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Utilization of Soft Drink Bottle Caps as Fiber in Concrete

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Abstract - Construction material development has brought concerns and challenges that have prompted global research programs and ongoing conventional and non-conventional applications, ultimately leading to ultimate cost savings. Researchers devised waste management systems in order to reduce waste and make better use of it. Bottle caps in concrete have environmental and economic benefits for all linked industries, especially in places where a significant amount of bottle cap waste is generated. Bottle caps have been used as additional reinforcing material in concrete due to the use of reinforcing steel in the manufacturing of reinforced concrete.The bottle caps of soft drink bottles are utilized as a fibre in concrete to improve the compressive, tensile, and flexural strength of the material. Concrete of the C25 and C30 grades were used in the construction. Before compression strength and splitting tensile testing, all specimens were cured for 28 days.

Index Terms - *Fiber Reinforced Concrete, Bottle caps, Mechanical Properties, Sustainable Concrete*

INTRODUCTION

Concrete is a brittle material that is reasonably strong in compression but weak in tension (IS: 456-2000).

Fiber reinforced concrete (FRC) is required at this stage to increase flexuraland tensileperfromance, as well as energy absorption capacity and toughness (Wafa et al., 1992). The bottle deforms into small fiber strips, similar to those used in concrete. The most significant component of the construction business is concrete. Because durability has become one of the most important issues in the building of conventional reinforced structures with more service periods and the development of construction techniques in modern years, it is necessary to constructsustainablestructures with durable materials . Concrete is the primary material for constructing strong and good constructions. Concrete, on the other hand, uses a lot of natural resources including sand, gravel, water, and cement.

Concrete is brittle in stress, with little ductility and crack resistance (M.S.Shetty 2000). Because of its low tensile strength, concrete has micro fractures. The majority of cracks in concrete appear during the hardening process. Concrete is the most commonly utilized building material. It has displaced stone and brick masonry due to its ability to be cast in any desired shape.

Many special concerts are now in use around the world, thanks to technological advancements and academic study. This is primarily for resolving issues encountered while working with concrete. These issues could include compaction and a long curing period, bleeding and segregation, a long setting time or strength gain, a higher building cost, crack work, and so on.

Chemical admixtures such as plasticizers or superplasticizers are used to make special concretes. It will aid in lowering the concrete mix's water cement ratio. Air entrainers are also utilized in concrete to improve workability and to protect hardened concrete from freezing and thawing damage.

Cementitious, very pozzolanic, usually pozzolanic, pozzolanic, and cementitious are mineral admixtures intended to eliminate or at least reduce the issues associated with concrete (M.S.Shetty 2000). FRC technology, often known as special concrete, was previously used to reduce cracking in concrete and improve its tensile strength. Steel fiber reinforced concrete(SFRC) improves the ductility of concrete elements (Qian Chunxiang et al., 1999). SFRC has better mechanical qualities than concrete with polyester, glass, coir, or jute fibers (Baruah et al., 2007)

Statement of the Problem

Currently, waste bottle caps may be found all throughout the country, contributing to the country's garbage output, which has a substantial impact on environmental pollution. As a result of the theory of steel fiber reinforced concrete, we intend to recycle and repurpose these resources for the creation of stronger concrete (R.Saravanakumar et al., 2012). Furthermore, when users agree with the research findings. It solves the issues involved with producing high-quality concrete for structures with longer service lives. On the one hand, it helps to reduce early demolition, and on the other, it helps to keep our planet clean.

General Objectives

The overall Objective of this research project is to test and assess the strength of FRC manufactured from steel bottle caps from beer or soft drinks. The study project's specific goal is to determine the appropriate percentage of fibers to add for increased strength, as well as to compare the test results of SFRC with plain cement concrete strength in terms of compressive and split tensile strength.

THEORETICAL BACKGROUND

Fiber Reinforced Concrete (FRC)

FRC is a composite material made up of cement, fine aggregate, coarse aggregate, and evenly scattered appropriate fibers. Steel fiber, glass fiber, natural fiber, and synthetic fiber are all examples of fibers.

Some benefits of FRC can be the following;

Fibers' primary function is to bridge cracks in concrete and increase the ductility of concrete parts. Concrete's post-cracking behavior has been improved. Increases resilience to the impact load. Controls shrinkage cracking in plastic as well as drying shrinkage cracking. Reduces water bleeding by lowering the permeability of the concrete matrix.

