EXPERIMENTAL INVESTIGATION OF STRENGTH PROPERTIES OF FLEXIBLE CONCRETE USING PLASTIC FIBERS

Abstract

This Study Intents to analyze the performance of flexible concrete reinforced with plastic fibers which are extracted from plastic wraps and PET bottles with a proper aspect ratio. The development of the flexible concrete is due to the low strain capacity of conventional, brittle nature and rigidity. The flexible concrete advances the flexibility and resistance to strain failure and this research project focuses on experimentally investigate the strength properties of flexible concrete. The concrete mixture consists of same fundamental materials as that of conventional concrete and the micro plastic fibers are incorporated to reinforce the flexible concrete. The significant issue with flexible concrete is less compressive strength than of conventional concrete to address this problem and to reduce the development of cracks in concrete the Pozzolana Portland Cement (PPC) is employed instead of Ordinary Portland Cement (OPC) due to its low heat of hydration and presence of cementitious materials that refines the compressive strength of flexible concrete. Additionally, High Water Reducing Agents (HRWR) are used to enhance workability. The pollution caused by plastics is drastic and hazardous causing threat to environment and human existence. For sustainable development and also reflecting upon the prompt demand on concrete, the plastic wraps are used as plastic fibers to minimize the pollution to an extent possibility. The investigation involves testing concrete cubes, beams and cylinders to evaluate strength properties by % addition of plastic fibers usually about 0.5%, 1%, 1.5% and also the flexibility characteristics of concrete are determined during flexural strength test.

Keywords: Flexible Concrete, Strain capacity, aspect ratio, plastic fibers, strength properties, super plasticizer.

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I. INTRODUCTION

Flexible concrete is also called as Engineered Cementitious Concrete (ECC) is futuristic construction material that access the surpassing flexibility and durability compared to conventional concrete. It is precisely designed to address the brittleness and limited strain capacity of standard concrete. In general, conventional concrete has high compressive strength but it also has low tensile strength, limited flexural strength, low resistance to formation of cracks that appear even before the load is applied as a result of volumetric changes resulting from shrinkage and temperature changes.

The materials used in the flexible concrete are same as that of conventional concrete expect the coarse aggregate is completely eliminated because the fundamental property of the flexible concrete is to reduce the formation of cracks whereas, the coarse aggregates tend to develop larger cracks which is not a prime property of ECC. The absence of coarse aggregates in flexible concrete assist to its upgraded flexibility and allowing to meet various design considerations and adapting to numerous construction challenges.

The addition of fibers to the concrete is one of the solution for this problems and it also enhances the properties of concrete. This addition of fibers to concrete is used in various applications such as industrial flooring, concrete paving, precast concrete, shotcrete and many other applications as well. Flexible concrete imparts high tensile ductility, enabling it to elongate and absorb energy in reaction to applied forces. This ductility property makes it exclusively convenient for applications where resistance to cracking and augmented ductility is vital like seismic- resistant structures.

II. METHODOLOGY

- Determining the material properties
- Design of concrete mix proportion
- Preliminary studies on mix proportion and plastic fiber content
- Study on workability of fresh concrete
- Casting of conventional concrete specimens and Flexible concrete specimens for varying fiber content
- Determining the strength properties such as compressive strength, flexural strength and split tensile strength of five series of flexible concrete.
- Comparison of properties of Flexible concrete with Conventional concrete.

III. MATERIALS USED

1. **Pozzolana Portland Cement (PPC):** The primary pozzolanic material used in PPC cement is usually fly ash. Fly ash is rich in silica and alumina, which react with calcium hydroxide in the presence of water to form additional cementitious compounds. This results in increased strength and durability of the concrete.PPC cement offers several advantages like better workability, improved resistance to cracks, reduced heat generation during hydration. It also exhibits slower initial setting time, allowing for extended workability periods. Additionally, PPC cement is more eco- friendly as it utilizes industrial by-products.

