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Partial replacement of conventional concrete by ECC

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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. Cementitious Composites abbreviated as ECC. This material is capable to exhibit considerably enhanced flexibility. An ECC has a strain capacity of more than 3 percent and thus acts more like a ductile metal rather than like a brittle glass. This project is based on the behavior of engineered cementitious composited (ECC) made by using cement OPC 53, Polypropylene fibers, silica sand, superplasticizer, and water. As for research, Polypropylene fibers are 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. For this research work, M20 grade concrete is using and tests will conduct for proportions of ECC concrete replacement with normal concrete of 0, 15 %, 20% and 25% (with total volume).ECC concrete can be double the cost as compared to conventional concrete but as it can amplify the duration of structure, it will be less costly than the conventional concrete.

Keywords: *ECC, Polypropylene fibers, Fly ash, Sulphonated melamine-formaldehyde, M sand, Bending stress.*

1. INTRODUCTION

Concrete is the most widely used construction material in the world. With the exponential growth of human population and industrialization, concrete is now used not only for buildings but also for highways, bridges, underground mass transit facilities, wastewater treatment systems, and marine structures. Modern structures are being exposed to more severe environmental and mechanical conditions than before, and the lack of durability is one of the most serious issues facing reinforced concrete infrastructures worldwide. One of the most severe concerns is the drastic decrease of durability associated with concrete cracking. Cracking is usually a result of various physical, chemical, and mechanical interactions between concrete and its environment, and it may occur at stages throughout the life of a structure. ECCs are designed to produce a strong and ductile material that can be used in several applications where fiber reinforced concrete may not be appropriate. Generally, brittleness of concrete increases with increase in compressive strength, which is a potential restriction on the use of high strength concrete in structures.

2. MATERIALS USED

For Conventional Concrete

Cement

Cement is the most important ingredient and acts as a binding material (having adhesive and cohesive properties). Cement is obtained by pulverising clinker formed by claiming raw materials primarily comprising of liming (CaO), Silica (SiO_2), Alumina (Al_2O_3 and Ferric Oxide (Fe_2O_3) along with some minor oxides. The Portland cement comprises of four principal compounds such as tri-calcium silicate.

Fine aggregate

Fine aggregate is a naturally occurring granular material composed of finely divided rock and mineral particles. It is distinguished from gravel only by the size of the grains or particles but is distinct from clays which contain organic matter. Sand that has been sorted out and separated from organic materials by the action of currents of water or by winds across arid lands are generally quite uniform in size.

Coarse aggregate

As explained aggregate used for concrete production is classified as fine aggregate and coarse aggregate depending on its particle size. The aggregate of size more than 4.75mm is called as coarse aggregate and is one of the most important ingredients of concrete. It gives strength to the concrete and constituents about 70 to 75 percent volume of concrete.

Water

Quality of mixing and curing water sometimes leads to distress and disintegration of concrete reducing the useful life of the concrete structure. Water used for concrete mixture should not contain substances which can have harmful effect of strength (i.e., on hydration process of 11 cement) or durability of the concrete in service.

For Engineering Cementitious Concrete (ECC)

Polypropylene fibers

Polypropylene fibers are hydrophobic, that is they do not absorb water. Therefore, when placed in a concrete matrix they need only be mixed long enough to insure dispersion in the concrete mixture. The mixing time of fibrillated or tape fibers should be kept to a minimum to avoid possible shredding of the fibers. Manufacturers recommend that the length of the fiber be greater than twice the diameter of the aggregate. This would be consistent with past experiences with steel fibers and also with current theories on fiber dispersion and bonding.

M sand

Manufactured sand is an alternative to river sand. Its have 50% to 60% of silica content. So it is used to replace the silica sand for ECC. Silica is hard, chemically inert and has a high melting point, attributable to the strength of the bonds between the atoms. The copper and zinc at some smelter use the sand as a fluxing agent which, in the molten state, reacts with various impurities in the ore and produces a slag.

Fly Ash

Fly ash contributes in a number of ways, including strength and durability. While flyash tends to increase the setting time of the concrete. The pozzolanic reaction removing the excess calcium hydroxide, produced by the cement reaction, and forming a harder CSH the present-day world is witnessing the construction of very challenging and aesthetic structures. Fly ash is a beneficial mineral admixture for concrete.

Sulphonated melamine-formaldehyde (Super (SUPERPLASTICIZERS)

Sulphonated melamine-formaldehyde condensates: These are polymers with the value of n (the condensation number) usually in the range 50-60, giving a molecular weight in the region of **20,000.** The calcium or alkali metal salts are employed in the admixture, the latter having the superior water-reducing capability. The basic repeating unit of the lignosulphonate molecule has a complex phenyl-propane skeleton. Substituent groups vary and may include phenolic, carboxylic and methoxy substances in addition to sulphonate. In solution, the molecule coils into a spherical configuration, with anodized groups at or near the surface.

