iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VI **Month of publication:** June 2019

DOI: http://doi.org/10.22214/ijraset.2019.6219

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

Experimental Study on Flexural Behavior of Engineering Cementitious Composite as Bendable Concrete

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***Abstract:** This paper describes the comparison between Conventional Concrete and ECC Concrete (Bendable Concrete). ECC Concrete also known as Engineered Cementitious Composites shortened as ECC. Conventional concrete have high compressive strength, low tensile strength, unbendable, rigid and brittle. ECC have bendable properties and can be bending up to certain limits. ECC control the micro cracks and sustain higher loads than conventional concrete. This project consists of different sets of tests such as slump test, compression test, and flexure test. Also the ECC is compared with conventional concrete with respect to its strength parameters.*
***Keywords:** Bendable concrete, Engineering Cementitious composite, Compressive strength, Flexural Strength.*

I. INTRODUCTION

Concrete is widely used as artificial material. It plays very important role in the civil engineering. Concrete is a rigid material and cracks easily when tensile load applied on it. Concrete is a solid form gained from a mixture of cement, sand, gravel or water with the proper mix proportion. Conventional concrete has micro voids. These micro voids turn in to large voids when load is applied. Concrete is rigid and brittle material, having no chance to bending. Due to this behavior cracks develop and lead to strain of concrete. In recent times, researchers have turned such conventional concrete into flexible concrete. For giving the concrete ductility we have to modify the material of the conventional concrete. This type of concrete is more ductile than conventional concrete and known as Engineered Cementitious Composites shortened as ECC. ECC Contains stuff of a ductile material as an alternative of a brittle material .For making ECC we use fibers as reinforcing material and eliminate coarse aggregates from conventional concrete. As a substitute of that we use the fibers that are used in the fiber reinforced concrete such as silica fibers, glass fibers, steel fibers, asbestos fibers, polyvinyl alcohol fibers, Nylon Fiber, Polypropylene fiber etc. It also performed as a reinforcement material in the concrete. We have used hooked steel fiber, Nylon Fiber, Polypropylene fiber and water reducing agent Conmix SP1030 as a plasticizer

A. Fibers

1) *Hooked Steel Fiber:* Hooked steel fibers addition into the concrete for improve the ductility or crack resisting capacity of the concrete. Traditional bars of steel are usually improve the tensile property of concrete in such a certain direction, but the hooked steel fibers are improve same properties in multiple direction. Hooked steel fiber we used with the size of 30mm in length and 1mm of diameter. The selection of hooked steel fibers is relative to the high performance of concrete. Percentage of Hooked Steel fibers is added in mix is 1% by weight of the cement.

Hooked steel fiber

2) *Polypropylene Fiber:* Polypropylene fibers are improved tensile strength, compressive strength and durability of concrete. The workability of concrete is decreased when using of Polypropylene fibers because of absorption of water and hence reduce the slump value of concrete. Polypropylene fibers are 20mm long or 0.35mm diameter. The threads of Polypropylene fibers decrease plastic shrinkage cracking it can be monitor when the concrete apparent is permissible to dry quickly.

Polypropylene fiber

3) *Nylon Fiber:* Nylon fiber is formed by forceful heated nylon over and done with small beginnings in a scheme named a spinneret the nylon pieces formerly stabilize strong on a thread afterward they are showing to appearance. These threads are moulded keep on rolls and stressed after they have cooled down. A procedure known as illustration unknots the thread. Length of Nylon fiber is 12 mm used. These process changes the constituent part in the thread arrangement similar appearance, which provides the nylon fiber with its elasticity, strength and resistance. Nylon is an artificial synthetic fiber that is strong, durable whereas very light in weight, properties that main to an extensive variety of uses such as textile, cable and baggage.

Nylon fiber

II. METHODOLOGY

Cube size of 150 x 150 x 150 mm and slab sizes of 700 x 150 x 30 mm, 700 x 150 x 50 mm is used to make cube and slabs of concrete or ECC mixes respectively. Mix proportion for altered mixes is taken and designed. Design mix M25 for concrete and ratio proportion 1: 2.67 with W/C ratio of 0.40 for Engineered Cementitious Composite. Material was composed by properties are detected by various tests. Materials are mixed as per mix design and mixed equivalently. Slump test also done for calculate workability of concrete. It is then casted in cube of 150 x 150 x 150 mm moulds and compressed with a tamping rod it is also done for slab size 700 x 150 x 30 and 700 x 150 x 50 mm for ECC mix. Slabs are casted as per bring up dimensions and compacted with tamping rod. After curing specimens are tested at 7 days and 28 days. The compressive strength and flexural strength of the specimens is tested.

