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Experimental Study on Flexible Concrete

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Abstract*: Our project deals with comparative study on flexible concrete with conventional concrete. Conventional concrete is composed of all traditional components which is almost unbendable and makes them highly brittle and rigid. This causes failure under strain .To overcome this type of failure flexible concrete is preferred. Flexible concrete is also known as engineered cementitious composite or bendable concrete. Flexible concrete is composed of all traditional concrete minus and it reinforced with polymer fibers. Fibers are reinforced in concrete to control and reduce the cracks due to plastic shrinkage and drying shrinkage. In our project we used poly vinyl alcoholic fiber to increase the flexibility and strength of concrete. The amount of fiber added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" typically ranges from 0.1 to 3%. super plasticizers are added to reduce the water content in the mixture and to increase the workability of concrete . Flyash coupled with ordinary portland cement to increases the binding property which is suitable for cementitious application. In this experimental work, two different mix proportion of fibers are added. The flexural strength and compressive strength of slabs and cubes is determined and also the flexibility characteristics of the concrete are checked during flexural strength test.

***Keywords*: polymer fibers, binding property, mix proportion, flexural strength.**

I. INTRODUCTION

The term Flexible concrete consist of special type of materials that makes it flexible is Engineered Cementitious Composite (ECC). It exhibits the property of a ductile material instead of a brittle material which is shown by the conventional concrete. For giving the concrete flexibility we have to alter the material of the conventional concrete. In the flexible concrete we eliminate the coarse aggregate. Instead of that we use the fibres that are used in the fibre reinforced concrete such as silica fibres, glass fibres, steel fibres, asbestos fibers, polyvinyl alcohol fibers, etc. The micro fibres provide the flexibility to the concrete. It also acts as a reinforcement material in the concrete. The basic difference in the properties of engineered cementitious composite and fiber reinforced concrete is that after cracking the engineered cementitious composite strain hardens while the fiber reinforced concrete does not exhibit such behaviour. In fiber reinforced concrete, the crack develops with the rupture of the fibers due to which the stress bearing capability is decreased. In addition, the engineered cementitious composites have a high fracture toughness that is similar to that of aluminium alloys, and the damage tolerance is extremely high. 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.

A. Fiber

Fibers are used in concrete for a variety of reasons, but not all fibers do the same thing or have the same effect. They can be used for reinforcing or can be used to prevent shrinkage and cracking.

1) When fibers are used for improving the flexural/tensile properties of the concrete, this is known as primary reinforcing.
2) When fibers are used for plastic shrinkage control, and to prevent crack creation and propagation in the cement matrix by bridging the microcracks, it is known as secondary reinforcing.

The choice of what fiber to use depends upon a variety of factors. In commercial construction, cost is often the primary factor, as most fibers are used for secondary reinforcement reasons. For concrete countertops and other creative concrete applications, the cost of the fiber is often less important than the effect of the fiber on the concrete's performance and on its appearance. Additionally, different mixes are best suited for different fibers. GFRC fibers must be used in high volumes, so the mix is built around a specific fiber used in a specific dose. ECC is the same way, but with different mix proportions and very different fibers.

B. Poly vinyl Alcohol Fiber

PVA fibers are used in ECC to provide both structural strength and shrinkage control. The combination of well-dispersed, micro PVA fibers and the strong, fine-grained homogeneous matrix is what results in the amazing ability of ECC to bend and crack without losing strength. Because of the highly dispersed microfibers, cracks tend to be small, and sometimes even invisible. ECC is a complex composite of PVA fibers, 1% to 2% of total mix weight, in a properly engineered mix utilizing very fine aggregates.

PVA fibers are transparent, short (only 6-8mm long), and their diameter is a fraction of the diameter of a human hair, they disappear in the mix. This greatly simplifies mixing and casting, as there is no need for a separate face coat. ECC can be made stiff and hand-packable, or, it can be made fluid and vibrated. Casting is faster and more efficient, as molds can be filled in one continuous pour, rather than in individual layers. The composite design of PVA fiber is due to its hydrophilic nature. The main objective of this paper is to provide a performance summary of an exemplary ECC-PVA.

