ductility and tight crack control behavior of ECC led to a 40% reduction in weight and 50% reduction in cost.

Fig. 1.3: Mihara Bridge, Hokkaido (Source: Kajima Corporation and Kuraray Co. Ltd)

- Similarly, a 225-mm thick ECC bridge deck on interstate 94 in Michigan was completed in 2005. 30 m3 of material was used, delivered on-site in standard mixing trucks. Due to the unique mechanical properties of ECC, this deck also used less material than a proposed deck made of ordinary portland cement. Both the University of Michigan and the Michigan Department of Transportation are monitoring the bridge in an attempt to verify the theoretical superior durability of ECC; after four years of monitoring, performance remained undiminished

- The 95 m (312 ft.) Glorio Roppongi high-rise apartment building in Tokyo contains a total of 54 ECC coupling beams (two per story) intended to mitigate earthquake damage. The properties of ECC (high damage tolerance, high energy absorption, and ability to deform under shear) give it superior properties in seismic resistance applications when compared to ordinary portland cement. Similar structures include the 41-story Nabeaure Yokohama Tower (four coupling beams per floor)

Figure 1.4: Glorio Roppongi high-rise residential building, Tokyo (Source: www.cif.org)

CHAPTER-2

LITERATURE REVIEW

Mustafa Sahmaran et al. (2012) experimentally studied to find out the influence of the high volumes of fly ash (FA) and micro poly-vinyl-alcohol (PVA) fibers on the cyclic freeze–thaw resistance and microstructure of the Engineered Cementitious Composites (ECC). They prepared ECC mixtures with two different FA– cement (FA/C) ratios (1.2 and 2.2 by weight), and at constant water-cementitious materials (fly ash and cement) ratio of 0.27. Experimental tests consist of measuring the residual mechanical properties (flexural strength, mid- span beam deflection and flexural stress-deflection curve), ultrasonic pulse velocity and mass loss were conducted. The results confirm that both ECC mixtures with high volumes of FA remain durable, and show a tensile strain capacity of more than 2% even after 300 freezing and thawing cycles. The results indicate that the addition of micro PVA fiber to the ECC matrix improved the frost resistance. The results of freeze–thaw tests indicated that the reduction of residual physical and mechanical properties with increasing number of freezes– thaw cycles is relatively more for ECC mixture with FA/C ratio of 2.2 than for ECC mixture with FA/C ratio of 1.2.

Suleyman Bahadir Keskin et al. (2014) published a correlation between the viscoelastic properties and cracking potential of engineered cementitious composites. Along with the mechanical properties of ECC, viscoelastic properties like autogenous shrinkage, drying shrinkage and tensile creep which were used to calculate ECC's cracking potential were studied. The tendency of ECC mixtures to crack under restrained shrinkage conditions was also investigated by him using restrained shrinkage rings. The results show that the compressive strength of the mixtures containing GGBFS was higher than that of the mixtures containing FA due to the earlier reaction, self-cementing property and high specific surface area of the GGBFS compared to FA. When the amount of the mineral admixture was increased, the drying shrinkage of the mixtures decreased significantly. Low compatibility of GGBFS is attributed to lower ductility, lower tensile creep and higher shrinkage, which in turn resulted in higher induced tensile stresses. Mixtures containing FA had higher tensile creep compared to the mixtures with GGBFS.

Salahuddin Qudah et al. (2014) carried out experimental study to evaluate the feasibility of using ultra- ductile Engineered Cementitious Composites (ECC) as a means to enhance the performance of Type-2 interior beam–column connections. They have tested interior connections at a zone 3 as per uniform building code (UBC) of high seismicity under reverse cyclic loading for simulating seismic excitation. The test results indicated that the use of ECC material in the connection plastic zone as a replacement of concrete and partial replacement of transverse reinforcement can significantly enhance the joint shear resistance, energy absorption capacity, and cracking response which enhancing the joint seismic resistance and reducing reinforcement congestion and construction complexity. They found that all ECC-enhanced specimens had exhibited a higher capacity compared to the control specimen. The amount of increase in the energy dissipation capacity obtained from the use of ECC ranged from 11% to 20%. The results show a reasonable safety factor against shear stress- induced joint failure under cyclic loading.

Li-li Kan et.al. (2012) investigated self-healing behavior of Engineered Cementitious Composites (ECC) materials. Crack characteristics of M45-ECC and HFAECC specimens pre-loaded to strain levels of 0.3%, 0.5%, 1.0% and 2.0% were investigated. This was done at different ages, resonant frequency and mechanical recovery behavior of re-healed ECC materials, new crack paths after reloading and the chemical analysis of healing products. Based on the experimental results, ECC with multiple micro-cracks benefits self- healing behavior. Longer aged samples and high fly ash contribute to create more cracks of smaller width. Ultimate tensile strength and tensile strain capacity of the majority ECC specimens at reloading are higher than the control specimens without cracks.

Yu Zhu et al. (2014) experimental studied on mechanical properties of engineered cementitious composites (ECC) produced by high volume mineral admixtures which are fly ash, slag and silica fume. The water–binder materials ratio (W/B) is kept at 0.25 for various ECC mixtures. The results indicate that the compressive strength has an inverse relationship with deflection, toughness index and fracture energy, respectively; but the compressive strength have a direct proportional relation with flexural strength, first cracking load, and peaking load, respectively. The ductility of ECC can be obviously improved by introducing high volume fly ash and slag replacing the cement, respectively. However, the compressive strength of ECC with fly ash and slag can reduce 40% and 14%, respectively. For the ternary system of binder materials with replacement 70% of cement, the combination of fly ash and slag can keep not only the excellent ductility of ECC, but also enough stronger matrix strength.

S.Z. Qian et al. (2010) investigated the self-healing behavior of Engineered Cementitious Composites (ECC) with focus on the influence of curing condition and precracking time. 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. After self-healing, flexural stiffness was also retained significantly compared with that from virgin samples, even though the level of retaining decreases with the increase of pre-cracking time. The flexural strength increases for samples pre-cracked at the age of 14 days and 28 days, presumably due to continuous hydration of cementitious materials afterwards. Furthermore, it was promising to utilize Nano clay as distributed internal water reservoirs to promote self-healing behavior within ECC without relying on external water supply.