III. INGREDIENTS OF CONCRETE MIX

A. *Engineered Cementitious Composite And Concrete Mix Is Composed Of*

In the ECC mix, coarse aggregates are intentionally not used for the reason that property of ECC Concrete is development of micro cracks with large refraction. Coarse aggregates increases crack width which disputes the stuff of ECC Concrete. Here coarse aggregate are used only for cube casting with or without fibers.

1) *Cement:* Portland Pozzolana Cement is component of cement which is formed by manufacturing Ordinary Portland Cement with pozzolanic material in certain amount. It is generally known as PPC cement. Pozzolana is a natural or non-natural material which has silica in the sensitive form. Portland Pozzolana Cement manufactured by mixing Pozzolanic material. This cement contains of OPC clinker, gypsum and pozzolanic materials in certain amount. PPC contain siliceous and aluminous material. PPC cement is eco-friendly or made of natural recycle waste. It contains siliceous material which decreases the cost and makes it efficient without changing the properties of cement.
2) *Fine Aggregate:* Fine aggregate is natural or artificial sand which has been washed and sieved to remove large size particle from the fine aggregate. Fine aggregate is important ingredient in concrete. The quality and density strongly impact toughened properties of concrete. It is well-known from gravel only by the size and shape of the particles. But it is different from clay which contains organic material.

3) *Coarse Aggregate:* Aggregate are the inert ingredients that are mixed in proportions with a mandatory material to produce concrete. These act as fillers or volume increasing ingredients on the responsible for the strength, durability and toughness of the concrete.
4) *Plasticizers:* Plasticizer used is Conmix SP1030 which is chloride free and admixture based on selected sulphate naphthalene polymers. It is delivered as a dark brown solution which is directly disperses in water.
5) *Water:* Water used for mixing and curing shall be clean and free from acids, alkalis, oils, salts and other organic impurities.

IV. MIX DESIGN

Concrete mix design is the procedure of calculating the proportions of concrete mix in expressions of ratio of cement, fine and coarse aggregate. The concrete mix design amounts are either by mass or by volume. The water-cement ratio is commonly conveyed in mass.

Design Mix of M25 grade for concrete 1 m^3

Sr. No.	Ingredients	Quantity per m^3 (Weight/Volume)
1	Cement	493 kg
2	Fine aggregate	670.80 kg
3	Coarse aggregate	1115.94 kg
4	Water	197.2 Litre
5	Fibers (Polypropylene, Nylon and Hooked steel fiber)	2.465, 2.465 & 4.93 kg
6	Plasticizers	9.86 Litre

Design Mix of ECC 1:2.67 for 1m^3

Sr. No.	Ingredients	Quantity per m^3 (Weight/Volume)
1	Cement	637.92 kg
2	Fine aggregate	1701.12 kg
3	Water	255.168 Litre
4	Fibers (Polypropylene, Nylon and Hooked steel fiber)	3.189, 3.189 & 6.379 kg
5	Plasticizers	12.758 Litre

A. Mixing

Mix a normal, minor batch of concrete will takings around 10-20 minutes generally. For hand mixing, the ingredients are set on a water-tight stage, which may be also of wood, steel or brick. The materials should be systematically mixed, at minimum three times; in dry condition earlier water is additional. The ready mix should be expended in 30 minutes later addition water.

B. Casting

The cube mould plates should be detached properly scrubbed assembled and all the bolts should be completely tight. A thin coating of oil then shall be applied on all the faces of the mould. It is significant that cube side faces must be parallel. The concrete sample shall be filled up into the cube moulds in 3 layers, each layer around 5 cm deep.