Poly Vinyl Alcohol Fiber

C. Advantages of Flexible Concrete:

1) Flexible concrete is more Stronger, more durable, ductile and lasts longer than conventional concrete.
2) Flexible concrete is not brittle like a glass.
3) It does not emit that amount of harmful gases as compared to conventional concrete.
4) It is more resistant to cracking. The flexible concrete is approximately 20 - 40 percent lighter than conventional concrete. It can be used as precast concrete.
5) The use of steel reinforcement is reduces and can be eliminated

II. METHODOLOGY

A cube size of 150 x 150 x 150 mm and slab sizes of 700 x 150 x 30 mm, 700 x 150 x 60 mm is used to make cube and slabs of various mixes respectively. Mix ratio for different mixes is taken and calculated. Material was collected by properties are observed by various tests. Material are batched for mixing as per mix design and mixed uniformly. Fresh concrete tests are done by slum test. It is then casted in cube of 150 x 150 x 150 mm mould and compacted with a tamping rod. Slabs are casted as per above mentioned dimensions and compacted with tamping rod. The specimens allowed for curing and tested periodically 7^{th} day and 28^{th} day. The compressive strength and flexural strength of the specimens is tested.

III. MATERIALS

A. Engineered cementitious composite is composed of,

1) Cement (53 grade of OPC)
2) Super plasticizer
3) PVA fibre (length is 12mm and diameter is 40µm).
4) Sand
5) Water

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 contradicts the property of ECC Concrete.

B. Preliminary Testing

We have tested all the materials that we collected i.e cement, coarse aggregate, fine aggregate etc in a correct manner without any errors.

C. Cement

Cement must develop the appropriate strength. It must represent the appropriate rheological behaviour. Generally some types of cement have quite different rheological and strength characteristics, particularly when used in combination with admixtures and supplementary cementing materials. Ordinary Portland cement (53grade) was used for casting all the specimens.

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1) *Standard Consistency Test :* The standard consistency of a cement paste is determined by vicat's apparatus and the result was found to be 560 min.

Test on standard consistency of cement

SI.NO	weight of cement(g)	% of water added (in terms of weight of cement)	Volume of water added (ml)	Reading on gauge (mm)
1	400	24	100	33
2	400	26	112	19
3	400	28	116	13
4	400	30	124	7

2) *Compressive Strength Of Concrete Cube:* The compression test of cube was determined by CTM equipment.

Compressive strength test of cement mortar cube (28^{th} days)

SI.NO	Load (KN)	Compressive strength (N/mm)
1	310	55.11
2	304	54.04
3	300	53.33
	Mean compressive strength (28 days)	54.16

D. Fine Aggregate

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm sieve will be used for casting al the specimens. The following experiments were conducted to find out the properties of fine aggregates as per IS-2386

1) *Specific gravity of fine aggregate:* The specific gravity of coarse aggregate is determined by using pycnometer and the result was found to be 2.69.

2) *Absorption test :* To determine the water absorption of fine aggregates as per IS : 2386 (Part III) 1963. It is determined by pycnometer an the result is 0.91%.
3) *Sieve analysis:* The main aim of this test is to find the fineness modulus of fine aggregate, Grading of fine aggregate (as per IS 383:1970) fineness modulus is 2.76

E. Super Plasticizers

Super plasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics of suspensions such as in concrete applications.

Super plasticizers

E. Flyash

Fly ash is a byproduct from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. The fine powder does resemble portland cement but it is chemically different. Fly ash chemically reacts with the by product calcium hydroxide released by the chemical reaction between cement and water to form additional cementitious products that improve many desirable properties of concrete. All fly ashes exhibit cementitious properties to varying degrees depending on the chemical and physical properties of both the fly ash and cement. Compared to cement and water, the chemical reaction between fly ash and calcium hydroxide typically is slower resulting in delayed hardening of the concrete.

VI. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible.

GRADE OF CONCRETE=M25

A. Mix Proporation Of Ecc

Size of slab	700 x 150 x 30mm
Weight of cement	550 kg/m³
Volume of slab	3.15×10^{-3} m³
Weight of cement	1.73kg
Weight of fine aggregate	2.5kg
Weight of fly ash	2.5kg
Amount of super plasticizer	30ml
Weight of PVA fibre	0.06kg
Amount of water	630ml

1) *Batching:* Batching is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture.
2) *Mixing:* Mixing of concrete needs careful conditions to avoid segregation and the difficulty of mixing the materials uniformly. Increase in the aspect ratio, volume percentage, size and quantity of fine aggregate intensify the difficulties and balling tendencies.