Mustafa Sahmaran et al. (2013) experimented on 36 different ECC mixtures to evaluate the combined effects of the following factors on workability and rheological properties: water-binder (w/b), sand-binder (s/b), super plasticizer-binder (SP/b) ratios and maximum aggregate size (Dmax). A mini-slump cone, a Marsh cone and a rotational viscometer was used to evaluate the workability and rheological properties of ECC mixtures. Experimental results indicate that w/b, s/b and SP/b parameters affect the rheological and workability properties. On the other hand, for the range of studied aggregate sizes, Dmax is found to be statistically insignificant on the rheological and workability properties of ECC, also in addition to those the mid-span beam deflection capacities, which reflect material ductility, of ECC mixtures varied noticeably with the change of s/b and Dmax design parameters. Both of these two parameters negatively affect the deflection capacity of the ECC mixtures. The other parameters have almost no effect on the mid-span beam deflection capacities of ECC mixtures.

Jian Zhou et al. (2012) experimented on improved fiber distribution by adjusting the mixing sequence. With the standard mixing sequence, fibers are added after all solid and liquid materials are mixed. The undesirable plastic viscosity before the fiber addition may cause poor fiber distribution and results in poor hardened properties. With the adjusted mixing sequence, the mix of solid materials with the liquid material is divided into two steps and the addition of fibers is between the two steps. In this paper, the influence of different water mixing sequences was investigated by comparing the experimental results of the uniaxial tensile test and the fiber distribution analysis. The result was concluded that compared with the standard mixing sequence, the adjusted mixing sequence increases the tensile strain capacity and ultimate tensile strength of ECC and improves the fiber distribution.

CHAPTER-3

OBJECTIVES OF PROPOSED WORK

The objectives of this study are listed as follows; -

- To study fresh and hardened properties of normal concrete with SBA.
- To study fresh and hardened properties of Engineering Cementitious Composites.
- To compare the Conventional concrete with Bendable Concrete.

CHAPTER-4

MATERIALS AND METHODOLOGY

4.1 INTRODUCTION

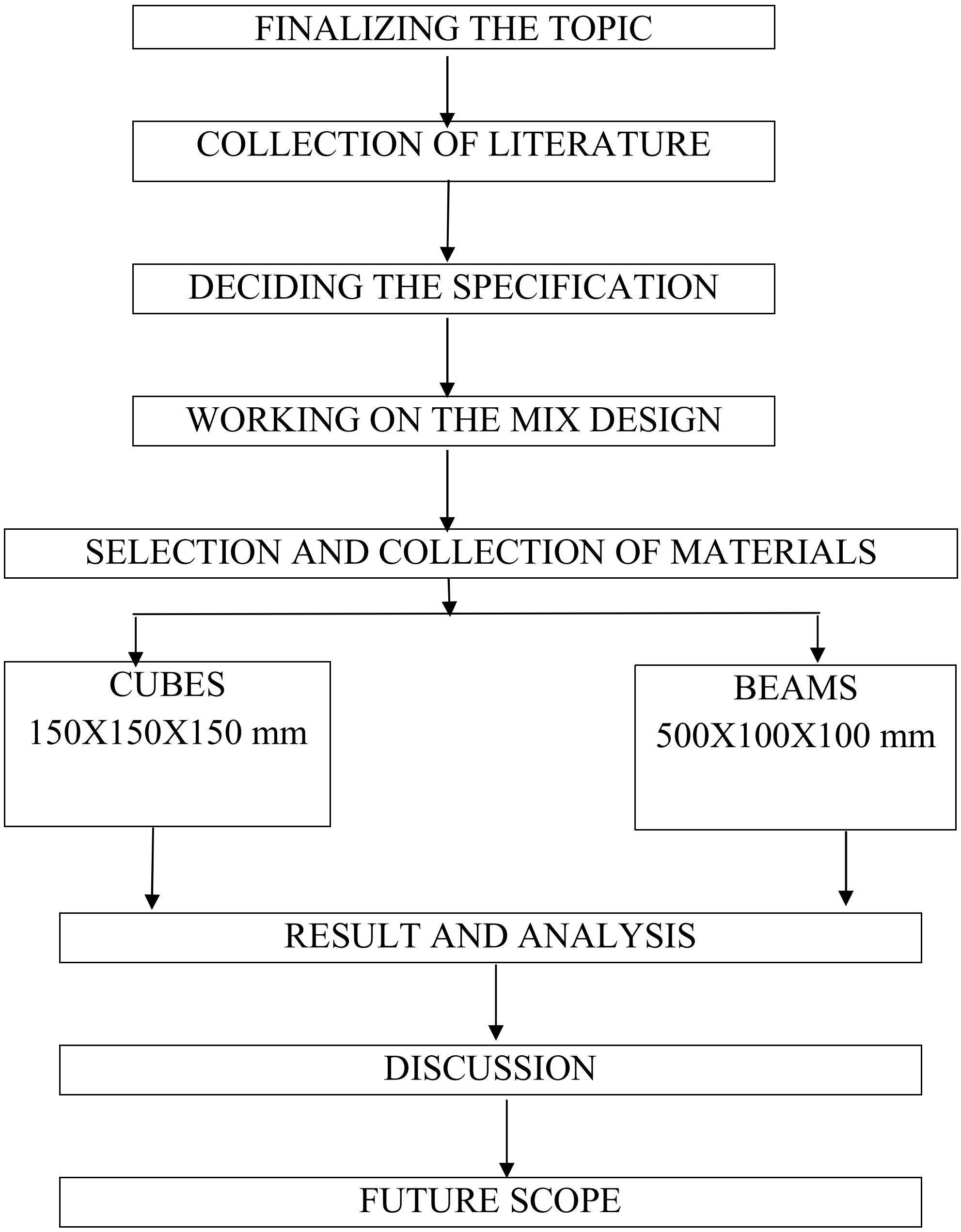
The Selection of materials places an important role in any experimental work. Hence, materials are selected from crusher. Fine aggregate, potable water, OPC 53 grade cement, mineral admixtures like Sugarcane Bagasse Ash, chemical admixtures like super-plasticizers. Each and every experiment conducted in our college.

Following are the steps involved:

- Research and discussion for project selection.
- Finalizing a topic after discussion and advice of project guide.
- Collection of data for detailed study of the project.
- Interim presentations.
- Planning and scheduling of project tasks.
- Conducting mix design and preparing concrete mix.
- Casting ECC as cubes and beams of suitable dimensions.
- Testing the casted specimens and obtaining results from tests performed.