C. Curing of Concrete

Curing of Concrete is a technique by which the concrete is secure counter to damage of moistness essential for hydration and retained inside the acclaimed temperature range. Curing will improve the strength and reduction the porousness of toughened concrete. Curing is the procedure of care the concrete moist to permit it to gain strength is called curing.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
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V. TEST AND RESULT

A. Compressive Strength Of Cube

The compressive strength of cubes test on compression testing machine equipment. Compressive strength is the capacity of material or structures to transmission the loads on its exterior without any crack or deflection. Compressive strength of concrete cube test delivers an indication about the physical characteristics of concrete.

Compression test of cube

Table 5.1 Compression Test Result

Type of Concrete	Testing Period	Ultimate load applied Avg. of 3 Cubes (Kn)	Area (mm^2)	Compressive strength (N/mm^2)
Conventional Concrete	7 Days	438.33	22500	19.48
	28 Days	635.00	22500	28.22
Bendable Concrete	7 Days	504.00	22500	22.40
	28 Days	760.00	22500	33.78

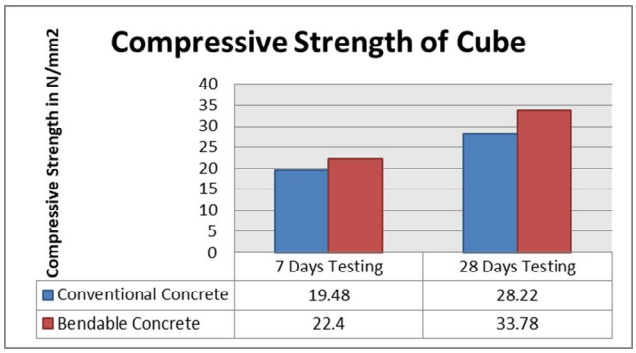

Figure 5.1 Compressive strength of Cube

B. Flexural Strength Of Slab

Flexural strength development varies with the thickness of concrete.

Testing of Flexural strength of slab

Table 5.2 Flexural Strength of slabs (N/mm^2)

Types of ECC	Testing Period	Flexural strength of Slab size 700×150×30 mm in (N/mm^2)	Flexural strength of Slab size 700×150×50 mm in (N/mm^2)
Conventional Concrete	7 day	2.55	3.81
	28 day	4.05	5.58
Bendable Concrete	7 day	3.81	4.95
	28 day	5.88	6.41

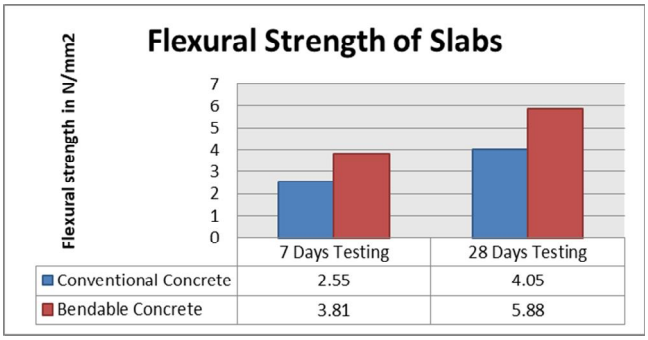

Figure 5.2 Flexural Strength of Slabs for 30mm thickness

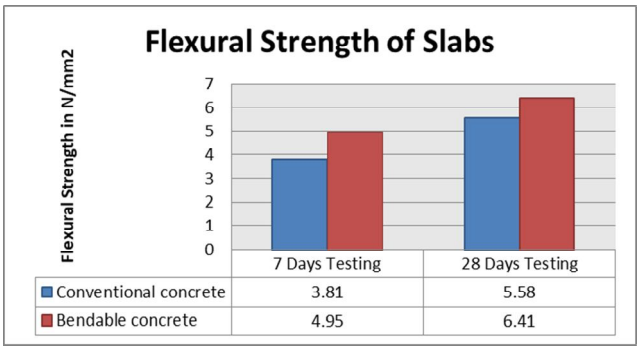

Figure 5.3 Flexural Strength of Slabs for 50mm thickness

VI. CONCLUSION

It can be determined that ECC has the more benefits over conventional concrete. It is experimental that ECC has high flexibility and hence is able to bend like a metal. It is observed that the addition of hooked steel, Polypropylene and Nylon fibers in the concrete mix, controlled the bleeding of fresh concrete. With the addition of hooked steel, Polypropylene and Nylon fibers, the concrete mix becomes harsher and not as much of workable. The compressive strength of the concrete cube with hooked steel, Polypropylene and Nylon fibers increase up to 20% by conventional concrete. The Flexural strength of ECC slabs increase up to 45% with hooked steel, polypropylene and nylon fibers.