Step1: cement+flyash+sand. Step2:cement+flyash+sand+PVA. Step3:+super plastizicers+water

3) *Casting*


Casting of cube casting of slabs

4) *Curing:* The cube specimens are remolded after 24 hours. Necessary identification marks were made and kept under water in a curing tank. The concrete beams were kept under water for 28 days. After curing, they were taken out from the curing tank and air dried before testing.


Curing of concrete cubes Curing of slabs

V. TESTS & RESULTS

A. Compressive strength of concrete cube

The compression test of cube was determined by CTM equipment.

Compression test of a cube

Compression strength test	Curing period	Ultimate load Applied (KN)	Area (mm^2)	Compressive strength (N/mm^2)
Conventional concrete	7^{th} day	585	22500	26
	28^{th} day	904	22500	40.2
Flexible concrete	7^{th} day	612	22500	27.2
	28^{th} day	936	22500	41.6

Comparison of flexible concrete and conventional concrete cubes

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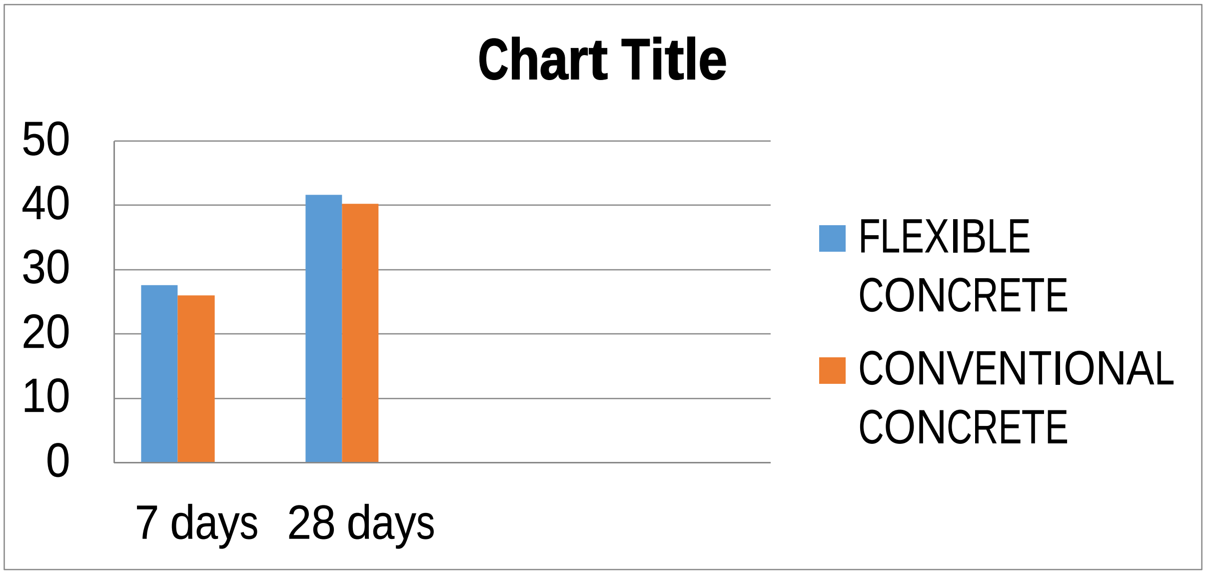
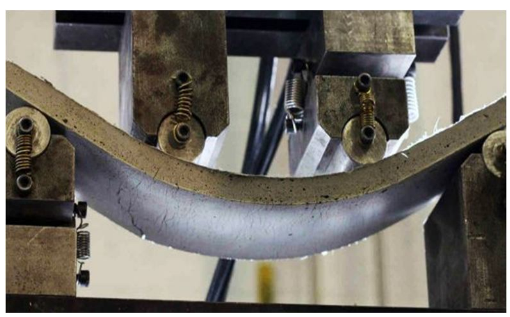
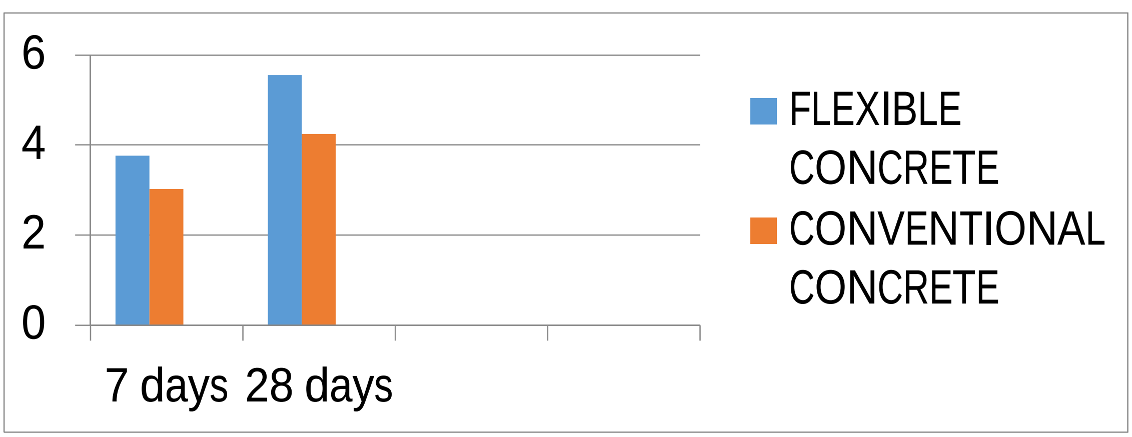