Figure a: shows the methodology adapted for the project. Following are the steps involved,

4.1.1.1 FLOW CHART



4.1.2 MATERIALS

4.1.2.1 CEMENT

Fig. 4.1: Cement

- Cement can be defined as, “bonding material” having cohesive and adhesive properties, which makes it capable to unite the different construction materials and form the compacted assembly is the widely used type of pot-land cement.
- Zuari Ordinary Portland cement of 53 grade conforming to IS: 12269:1987 used for this experimental work.

4.1.2.2 FINE AGGREGATES

Fig. 4.2: M-Sand

Fine aggregate is defined as any aggregate passes through 4.75 mm sieve. Fine aggregate can be natural or manufactured. Particles smaller than 0.125 mm that is 125-micron sizes are considered as fines which contribute to powder content.

4.1.2.3 SUGARCANE BAGASSE ASH (SBA)

The Sugarcane Bagasse Ash influences the quality of cement. It has a good chemical composition and physical properties such as Fineness, Expansion, Setting time and compressive strength.

Fig. 4.3: Sugarcane Bagasse Ash

4.1.2.4 SUPER PLASTICIZER

Super-plasticizers and plasticizing solution have important role in self compacting concrete as well as in concrete technology. Since, these plasticizers reduce water/cement ratio by 30%, without any corresponding effect on workability of concrete these solutions were called as water reducers or super-plasticizers. They were developed during 1970's and were developed from sulfonated naphthalene formaldehyde which is sub classified as naphthalene based super-plasticizers.

Fig. 4.4: Super Plasticizer

Properties of Superplasticizer

1. Name is Polytancrete NGT.
2. Color tone is Dark Brown.
3. State: Liquid.
4. Specific Gravity is 1.07 kg/l

4.1.2.5 POLYPROPYLENE FIBER

Sample of 100 grams of cement is weighed in a weighing machine and is sieved in a standard sieve of size 90µm. the cement of good quality should have less than 10% weight of cement when sieved. Obtained fineness of 53 grade zuari cement is 6% which is less than 10% thence it is suitable to carry out experimental work.

Fig. 4.5: Polypropylene Fibers

Properties of Polypropylene fiber

1. Fiber length: 12mm.
2. Specific Gravity: 0.91 g/cc
3. The young's modulus of Polypropylene fiber is 6000 MPa.
4. The tensile strength of Polypropylene fiber is 523 MPa
5. Fiber thickness is 25 microns.
6. Elongation is 25-40%
7. Melting Point is 160 °C

4.1.2.6 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. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates.

4.1.3 COLLECTION OF RAW MATERIALS

The materials used for the Project are Listed below as follows:

Table 4.1: Raw Materials

CEMENT	Zuari Cement of OPC 53 Grade
FINE AGGREGATES	M-SAND from Construction site near campus
WATER	Collected from local fresh water source
POLYPROPYLENE FIBER	Ordered through Online
SUPERPLASTICIZER	Ordered through Online
SUGARCANE BAGASSE ASH	Collected from sugar industry

4.2 PROPERTIES OF MATERIALS USED

In the initial stage preliminary tests were conducted on materials (cement and fine aggregate).

4.2.1 TESTS PRFORMED ON CEMENT

Cement is an important constituent in concrete. The process of manufacture of cement consists of grinding the raw materials mixing them intimately in certain proportions and burning them in kiln at a temperature1300C to 1500'C. To determine the various properties of cement different tests are done. They are:

- Specific gravity of cement.
- Standard consistency of cement.
- Setting time of cement.
- Fineness of cement.

4.2.1.1 SPECIFIC GRAVITY TEST ON CEMENT

This test is conducted as per, IS 4031 using density bottle. Specific gravity of cement is defined as the mass of cement of specified volume to the mass of water of the same volume of cement.

Table 4.1: **Specific gravity of cement**

DESCRIPTION	**TRIAL-1**	**TRIAL-2**	**TRIAL-3**
Empty weight of density bottle(W_1) in g	69	67	68
Weight of Density bottle + 1/3 of cement (W_2) in g	111	112	112
Weight of Density bottle + kerosene + cement (W_3) in g	181	180	180
Weight of Density bottle + kerosene(W_4) in g	150	147	148
Weight of bottle + water (W_5) in g	170	168	170

Results: the obtained specific gravity for OPC 53 grade zuari cement =3.15

Fig. 4.6: Density Bottle

4.2.1.2 STANDARD CONSISTENCY TEST

This experiment is carried out in accordance to IS 403(part - 40 1988) coda provision. Standard consistency is defined as the percentage of water to be added to get a paste such that the plunger penetrates up to a mark 5 to 7 mm from bottom. The obtained consistency that is used to fix the quantity of water to be mixed in cement before performing test for tensile strength, and setting time of concrete. The apparatus used for this experiment is called Vicat Apparatus. In general, standard consistency of Portland cement should be 32 to 35% of water.

Table 4.2: Standard consistency

Sl. no	Description	Trial-1	Trial-2	Trial-3	Trial-4
1	% Of water added	26	28	30	31
2	Initial reading (mm)	40	40	40	40
3	Final reading (mm)	37	21	11	7
4	Height penetrated (mm)	3	19	29	33
5	Height not penetrated (mm)	37	21	11	7

Results: standard consistency of cement is = 31%

Fig. 4.7: Vicat Apparatus

4.2.1.3 INITIAL AND FINAL SETTING TIME

Initial setting time is a stage in the process of hardening after which any crack that may appear will not reunite. On the other hand, final setting is a stage when cement has obtained sufficient strength and hardiness.

1. Weight of cement taken for one mould = 400gm
2. Percentage of water added = $\frac{31 \times 400}{100}$ = 124 ml

Table 4.2: Initial setting time

Sl no.	Time taken in (min)	Initial reading (mm)	Final reading (mm)	Height net penetrated (mm)
1	5	40	0	0
2	10	40	0	0
2	15	40	0	0
3	20	40	0	0
4	25	40	0	0
5	30	40	1	1
6	35	40	3	3
7	40	40	7	7

Table 4.3: Final setting time

Time	0	30	60	90	120	150	180	210	240	270	300	330	360	390
impression Y= Yes N= No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N

Results:

Initial setting time	: 40 min
Final setting time	: 390 min

4.2.1.4 FINENESS TEST ON CEMENT

Sample of 100 grams of cement is weighed in a weighing machine and is sieved in a standard sieve of size 90µm. the cement of good quality should have less than 10% weight of cement when sieved. Obtained fineness of 53 grade zuari cement is 6% which is less than 10% thence it is suitable to carry out experimental work.