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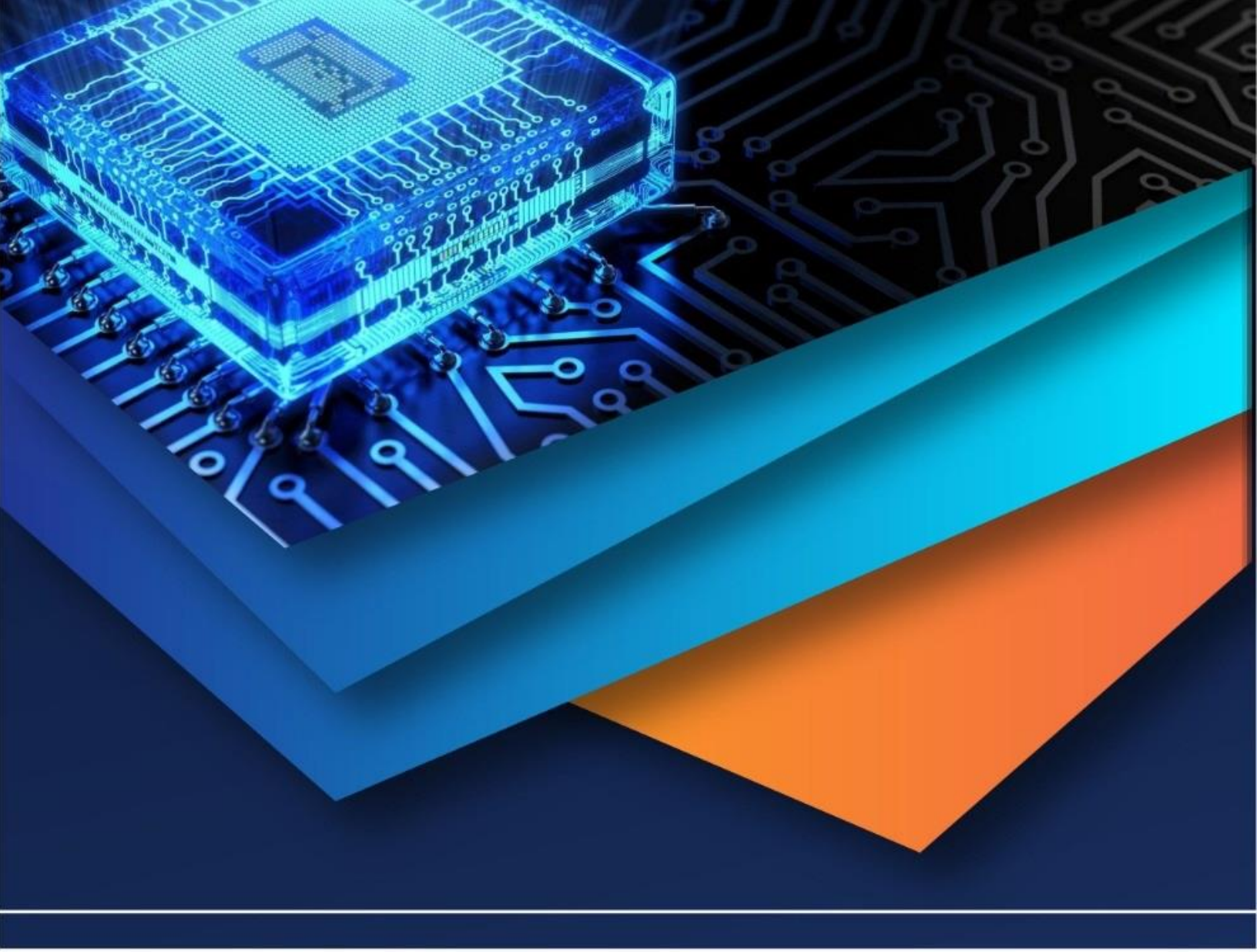

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