2. **Fine Aggregate:** Fine aggregate is typically composed of small particles, often smaller than 4.75 millimetres (mm) in size. It can consist of natural materials such as sand, crushed stone, or gravel, or it can be manufactured, such as with crushed rock fines or artificial sand.The primary function of fine aggregate in concrete is to fill the voids between the coarse aggregate particles, providing stability, workability, and strength to the mixture. It plays a crucial role in the overall performance of concrete by contributing to its density, workability, and durability.

3. **Plastic Fibers:** Plastic fibers offer several advantages, including their versatility, durability and resistance to chemicals and moisture. They can be easily produced in different shapes and sizes, additionally plastic fibers can be engineered to have specific properties such as flame resistance, UV resistance and antimicrobial properties.

4. **Super Plasticizer:** Superplasticizer, also known as a high-range water reducer, is a chemical additive used in concrete and cement mixtures to improve the workability and flow characteristics of the material. It is primarily used to reduce the amount of water needed to achieve a desired consistency while maintaining the desired strength and durability of the concrete. The use of superplasticizers offers several benefits, that includes the enhanced workability, high strength, improved durability.

IV. MIX PROPORTION

We reviewed various research journals and found that different mix proportions (1:2, 1:3, and 1:6) have been used for casting flexible concrete. In our experiment, we focused on the 1:2 and 1:3 mix proportions for evaluating the flexural strength of conventional beams after 7, 14, and 28 days of curing.

The results indicated that the beams cast with the 1:2 mix proportion exhibited higher strength compared to those cast with the 1:3 mix proportion. As a result, we decided to proceed with the 1:2 mix proportion for the remaining project phases to take advantage of its superior strength characteristics.

Concrete Placement:

1. **Mixing:** In this study, hand mixing is adopted. First clean the mixing area by removing all the dirt and debris. Now collect the materials required by ensuring good quality and accurately proportioned as per the mix design by weighing using measuring balance. Infuse the measured quantities of cement, Fine aggregates and mix the dry ingredients uniformly now incorporate the plastic fibers with different proportions into the dry mix with proper homogeneity. Add the water which is combined with superplasticizer to a precise dosage as per the W/C ratio and mix the whole matrix equitably using shovel.

Figure 1: Mixing of the Concrete

2. **Casting of Concrete Specimens:** After mixing all the ingredients is done in a required proportions, the concrete in its fresh state has to be cast into the cube, beam, cylinder specimens for both the conventional concrete and flexible concrete with varying proportions of plastic fibers. The specimens have to be corrected and fixed properly using bolts and nuts. The grease is applied all over the specimens before placing the concrete into the specimens. Now the concrete is added into 3 layers by properly tampered using a tamping rod for good compaction and to eliminate the air voids in concrete and once the concrete is filled into the specimens the surface is levelled using a trowel.

Figure 2: Casting of Conventional and Flexible Concrete Specimens

3. **Curing Process:** After the casting process of cubes, beams and cylinders specimens of conventional concrete and flexible concrete are completed leave the specimens for a day (24 hours). Then the concrete cubes, beams and cylinders are detached from the specimens and placed in the curing tank which is made ready previously before casting with good quality of water which are free from all the debris and is chemically inert. The concrete cubes, beams and cylinders are cured for the required days at subtle temperatures and are used for testing. These cubes, beams and cylinders are cured for 7 days, 14 days and 28 days.

V. RESULTS AND DISCUSSIONS

1. **Flexural Strength:** The prepared beam specimens of conventional concrete (M20, 1:2 and 1:3 proportion) and flexible concrete of 0.5%, 1%, 1.5% after casting and curing of 7 days, 14 days and 28 days are tested for Flexural strength using Flexural strength Testing Machine. Adjust the cube specimens under the load properly and apply the load gradually and record the values.