4.2.2 TESTS CONDUCTED ON FINE AGGREGATES

4.2.2.1 SPECIFIC GRAVITY TEST ON FINE AGGREGATE

The main aim of finding fineness modulus is to grade the given aggregate for the most economical mix and workability with minimum quantity of cement. It is obtained by saving known weight of given aggregate in a set of standard sieves of size 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ, pan and by dividing the percentage weight of material retained on all the sieve and dividing the total percentage by 100.

Fig. 4.8: Pycnometer Bottle

Table 4.4: Specific gravity of fine aggregate

Sl.no	Description	Trial-1	Trial-2	Trial-3
1	Weight of empty pycnometer (W_1) in g	575	575	575
2	Weight of pycnometer + 1/3 of fine aggregate (W_2) in g	1044	1052	1049
3	Weight of pycnometer + 1/3 of fine aggregate + water (W_3) in g	1758	1766	1760
4	Weight of pycnometer + water (W_4) in g	1467	1467	1467

Result: the specific gravity of fine aggregate is = 2.63

4.2.2.2 SIEVE ANALYSIS OF FINE AGGREGATE

The main aim of finding fineness modulus is to grade the given aggregate for the most economical mix and workability with minimum quantity of cement. It is obtained by saving known weight of given aggregate in a set of standard sieves of size 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ, 150μ, pan and by dividing the percentage weight of material retained on all the sieve and dividing the total percentage by 100.

Result: fineness modulus of fine aggregate=2.32

Fig. 4.9: Sieve Shaker

4.2.3 TESTS PERFORMED ON SUGARCANE BAGASSE ASH (SBA)

4.2.3.1 SPECIFIC GRAVITY OF SBA

Table 4.5: **Specific gravity of SBA**

DESCRIPTION	TRIAL-1	TRIAL-2	TRIAL-3
Empty weight of density bottle(W_1) in g	69	67	68
Weight of Density bottle + 1/3 of SBA (W_2) in g	102	101	102
Weight of Density bottle + kerosene + SBA (W_3) in g	171	168	168
Weight of Density bottle + kerosene(W_4) in g	150	147	148

Result: Specific Gravity of Sugarcane Bagasse Ash = 2.52

4.2.4 SUMMERISED PROPERTIES OF MATERIALS:

4.2.4.1 Properties of cement:

The physical and structural properties of cement have been determined by conducting test in the laboratory according to IS: 4031-1991. The results are summarized in table 3.3.

Table 4.6: Physical and Structural properties of OPC-53 grade

Sl. No.	Particulars	Results
1	Specific Gravity	3.15
2	Setting time a) Initial setting time b) Final setting time	 35 Minutes 270 Minutes
3	Soundness	4.8mm
4	Standard Consistency	31%
5	Fineness	6%

INFERENCE:

The values obtained for previous of cement are within the range specified by IS code. So, the given cement is suitable for construction.

4.2.4.2 Properties or fine aggregates:

The physical and structural properties of fine aggregates have been determined by conducting tests the laboratory according to IS:2386-Part l-1963. The results are in table 3.4.

Table No. 4.7: Properties of M-Sand (Fine aggregates)

Sl.no	Particulars	Results
1	Specific gravity	2.63
2	Fineness modulus	2.32

INFERENCE:

The properties obtained for fine aggregates are within the range given by IS code. So, the fine aggregates are good for concreting.

4.2.4.3 Properties of Sugarcane Bagasse Ash:

The physical and structural properties of fine aggregates have been determined by conducting tests the laboratory according to IS 2386-Part l-1963. The results are in table 3.4.

Table No. 4.8: Properties of SBA;

Sl.no	Particulars	Results
1	Specific gravity	2.52

4.3 PROCEDURE FOR MAKING ECC CONCRETE

4.3.1 MIX RATIO

The initial mix proportion was Polypropylene fiber at 1% and super plasticizer dose was 15ml per beam mould (500x100x100 mm) and 15ml per cube mould (150x150x150 mm), then water to cement ratio of 0.45. By using this proportion workability was achieved. The ratio of concrete mix is 1:2(cement: sand) and w/c=0.45. We can replace 15% of cement with bagasse ash for decrease hydration heat and improve concrete durability.

4.3.2 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 was carried out on the beam during the mixing & after the placement of fresh concrete. A proper mixing of concrete is encouraged to obtain the strength of concrete & better bonding of cement with the Polypropylene 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, SBA, add the Polypropylene fibers slowly then add 50% of water & super plasticizer. Add slowly remaining quantity of water & super plasticizer and mix till the homogenous mixture is formed.

Fig. 4.10: Mixing of ECC Concrete

4.3.3 PLACING, COMPACTING & CASTING OF CONCRETE SPECIMEN.

Before placing of concrete, the concrete mould must be oiled for the ease of concrete specimens stripping. Once the workability test of ECC concrete was done, the fresh concrete must be placed into the concrete moulds for hardened property tests. During the placing of fresh concrete into the moulds, tamping was done using Tamping rod in order to reduce the honeycombing. It allows full compaction of the fresh concrete to release any entrained air voids contained in the concrete. If the concrete was not compacted in a proper manner, the maximum strength of the concrete cannot be achieved. After this operation, the levelling of concrete was done on the surface of the concrete. Levelling is the initial operation carried out after the concrete has been placed & compacted. After the levelling of the fresh concrete was done, the concrete in the mould was left over night to allow the fresh concrete to set.

Fig. 4.11: Placing of Concrete

4.3.4 CURING OF CONCRETE SPECIMEN.

After 24 hours, the concrete specimens are demoulded from the moulds. All the concrete specimens were placed into the curing tank with a controlled temperature of 25°C for a period of 7 and 28 days to attain the hardening property 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 7 and 28 days of curing, the concrete specimens were removed from the curing tank to conduct hardened properties test of ECC Concrete.