B. Flexural strength of Concrete slab

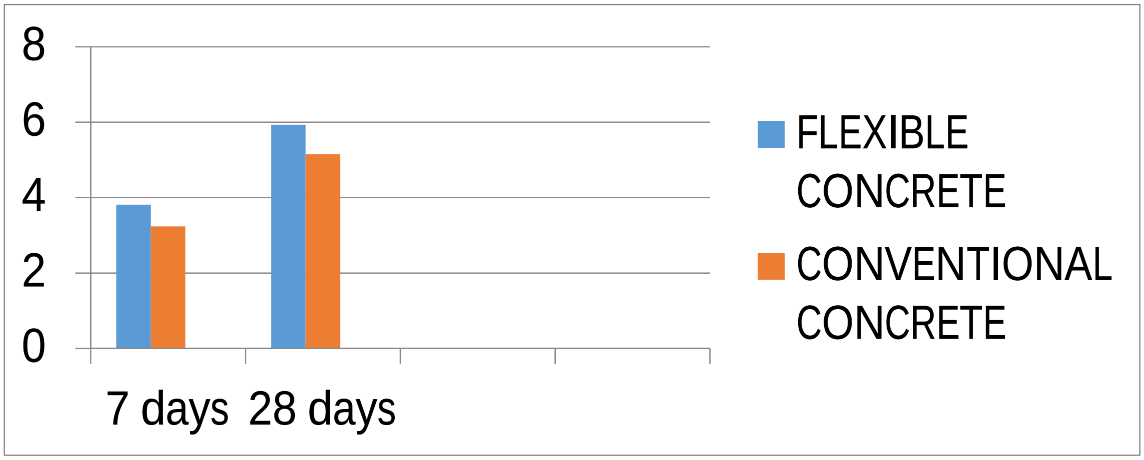
Flexural strength (N/mm²)			
Slab size	Curing period	Flexible concrete	Conventional concrete
700 x 150 x 30 mm	7th days	3.76	3.03
	28th day	5.56	4.24
700 x 150 x 60 mm	7th days	3.81	3.20
	28th day	5.92	5.15



Testing of slab



Slab (30mm) Average Flexural Strength N/mm²



Slab (60mm) Average Flexural Strength N/mm²

VI. CONCLUSION

This experimental study was carried out to determine the mechanical properties of adding poly vinyl alcoholic fiber in concrete. In this regards, comparison of compression strength and flexural strength of the flexible concrete is higher than the conventional cubes and slabs. The mix proportion of flexible is derived in this experimental study. The reason behind the strengths of flexible concrete is due to the presence of PVA fiber as reinforcement. The strength of conventional cubes and slabs is low, since it is not reinforced. Therefore it is proved that the flexible concrete is more strength than the conventional concrete and it is more flexible so that it resists cracks and acts as more efficiency in seismic regions.