Table 1: Flexural Test Values of Conventional and Flexible Beams

S.no	Specimens	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
I	**Conventional Concrete**			
1	M20	3.23	3.89	4.24
2	1:2	3.42	4.10	4.38
II	**Flexible Concrete (% addition of fibers)**			
1	0.5	3.67	4.83	5.07
2	1	3.81	5.04	5.21
3	1.5	3.73	4.92	5.11

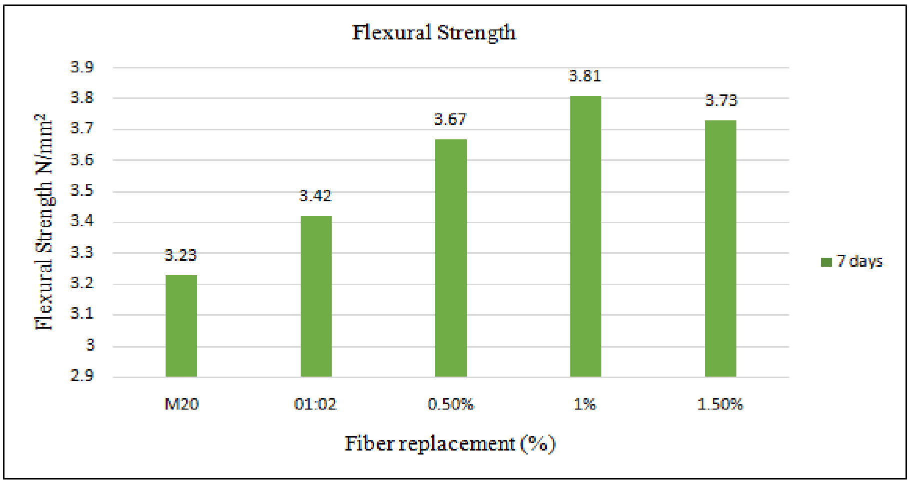

Figure 3: Flexural Strength Values of Conventional and Flexible Concrete for 7 days of Curing.

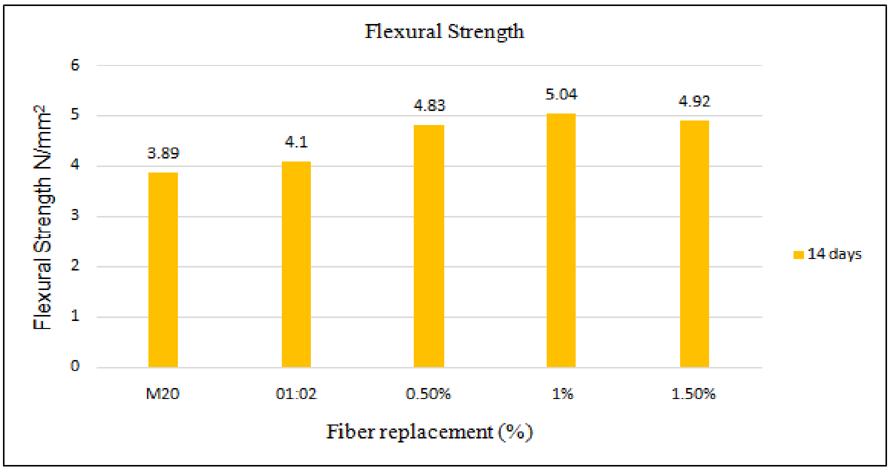

Figure 4: Flexural strength values of conventional and flexible concrete for 14 days of curing.

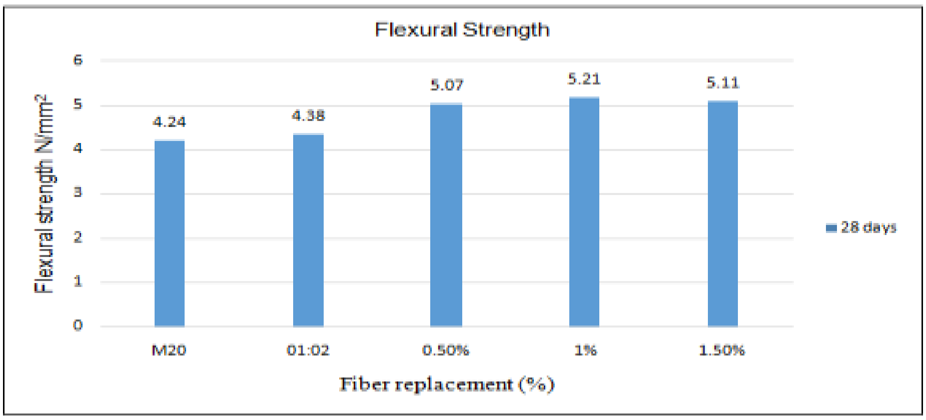

Figure 5: Flexural strength values of conventional and flexible concrete for 28 days of curing.