Fig. 4.12: Curing of Cubes and Beam

4.4 TESTS CONDUCTED ON CONVENTIONAL CONCRETE AND ECC CONCRETE

4.4.1 FRESH PROPERTIES TESTS ON NORMAL CONCRETE AND ECC CONCRETE

4.4.1.1 MARSH CONE TEST

Marsh cone test is reliable and simple method to study the rheological properties of cements and mortars. Flow time of cement/mortar through marsh cone is indicator of viscosity, which depends upon cement super plasticizer compatibility. It is widely used to study cement super plasticizer compatibility and to determine optimum super plasticizer dosage of a specific cement-super plasticizer combination.

The time needed for a certain amount of material to flow out of the cone is recorded. This measured flow time is linked with the fluidity of the tested material. The longer the flow time, the lower is the fluidity. It is used in cement-based materials mix design in order to define the saturation point, i.e., the dosage beyond which the flow time does not decrease appreciably. The saturation point is defined as the chemical admixture dosage beyond which the flow time dose not decrease appreciably.

4.13: Marsh Cone

4.4.1.2 FLOW TABLE TEST

The flow table test of cement mortar is done only to calculate the amount of water required for gauging for conducting strength test of masonry cement and for drying shrinkage test of cement. It also gives us some idea on the workability of cement mortar. Various researchers have conducted experimental studies on cement mortars and reported that M-sand mortar is less workable due to angular shaped particles and rough surface texture when compared to natural river sand. The flow table test conducted on cement sand ratio of 1:2.

Fig 4.14: Flow Table

4.4.2 HARDENED PROPERTIES TESTS ON NORMAL CONCRETE AND ECC CONCRETE

After curing process, the specimens have to be tested. Investigations are carried out by testing cubes and beams for 7 and 28 days.

4.4.2.1 COMPRESSION TEST

Cube moulds are cast according to the mix design data of ECC as well as conventional concrete with and without Polypropylene fibers.

Out of six cubes three were tested for 7 days and remaining three were tested for 28 days test in compression testing machine by applying a load of 5.25 kN/sec [IS 4031(part 6)]

. **Fig. 4.15: Compression Testing Machine**

DESIGN DETAILS OF SPECIMEN

10 Cubes were designed as per the standards.

MATERIALS QUANTITY

Quantity of Materials Used for Cubes

The Cubes of size 150mm×150mm×150mm are used for find out Compressive strength of the ECC and Conventional Concrete.

The materials required for casting each Cubes are calculated below

Volume of mould: 0.15m × 0.15m × 0.15m= 0.003375 m^3

Cement weight = Density of cement × volume of mould × Specific gravity

= 1440 × 0.003375 × 1.33 = 6.46÷3 = 2.15 kg, the ratio of 1:2

Then we replace the 15% of cement with SBA.

Therefore, Cement weight = 1.82 kg

Sugarcane Bagasse Ash weight = 0.32 kg

Fine aggregate (M Sand): 2.15 × 2 = 4.3 kg

Water: A1 mix 2.15 × 0.45 = 0.96 lts

A2 mix, 2.15 x 0.50 = 1.07 lts

A3 mix, 2.15 x 0.55 = 1.18 lts

A4 mix, 2.15 x 0.60 = 1.29 lts

A5 mix, 2.15 x 0.65 = 1.39 lts

Polypropylene fibers 1% = 64.5 gm

2% = 129 gm

3% = 193.5 gm

4% = 258 gm

4.4.2.2 FLEXURAL TEST

Beam moulds casted according to the mix design data of ECC as well as conventional concrete with and without Polypropylene fibers. Mark the beam from a distance of 10cm from either edge towards inside, also exactly at its center.

Fig. 4.16: Universal Testing Machine

Keep the one-point load exactly on the center mark. Feed the required data in the system and apply the load slowly until the specimen brake. Note down the distance from center line of specimen to the crack point of the specimen for calculation.

DESIGN DETAILS OF SPECIMEN

10 Beams were designed as per the standards.

MATERIALS QUANTITY

Quantity of Materials Used for Beam

The Beam of size 500mm×100mm×100mm are used for find out Flexural strength of the ECC and Conventional Concrete.

The materials required for casting each Cubes are calculated below

Volume of mould: 0.5m × 0.1m × 0.1m= 0.005 m^3

Cement weight = Density of cement × volume of mould × Specific gravity

= 1440 × 0.005 × 1.33 = 9.576÷3 = 3.19 kg, the ratio of 1:2

Then we replace the 15% of cement with SBA.

Therefore, Cement weight = 2.71 kg

Sugarcane Bagasse Ash weight = 0.47 kg

Fine aggregate (M Sand): 3.19 × 2 = 6.38 kg

Water: A1 mix 3.19 × 0.45 = 1.43 lts

A2 mix, 3.19 x 0.50 = 1.59 lts

A3 mix, 3.19 x 0.55 = 1.75 lts

A4 mix, 3.19 x 0.60 = 1.91 lts

A5 mix, 3.19 x 0.65 = 2.07 lts

Polypropylene fibers 1% = 96 gm

2% = 192 gm

3% = 288 gm

4% = 384 gm

CHAPTER-5

RESULTS AND DISCUSSION

5.1 FRESH PROPERTIES OF CONVENTIONAL CONCRETE WITH AND WITHOUT FIBERS

5.1.1 MARSH CONE TEST

Super plasticizer dosage was decided by this test. Table 5.1 shows the data acquired after performing test using 400gm of cement with varying plasticizer dosage. w/c ratio was kept as 0.45

Table 5.1: Marsh Cone Test Results

Cement (gm)	Water (ml)	Dosage (ml)	Marsh cone time (s)
400	160	10	30
400	160	11	27
400	160	12	26
400	160	13	24
400	160	14	22
400	160	15	17
400	160	16	17
400	160	17	16.5