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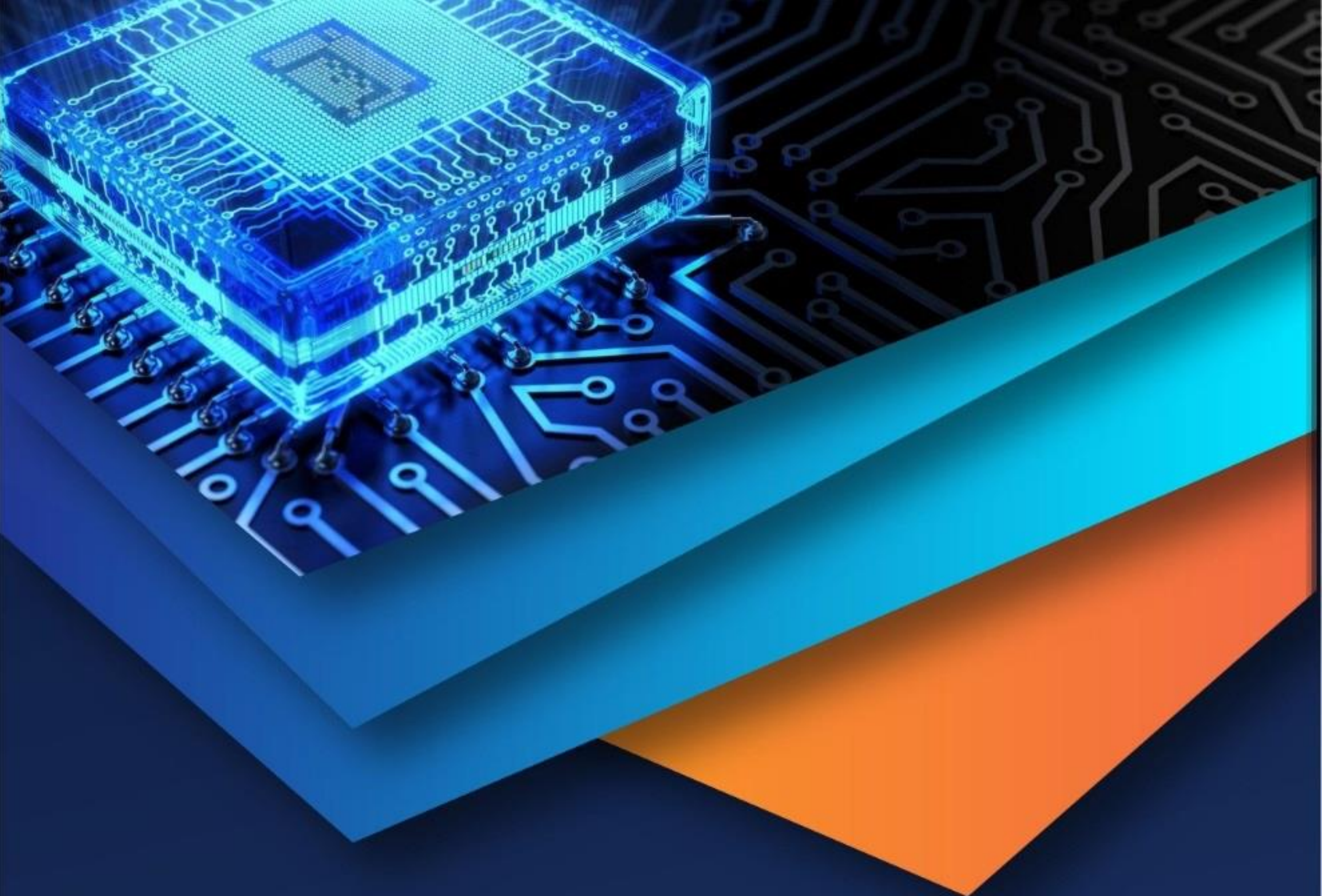

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