2. **Compressive Strength:** The prepared cube specimens of conventional concrete (M20 and 1:2 proportion) and flexible concrete of 0.5%, 1%, 1.5% after casting and curing of 7 days, 14 days and 28 days are tested for compressive strength using Compression Testing Machine (CTM). Adjust the cube specimens under the load properly and apply the load gradually and record the values.

Table 2: Compressive Strength Test Values of Conventional and Flexible Concrete.

S.no	Specimens	7 days (N/mm^2)	14 days (N/mm^2)	28 days(N/mm^2)
I	**Conventional Concrete**			
1	M20	22.23	29.78	31.11
2	1:2	24.45	28.88	33.34
II	**Flexible Concrete (% addition of fibers)**			
1	0.5	28.88	32.88	36.89
2	1	33.77	35.56	40
3	1.5	31.11	33.34	36.44

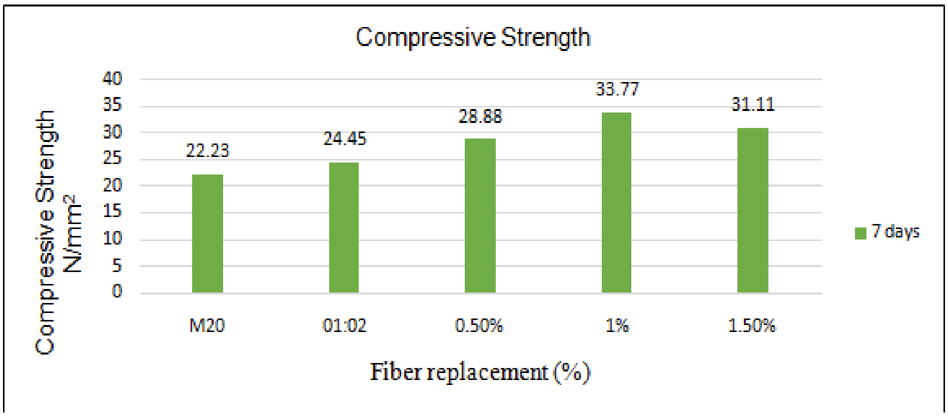

Figure 6: Compressive strength values of conventional and flexible concrete for 7 days of curing.

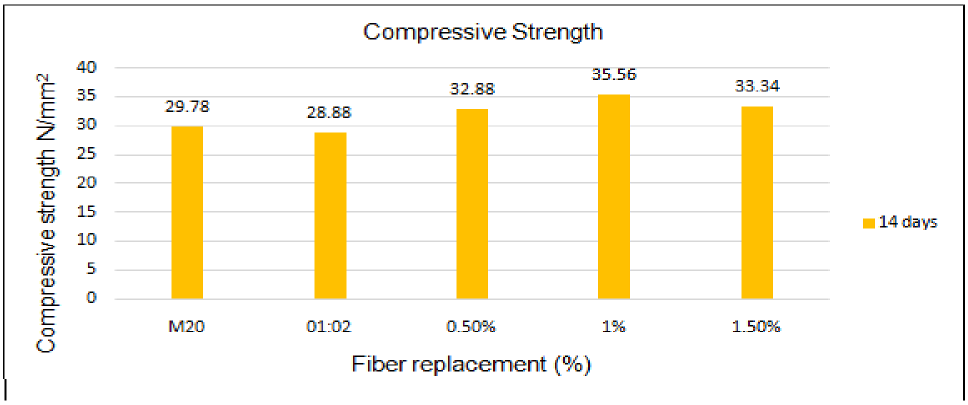

Figure 7: Compressive Strength Values of Conventional and Flexible Concrete for 14 days of Curing.