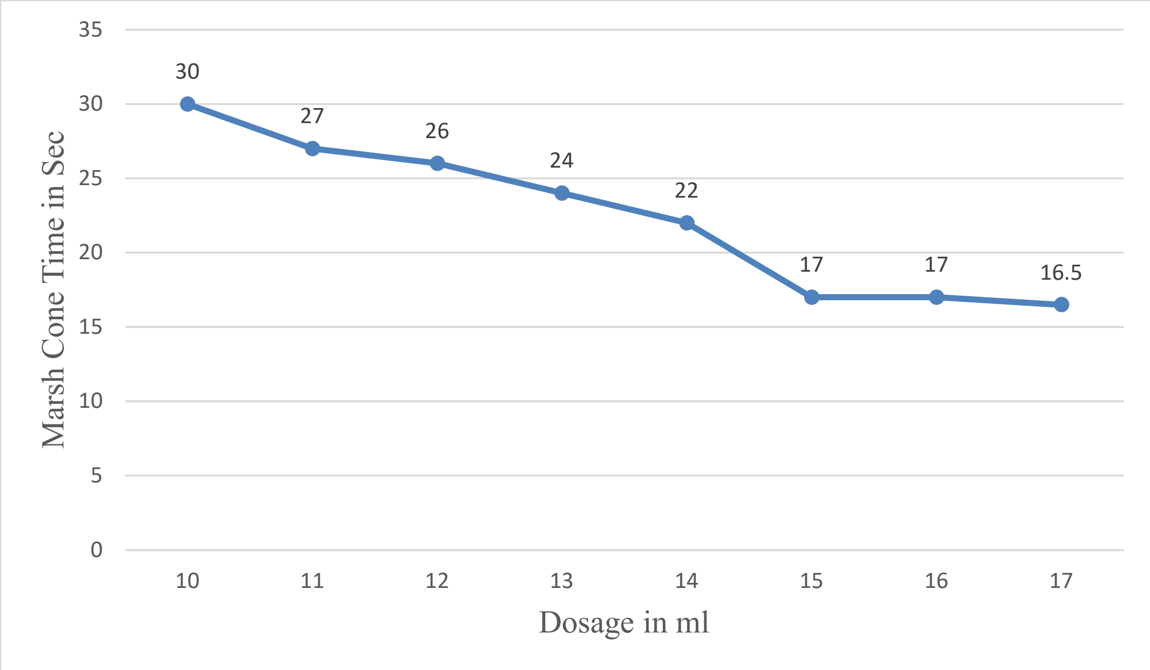


Fig. 5.1: Marsh Cone Test

The experimental results, as seen in Fig 5.1 indicate that marsh cone time has decreasing trend as the dosage of super plasticizer is increased. Once the dosage exceeds 15ml, marsh cone time remains constant. From the results super plasticizer dosage was fixed as 15ml.

5.1.2 FLOW TABLE TEST FOR DIFFERENT CONCRETE MIX

Table 5.2: Flow Table Test for Different Concrete Mix

SL No.	Type of Mix	Water - Cement Ratio	Average Base Diameter in cm	Flow In %
1	A1	0.45	18.0	80
2	A2	0.50	18.0	80
3	A3	0.55	18.0	80
4	A3	0.60	18.0	80
5	A4	0.65	18.0	80

A1 = 0% fiber and 15% SBA
A2 = 1% fiber and 15% SBA
A3 = 2% fiber and 15% SBA
A4 = 3% fiber and 15% SBA
A5 = 4% fiber and 15% SBA

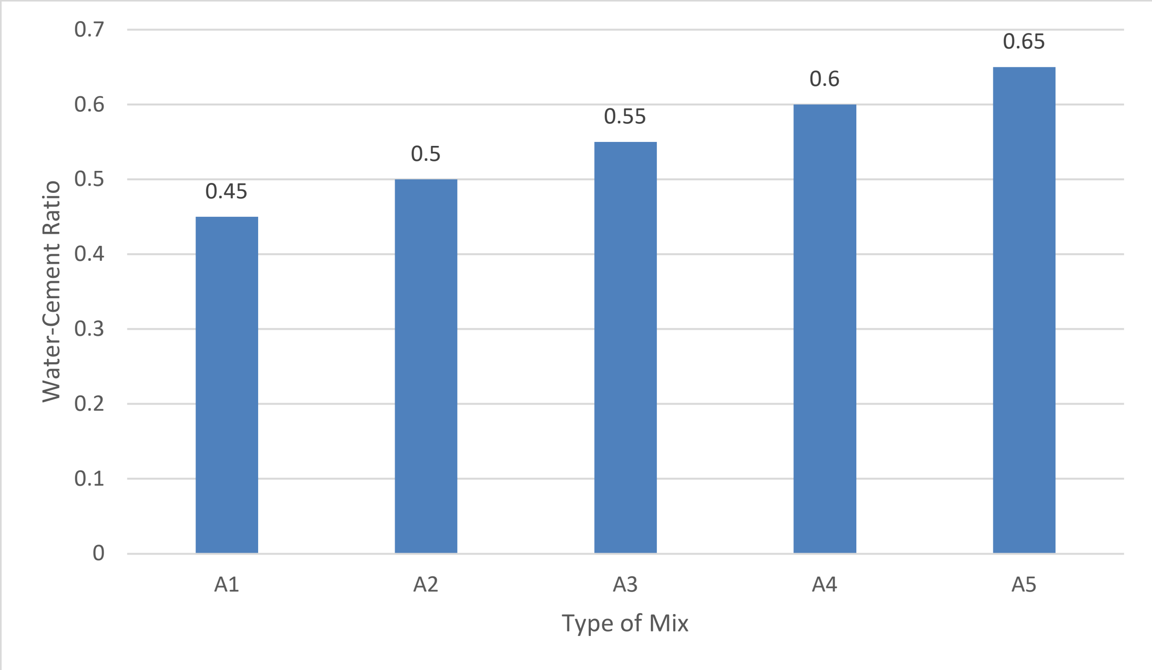


Fig. 5.2: Flow Table Test

5.2 HARDENED PROPERTIES OF CONVENTIONAL CONCRETE WITH AND WITHOUT FIBERS

5.2.1 COMPRESSIVE STRENGTH FOR DIFFERENT CONCRETE MIX

TABLE 5.3: 7 days compressive strength of Different concrete Mix

SL NO.	Type of Mix	Load in kN	Compressive Strength in N/mm^2
1	A1	301	13.37
2	A2	327	14.53
3	A3	346	15.37
4	A4	362	16.08
5	A5	353	15.68