Reasons for crack in concrete

Temperature changes cause concrete to expand and contract. Structure settlement, Because of the tremendous load, Surface shrinkage happens as a result of water loss from concrete. When laying the concrete, there was insufficient vibration. During the concreting process, an inadequate cover was given. Due to corrosion of reinforcement steel and a high water cement ratio needed to make the concrete workable.

Factors affecting the properties of FRC

The following may influence the good performance of fiber.

Volume of fiber: - the percentage of fibers to be added in the concrete should correctly be studied and carefully examined.

Aspect ratio of fiber: - as the length to diameter or width ratio varies characteristics of fiber added concrete will also vary.

Orientation of fiber: - orientation or location of fibers dispersed in concrete will also affect the performance.

Relative fiber matrix stiffness: - it is obvious that the quality of the fiber material and relative fiber matrix stiffness.

Types of fibers used in FRC

- Steel Fiber Reinforced Concrete (SFRC)
- Polypropylene Fiber Reinforced (PFR) concrete
- GlassFiber Reinforced Concrete (GFRC)
- Carbon fibers Reinforced Concrete (CFRC)

Effect of Fibers in Concrete

Plastic shrinkage cracks and drying shrinkage cracks are usually controlled with fibers in concrete. Concrete with certain types of fibers has a higher impact and abrasion resistance.

The volume fraction refers to how much fiber is added to a concrete mix as a percentage of the overall volume of the composite. The volume fraction usually ranges from 0.1 to 3%. The aspect ratio is derived by dividing the length of the fiber by the diameter or thickness of the fiber. To generate a sufficient binding between the concrete and the fiber, a correct shape and greater aspect ratio are also required. Fiber aspect ratio and volume fraction, as well as the workability of plain concrete, affect the workability of SFRC. Crack density is higher in FRC, but crack size is smaller.

Mix Design

The goal of mix design is to figure out what proportions of ingredients will result in a practical concrete mix that is durable, strong, and affordable (IS: 10262-1882).

To achieve a dense mix, gravel and sand are blended in specified proportions. Volumetric (arbitrary) and mass proportioning are the two most frequent mix design methods. The mass proportioning approach is particularly promising because of its accuracy, speed, efficiency, and quality.

Table 1. Mix Proportion

Design strength	Cement	Fine Aggregate	Coarse Aggregate	W/C Ratio
C25	1	1.5	3	0.5
C30	1	1	2	0.5

MATERIALS AND METHODS

The goal of this experiment was to explore the strength of various types of concrete, including compressive, flexural, and tensile strengths, using the right percentage of bottle caps as fiber in the concrete.

Cement

The cement used should meet all IS requirements. On the market, there are a variety of cements to choose from. Portland cement is the most well-known and widely available of these. For this study, the PPC.53 grade was used.

Fine aggregate

Locally available river sand with a grain size of 4.75mm and a specific gravity of 2.59.

Coarse aggregate

Concrete coarse aggregates must be strong, impermeable, long-lasting, and capable of producing enough workable mix to attain optimum strength. The coarse aggregate utilized is 20mm in size. Coarse aggregate has a specific gravity of 2.63.

Water

The amount of water used in concrete mixing has an impact on the final hardened product. Water impurities can interfere with cement setting, reducing the strength and longevity of concrete. For casting and curing the specimen, fresh and pure water that is free of organic debris, silt, oil, and acid material is employed.

Bottle caps fiber

- The steel bottles are made of steel with aluminum coatings on the outside. The fiber strips are cut into small strips from the bottles. Bottle fiber has a 25 aspect ratio.

METHODOLOGY

After the collection of bottle caps and removal of the rubber inside of each cap,fiber pieces can be prepared using paper or photo cutting machine with respect to the pre-defined aspect ratio.

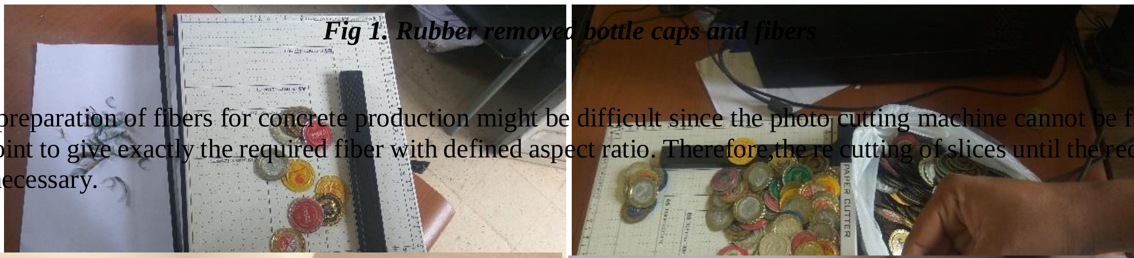

Fig 1. Rubber removed bottle caps and fibers

Sometimes preparation of fibers for concrete production might be difficult since the photo cutting machine cannot be fixed at some particular point to give exactly the required fiber with defined aspect ratio. Therefore,the re cutting of slices until the required aspect is found is necessary.