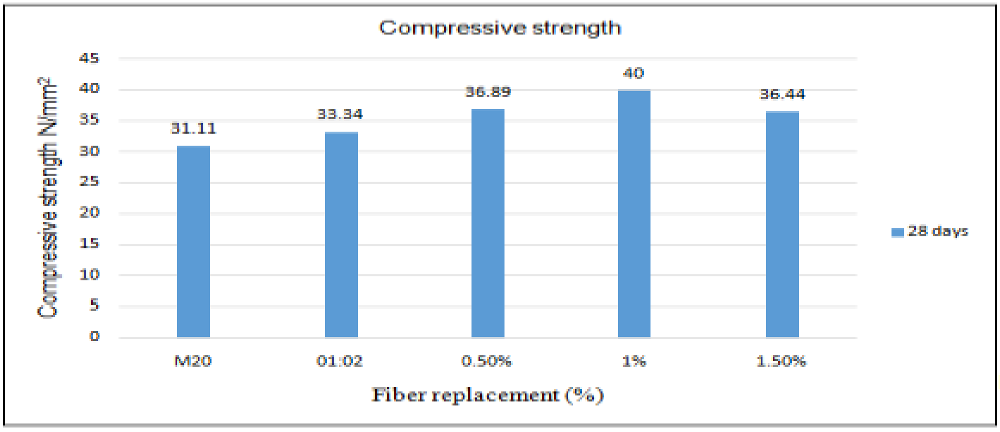

Figure 8: Compressive Strength Values of Conventional and Flexible Concrete for 28 days of Curing.

3. **Split- Tensile Strength:** The prepared cylinder specimens of conventional concrete (M20 and 1:2 proportion) and flexible concrete after casting and curing of 7 days, 14 days and 28 days are tested for split- tensile strength using Compression Testing Machine (CTM). Adjust the cube specimens under the load properly and apply the load gradually and record the values.

Table 3: Split- Tensile Strength Test Values of Conventional and Flexible Concrete

S.no	Specimens	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
I	**Conventional Concrete**			
1	M20	1.13	1.98	2.15
2	1:2	1.29	2.03	2.23
II	**Flexible Concrete (% addition of fibers)**			
1	0.5	1.32	2.05	2.58
2	1	1.58	2.4	3.08
3	1.5	1.48	2.26	2.84

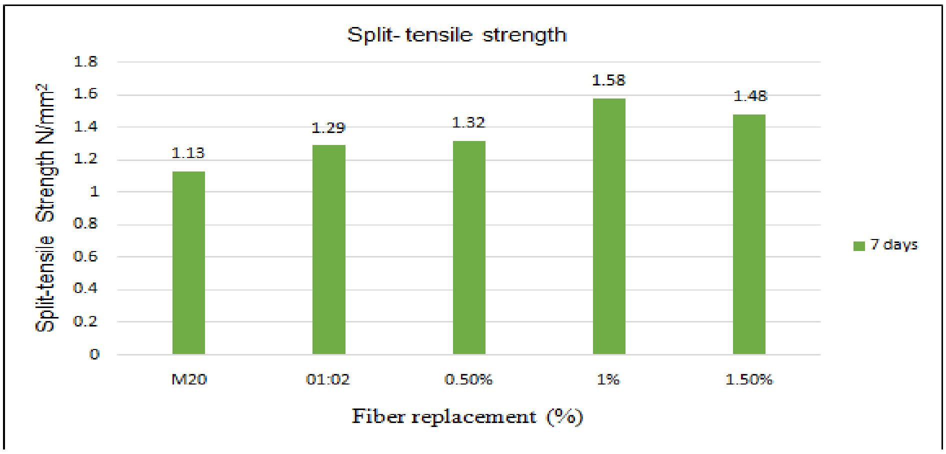

Figure 9: Split – Tensile Strength Values of Conventional and Flexible Concrete for 7 days of Curing.