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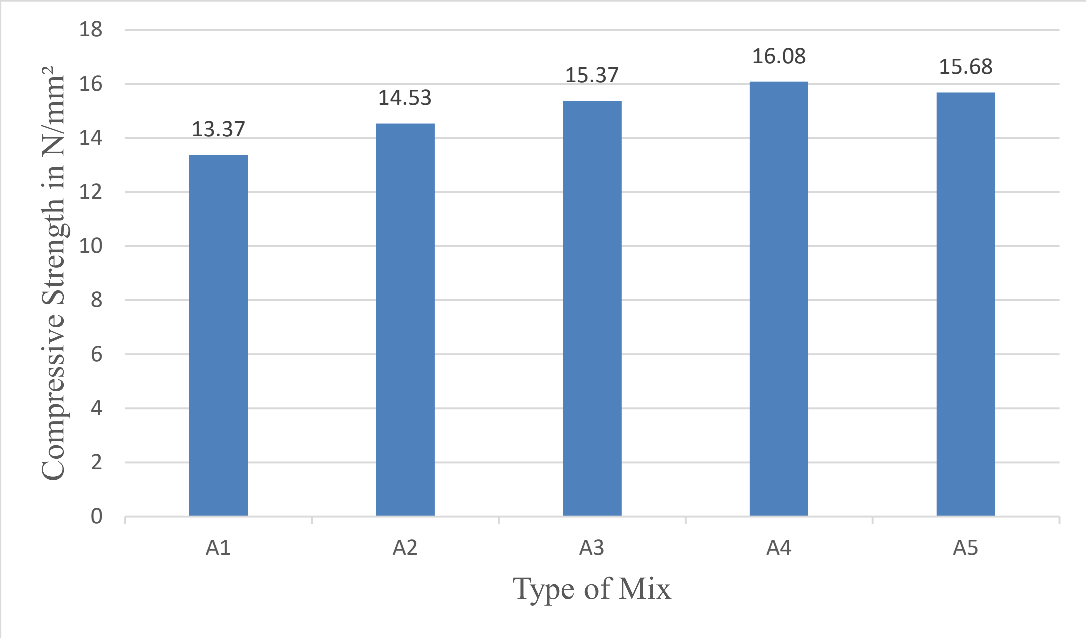

Fig. 5.3: 7 days Compressive Strength

TABLE 5.4: 28 days compressive strength of Different concrete Mix

SL NO.	Type	Load in kN	Compressive Strength in N/mm^2
1	A1	506	22.48
2	A2	535	23.77
3	A3	552	24.53
4	A4	568	25.24
5	A5	560	24.88

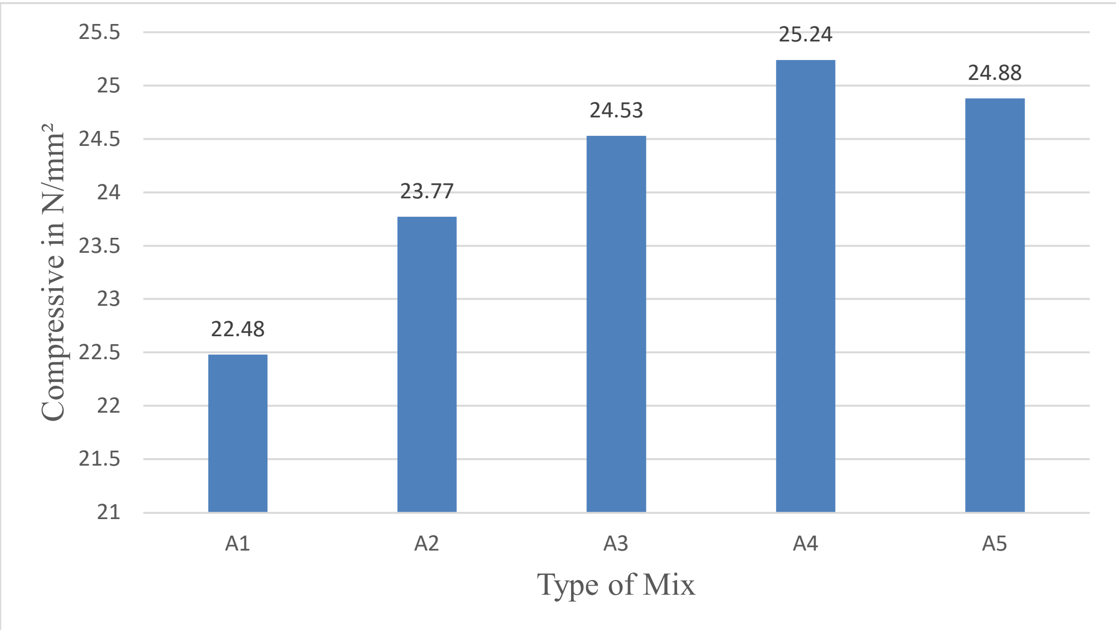

Fig. 5.4: 28 days compressive strength

5.2.2 FLEXURAL STRENGTH ON DIFFERENT CONCRTE MIX

TABLE 5.5: 7 days Flexural strength of Different concrete Mix

SL NO.	Type	Load in kN	Distance b/w Crack and Nearest Support (a) in mm	Flexural Strength in N/mm^2
1	A1	7	120	2.52
2	A2	7	129	2.71
3	A3	8	125	3.00
4	A4	8	136	3.26
5	A5	7	130	2.73