3. MIX PROPORTION AND EXPERIMENTAL INVESTIGATION

Conventional Mix Design

For this research work, M20 grade concrete is using and tests will conduct for proportions. The process of selecting suitable ingredients of concrete and determine their relative amounts with the objective of producing a concrete of the required strength, durability and workability as economically as possible, is termed the concrete mix design the proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely plastic and hardened states if the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

Engineering Cementitious Concrete Design

This is a most rational approach to the selection of mix proportions with a specific material in mind possessing more or less unique characteristic, however, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance.

Table-1: The Conventional Concrete Mix Proportion

Cement	Fine aggregate	Coarse aggregate	water
350 kg/m^3	785 kg/m^3	1117 kg/m^3	186 kg/m^3
1	2.243	3.191	0.53

Table-2: The ECC mix Proportion

Cement	Silica sand	Fly ash	water	Polypro-pylene fiber	Melamine formaldehe sulphonate
452 kg/m^3	452 kg/m^3	452 kg/m^3	199 kg/m^3	2%	9.03kg/m^3

4. MIXING PROCESS

Conventional Concrete Mixing

The Mix design Concrete is to be done. Then to be the measured material of concrete with proportions. They are mixed well with the minimum amount of water content because to add the Ecc, its have a plasticizer to balance the mix. This mix is done with a hand mixer or machine mixer.

Engineering Cementitious Concrete Mixing

The fixed amount of material weight ages. Hereafter to be added the materials one by one into the mixer. In this mixing process to be essential to use a mixer. First to be added and mix well Fly ash and M sand, after tat to be added Plasticizer. After that, the mixer is to be mixed with 20 to 25 rpm speed. Atlast the Polypropylene Fiber is to add and mixed well. In this process take a 10 to 15min time. In main effectiveness of Ecc is based on mixing process.
After the complete those process of mixing. The two type of concrete is to be mixed with a proportion of abstract. In this process are completed with in 15min.

Mixing process of ECC and Conventional Concrete

The casting of concrete:

Steel moulds of cubes (0.15×0.15×0.15m), cylinder (diameter of 0.15m and height of 0.3m) and prism (length is 0.5 and depth is 0.1m) were coated initially with oil as to enable easy removal of the moulds. The surface was cleared off.The moulds were placed on an even surface. The moulds were tightened well on all the sides so as to prevent the bulking of the specimens once the concrete is poured inside. In this process is to be done after the good mixing of that concrete.

Casting process

5. CURING PROCESS

Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth and hear the surface, for extended periods of time. After 28 days of curing process to get good result of an concrete strength.

Curing process

6. TEST SETUP

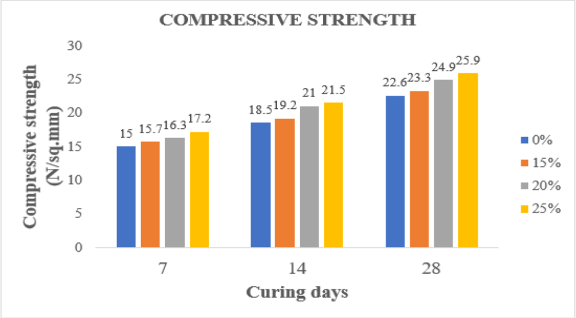
Compressive strength:

The concrete specimens of the cube are tested by compression test machine after the curing period of 24 hours. The load should be applied gradually at the rate of 140 kg/cm^2 per minute, till the specimens fail. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Compression Test

Table-3: Compression Test Result

Replacement Details	Average 7thday compressive Strength (N/mm ^{2})	Average 14thday compressive Strength (N/mm ^{2})	Average 28thday compressive Strength (N/mm ^{2})
Nominal Mix	15	18.5	22.6
ECC Concrete (15%)	15.7	19.2	23.3
ECC Concrete (20%)	16.3	21	24.9
ECC Concrete (25%)	17.2	21.5	25.9



Result Bar Chat

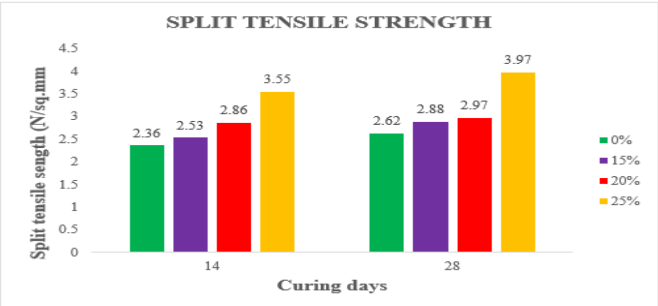
Split Tensile Strength:

Apply the load continuously without the shock at a rate of approximately 14 to 21 kg/cm^2 per minute which corresponds to a total load of 9900 kg/min to 14850 kg/min note down the failure or breaking load.