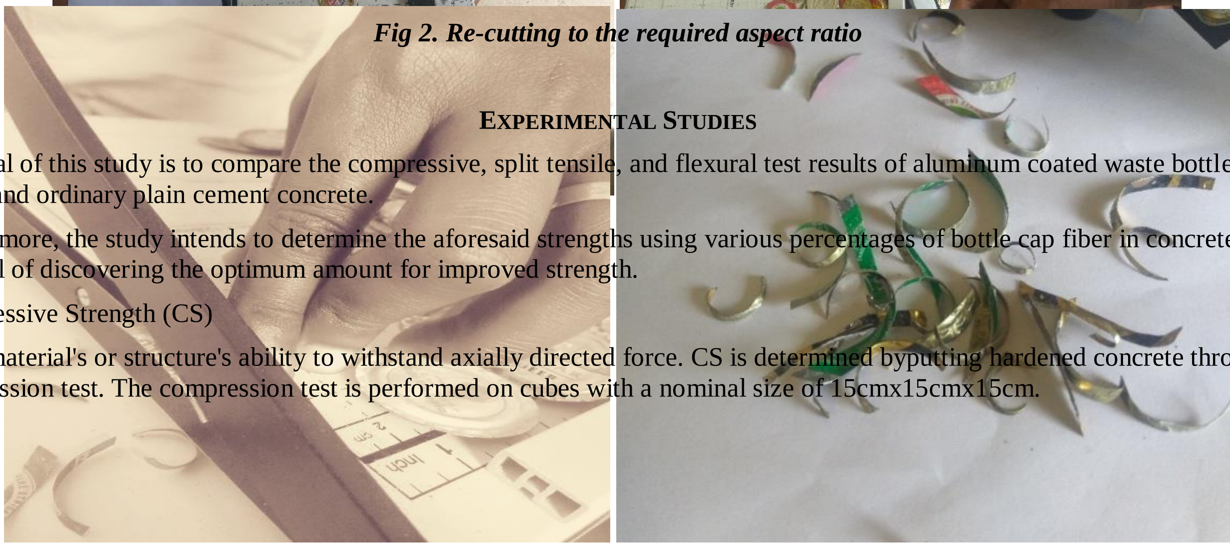

Fig 2. Re-cutting to the required aspect ratio

EXPERIMENTAL STUDIES

The goal of this study is to compare the compressive, split tensile, and flexural test results of aluminum coated waste bottle caps SFRC and ordinary plain cement concrete.

Furthermore, the study intends to determine the aforesaid strengths using various percentages of bottle cap fiber in concrete, with the goal of discovering the optimum amount for improved strength.

Compressive Strength (CS)

It is a material's or structure's ability to withstand axially directed force. CS is determined byputting hardened concrete through a compression test. The compression test is performed on cubes with a nominal size of 15cmx15cmx15cm.

Fig. 3. Cubic test samples and compressive test.

Split Tensile Strength (STS)

STS is obtained by conducting tensile test on hardened concrete. Split tensile test is carried out by placing a cylindrical specimen horizontally in between the loading surfaces of compression testing machine and the load is applied until failure of the cylinder, along the vertical chamber.

Fig. 4. Cylinder concrete test specimen and split tensile test.

RESULTS AND DISCUSSION

The desired compressive and STS values are computed after laboratory experiments. All specimen test results are shown in the table below, with all digits rounded to two decimal places.

The ultimate maximum average result achieved with the test result is as follows:

Conventional concrete C25:

CS of concrete - 24.91 N/mm^2

STS of concrete - 2.58

N/mm^2

FRC with maximum 0.30 percentages:

CS of concrete - 31.9 N/mm^2

STS of concrete - 3.81 N/mm^2

Conventional concrete C30:

CS of concrete - 29.13 N/mm^2

STS of concrete - 2.79 N/mm^2

FRC with maximum 0.30 percentages:

CS of concrete - 41.86 N/mm^2

STS of concrete - 4.11 N/mm^2

Graphical representation of results

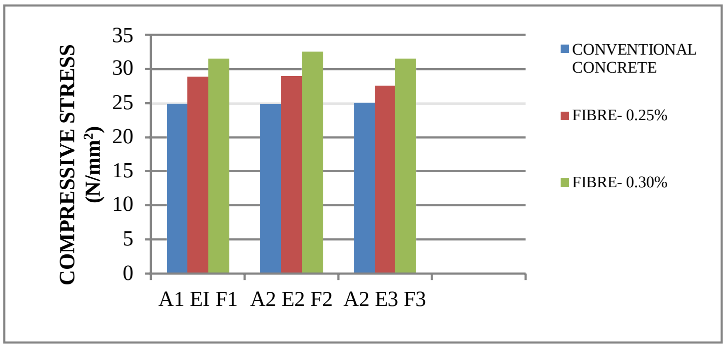

Fig.5. Compressive Test on Cubes C-25

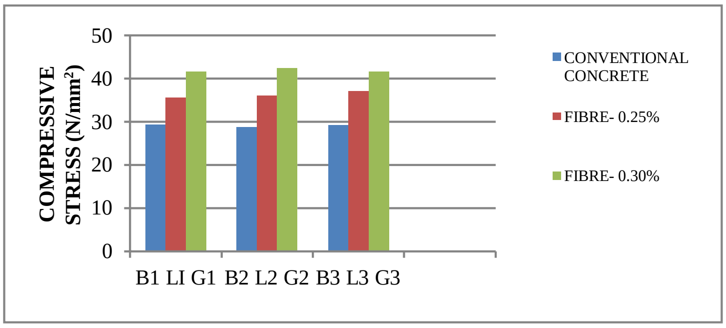

Fig. 6. Compressive Test on Cubes C-30

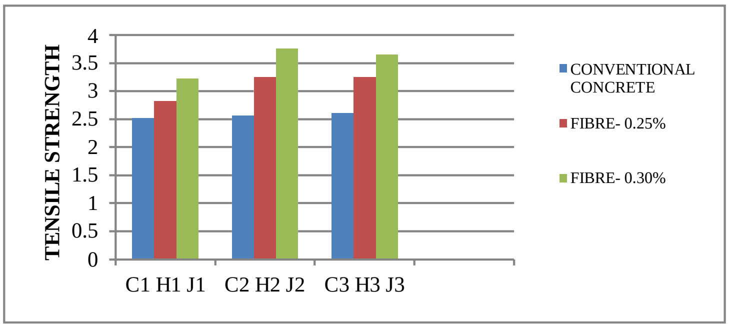

Fig. 7. Split Tensile Test on Cylinder on C-25

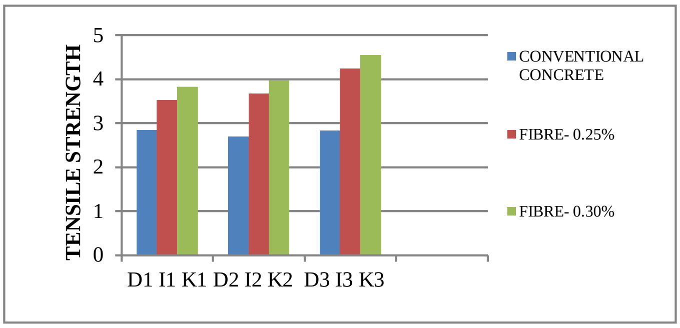

Fig.8. Split Tensile Test on Cylinder on C-30

In fiber, the maximum CS and STS was attained in 0.30 percent of the total weight fraction. FRC cubes had 1.28 times the CS of ordinary concrete in the C-25 grade. cubes had 1.48 times the CS of ordinary concrete in the C-30 grade. FRC cylinders had 1.48 times the STS of ordinary concrete in the C-25 grade. FRC cylinders had 1.47 times the STS of ordinary concrete in the C-30 grade.

CONCLUSION

In addition to enhancing the strength, usage of Soft drink or bear bottle caps as fiber in concrete production can also be important in waste management system of the countries. Besides this, recycled waste bottle caps are valuable admixture materials for the production of more stiff concrete with a minimum incurred cost.

Volume, aspect ratio, orientation of fiber and fiber matrix stiffness are those factors affecting the properties of FRC. The experimental study shows that the optimum strength is obtained by adding soft drink bottle as fiber reinforcement in about 0. 25% and 0.30% from the total volume of concrete. Usage of bottle as additional reinforcing material gives better strength result than ordinary conventional concrete of C25 and C30 grade. Both conventional concrete and FRC have been successfully tested for the compressive, split tensile strengths. This project concludes that the usage of discreet soft drink bottle gives better strength results on fiber reinforced concrete.

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