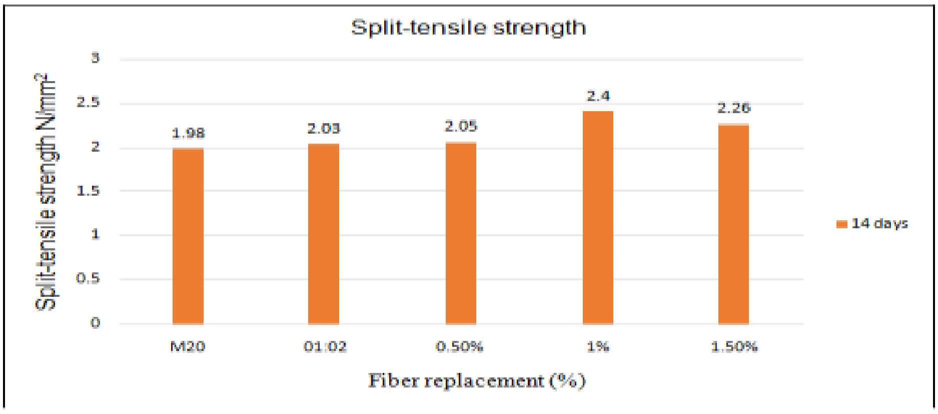

Figure 10: Split – Tensile Strength Values of Conventional and Flexible Concrete for 14 days of Curing.

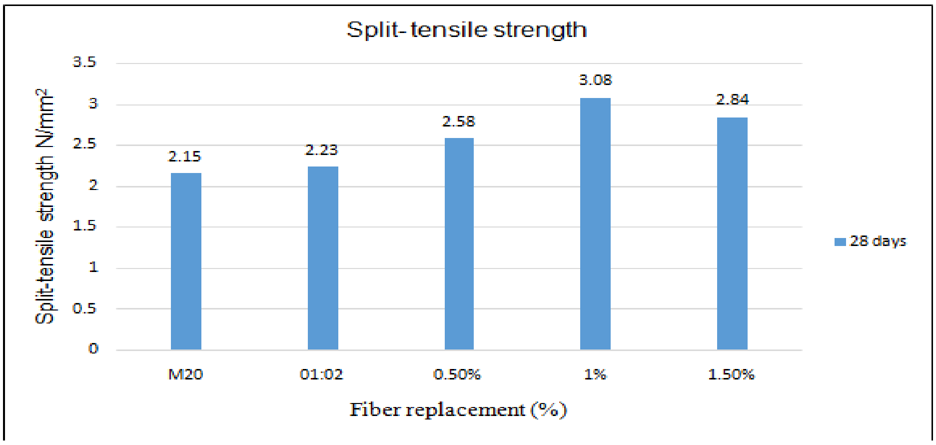

Figure 11: Split – Tensile Strength Values of Conventional and Flexible Concrete for 28 days of Curing.

VI. CONCLUSIONS

- From the observations on test results on cubes, beams and cylinders for 7, 14 days the Flexible concrete with 1% of addition of plastic fiber has shown optimum results compared to 0.5% and 1.5%. Therefore, the optimum content of plastic fiber to be used is 1% to the volume of concrete.
- The compressive strength of conventional concrete for 28 days of curing was attained as 33.34 N/mm^2 and for flexible concrete is 40 N/mm^2 . The flexible concrete exhibited a significant 22.225% increase in compressive strength compared to standard concrete.
- The flexural strength of conventional concrete after 28 days of curing was measured at 4.24 N/mm^2, while the flexible concrete exhibited a significantly higher flexural strength of 5.21 N/mm^2. This indicates a notable increase of 15.83% in compressive strength compared to the standard concrete.
- After 28 days of curing, the split- tensile strength of conventional concrete was measured at 2.15 N/mm^2. In contrast, the flexible concrete demonstrated a significantly higher flexural strength of 3.08 N/mm^2, representing a notable increase of 30.19% compared to the standard concrete.

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