Split Tensile Strength Test

Table-4: Split Tensile Test Result

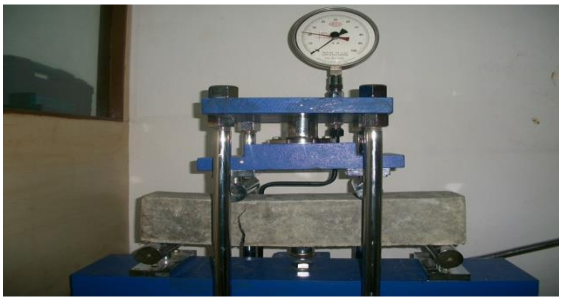
Replacement Details	Average 14th day Split Tensile Strength(N/mm ^{2})	Average 28th day Split Tensile Strength(N/mm ^{2})
Nominal Mix	2.36	2.62
ECC Concrete (15%)	2.53	2.88
ECC Concrete (20%)	2.86	2.97
ECC Concrete (25%)	3.55	3.97



Result Bar Chat

Flexural strength:

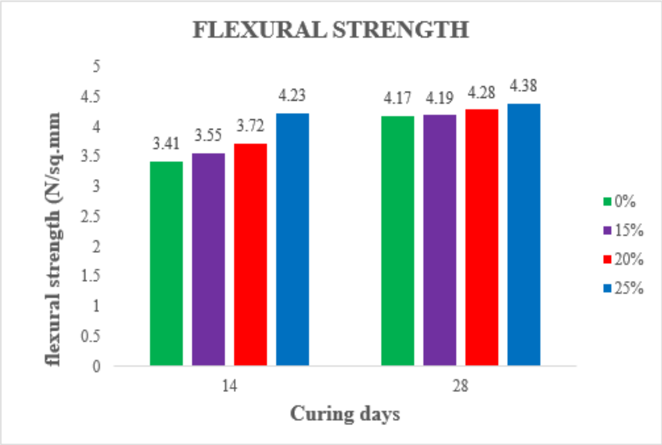
The flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand a failure in bending. The flexural test on concrete can be conducted using either three-point load test (ASTMC78) or center point load test (ASTM C293).



Flexural Strength Test

Table-5: Flexural Strength Result

Replacement Details	Average 14th-day Flexural Strength (N/mm²)	Average 28th-day Flexural Strength (N/mm²)
Nominal Mix	3.41	4.17
ECC Concrete (15%)	3.55	4.19
ECC Concrete (20%)	3.72	4.28
ECC Concrete (25%)	4.23	4.38



Result Bar Chat

7. RESULTS

Compression strength result

- ECC Concrete (15%), the compressive strength has increased to about 22.6 N/mm^2 from 23.3 N/mm^2 when compared to conventional concrete.
- ECC Concrete (20%), the compressive strength has increased to about 22.6 N/mm^2 from 24.9 N/mm^2 when compared to conventional concrete.
- ECC Concrete (25%), the compressive strength has increased to about 22.6 N/mm^2 from 25.9 N/mm^2 when compared to conventional concrete.

Flexural Strength Result

- ECC Concrete (25%), the flexural strength has increased to about 4.17 N/mm^2 from 4.19 N/mm^2 when compared to conventional concrete.
- ECC Concrete (25%), the flexural strength has increased to about 4.17 N/mm^{2}from 4.28 N/mm^2 when compared to conventional concrete.
- ECC Concrete (25%), the flexural strength has increased to about 4.17 N/mm^{2}from 4.38 N/mm^2 when compared to conventional concrete.

Split Tensile Strength result:

- ECC Concrete (15%), the split tensile strength has increased to about 2.62 N/mm^2 from 2.88 N/mm^2 when compared to conventional concrete.

- ECC Concrete (20%), the split tensile strength has increased to about 2.62 N/mm^2 from 2.97 N/mm^2 when compared to conventional concrete.

- ECC Concrete (25%), the split tensile strength has increased to about 2.62 N/mm^2 from 3.97 N/mm^2 when compared to conventional concrete.

Failures Stages of Specimens

After the testing process of Specimens

8. CONCLUSIONS

The various investigations carried out by several authors related to the development of Engineered Cementitious Composite (ECC) and its applications in the real world proves to be one of the best sustainable concrete materials of the future generations.Compared to conventional concrete the ECC concrete is much tougher and has good compressive strength for 7 days and 28 days and the split tensile strength of the ECC concrete was better when compared to the conventional concrete ECC can be accepted as a virtually crack-free concrete, and it is expected to aid in extending the service life of concrete structures exposed to severe environments. Concrete is one which extremely accepted as a vital component of today's society and is being used in various and different infrastructures that are very critical for the flawless and comfortable function of the world. Due to the property of very strong in compression yet comparably weak in tensile nature of cement concrete resulted in the development of Engineered Cementitious Composite with unique and distinctive properties of self-healing, high, tensile strength and ductility where tensile strength is almost 500 times that of standard concretes.

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