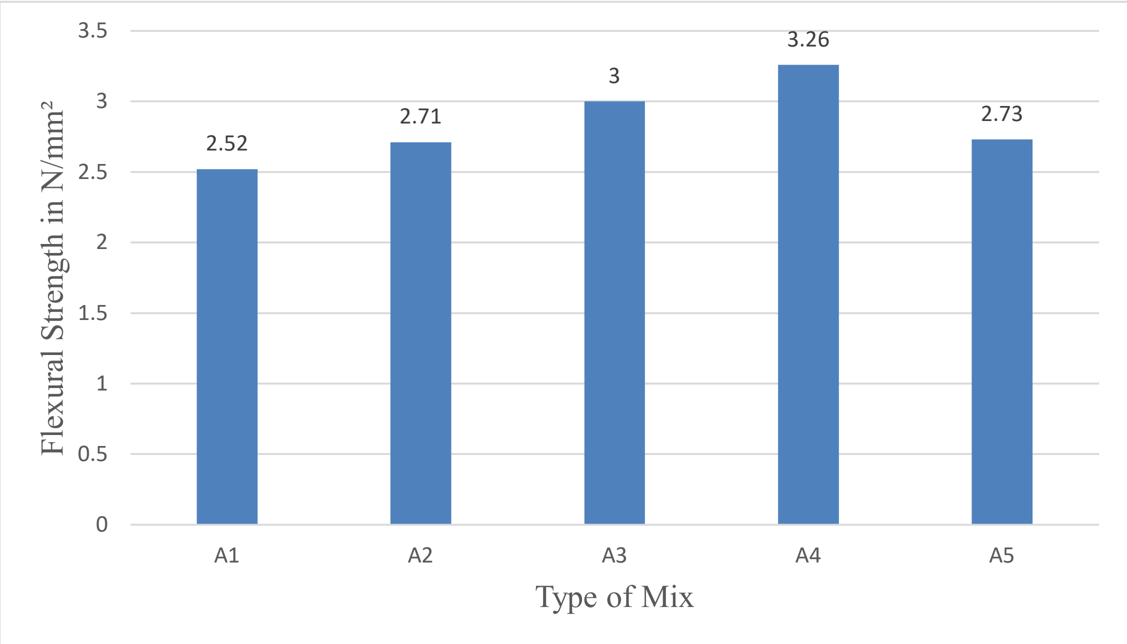

Fig. 5.5: 7 days Flexural Strength

TABLE 5.6: 28 days Flexural strength of Different concrete Mix

SL NO.	Type	Load in kN	Distance b/w Crack and Nearest Support (a) in mm	Flexural Strength in N/mm^2
1	A1	10	129	3.87
2	A2	11	128	4.22
3	A3	12	130	4.68
4	A4	13	128	4.99
5	A5	11	130	4.29

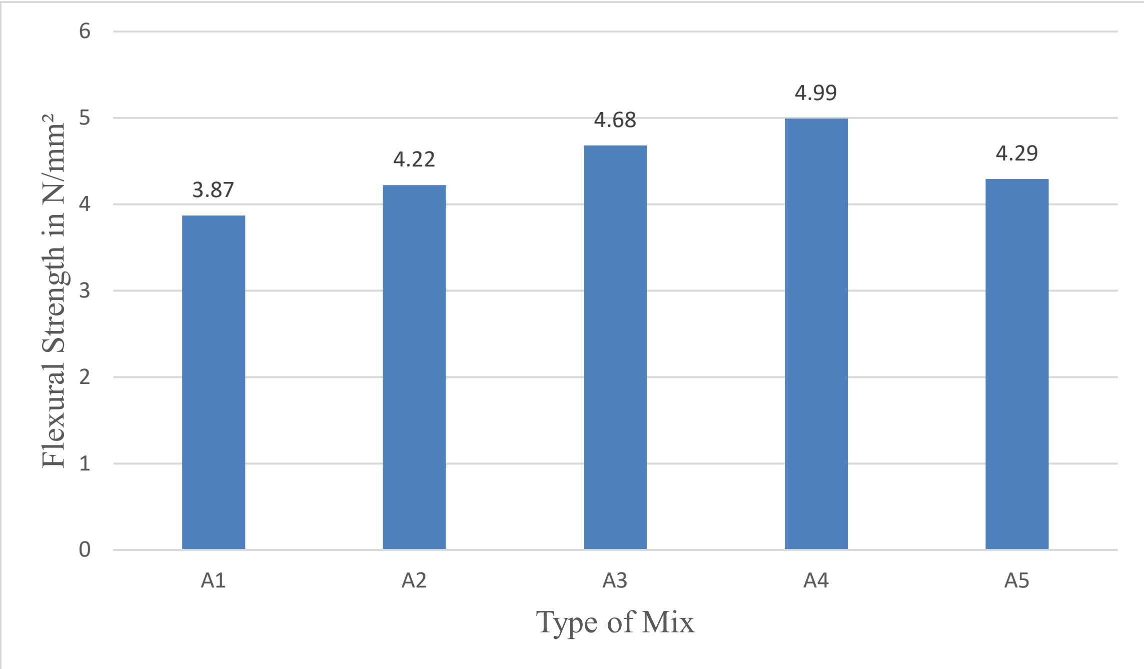

Fig. 5.6: 28 days Flexural Strength

5.3 Weight Analysis

Weight of different ingredients for 1m^3 of ECC:

1. Weight of cement = 638 kg
2. Weight of sand = 1276 kg
3. Superplasticizer = 24 kg
4. Weight of fibers = 57 kg

Total weight = 1995 kg/m^3

5.4 Cost Analysis

5.4.1 Conventional concrete

For 1m^3 of M20 grade of concrete (1:2:4), cost analysis is as follows:

1. Quantity of cement = 5 bags

   Cost of cement = 5x450 = Rs.2250
2. Quantity of fine aggregates =.286m^3

   Cost of fine aggregates = 0.286x750 = Rs.214
3. Quantity of coarse aggregates = .571m^3

   Cost of coarse aggregates =0.571x1155 = Rs.660

- ✓ Total cost of M20 Grade concrete for 1m^3 = Rs.3124

5.4.2 Engineered Cementitious Composites

- ➢ For 1m^3 of ECC, cost analysis is as follows:

1. Quantity of cement = 12bags

   Cost of cement = 12x450 = Rs.5400
2. Quantity of fine aggregates = 0.798m^3

   Cost of fine aggregates = 0.798x750 = Rs. 600
3. Super plasticizer Quantity = 30 ml/kg of cement x 638 =19 kg

   Cost of Superplasticizer = 19 x 100 = Rs. 1900

4. Quantity of Fibers = 42 kg

   Cost of Fibers= 42x120 = Rs. 5040

- ✓ Total Cost of 1 m3 of ECC = Rs. 12940

5.5 DISCUSSION OF RESULTS

In line with the results obtained in chapter 5 and their succeeding analysis, it can be concluded that ECC has the following advantages over conventional concrete:

1. From the Results, it is found that the compressive strength of the ECC concrete was found to be maximum with fibers of 3%. As the fiber content was increased to 4% there was drop in compressive strength.

2. The flexural strength of the ECC concrete was found to be maximum with fiber of 3%. As the fiber increased to 4% there was drop in flexural strength.

3. Cost of $1m^3$ ECC is found to be 4 times when compared to the cost of $1m^3$ of conventional concrete.

4. From the Results, Flow rate for the Conventional Concrete is more compared to the ECC Concrete.

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