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EXPERIMENTAL INVESTIGATION OF AUXETIC MATERIAL BY USING FIBRE RUBBERIZED CONCRETE

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ABSTRACT:- This work presents the mix design and the analysis of the strength of rubberized concrete. The carbon fibre are cut in prescribed ratio and used for the partial replacement of coarse aggregates.
In the proposed research, carbon fibres were mixed with the concrete to form a Rubberized concrete. For a rubberised concrete mixture, all mix design parameters were kept constant as given by the IS-456 method except for the coarse aggregate constituents. The coarse aggregate of the concrete was replaced by 5%, 10%, 15%, and 20% of its weight. The fine aggregate was sieved using 2.36mm in order to pass through the holes of the carbon fibre to make a strong contact with cement matrix.
From the some experimental results of compressive strength testing it was observed that both plain and rubberized concrete developing similar strength over the curing period as expected. For all concrete mixtures, the rate of compressive strength developed was high between 7 and 14 days and slow between 14 and 28 days. Also it was noted that irrespective of curing period, there was a systematic reduction in compressive strength with increasing rubber content of the composite. Some experimental investigation observed that high percentage carbon fibre mixed cylinders took longer time to crack down because of the elastic nature of the fibres when bearing the loading. Moreover, it was observed that the above said rubberized concrete did not exhibit brittle failure under compression or split tension.

Keywords: Fibre rubberized concrete, Auxetic material, Compressive strength testing

INTRODUCTION

Globally, there are over 2.2 billion tons of concrete produced annually (Crow, 2008). As one of the most abundant construction materials, concrete has one glaring weakness, that it is much weaker under tensile stresses than it is under compression. This often requires reinforcement to limit the development of tensile stresses in concrete members, which increases the cost of the member. In nearly all construction projects, cost impacts design choices heavily.

Typical reinforced concrete design utilizes the reinforcing steel to resist tension forces, and relies on concrete to resist compressive forces. Under this typical design style, the concrete can still fail due to tensile forces. This comes from concrete possessing a positive Poisson's ratio, which relates how the material deforms along two axes. As the concrete compresses, it is free to expand proportionally along a perpendicular axis. To remedy this issue, a negative Poisson's ratio can be induced.

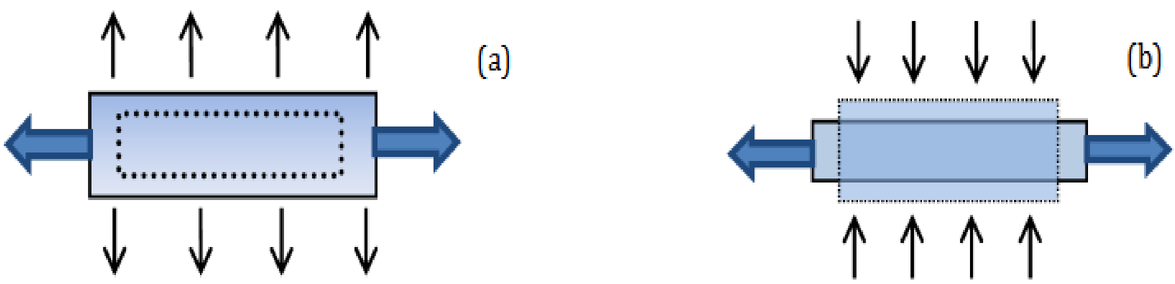

Figure 1 **(a)** Auxetic Material **(b)**Conventional material

Auxetic materials which have a negative Poisson's ratio demonstrate an extraordinary behaviour in that they get fatter when they are stretched, and become thinner when compressed (Figure 1). These characteristic materials display properties such as improved strength, acoustic behaviour, improved fracture toughness, superior energy absorption, damping improvement, and indentation resistance, Fibres have been used in the construction field since ancient time. Straw and hair fibres were used to reinforce brittle materials which were used to build house. In late 19th century, asbestos fibre was used in large quantity in the construction field. However, due to health hazards associated with asbestos fibres, alternate fibres started to be introduced in the field since 1950s. Glass and steel fibres were used as reinforcing elements into concrete and its behaviour extensively studied. The use of fibre reinforced construction materials offers many improvements in the properties, when compared to conventional materials, including tensile strength, elastic modulus, compressive strength, durability, crack resistance, crack control, fatigue life, etc.

The tyre fibres were mixed with the concrete to form a Rubberized concrete. For a rubberised concrete mixture, all mix design parameters were kept constant as given by the IS method except for the coarse aggregate constituents. The coarse aggregate of the concrete was replaced by 5%, 10%, 15%, 20% a of its weight by tyre fibers designated as L25-D4, D5, , L50-D4, D5, and L75-D4, D5, .The fibers were randomly distributed in the rubberized concrete. The tyre fibres were cleaned by using analytical grade NaOH done by Serge et al to remove grease and other impurities in rubber in order to improve adhesion with the cement matrix. The fine aggregate was sieved using 2.36mm in order to pass through the holes of the tyre fiber to make a strong contact with cement matrix. Water with neutral pH value has been used for mixing. All these works were done under room temperature.

Carbon fibre can be produced from the three types of polymer precursors:
Poly acrylonitrile (PAN), rayon, and pitch. Pitch fibres are cheaper than PAN based fibres, but possess lower strength. The tensile stress-strain curve is linear to the point of breakage. Carbon fibres are light weight and strong with excellent chemical resistance. Carbon fibres have lower thermal expansion co-efficient than both aramid and glass fibres. The fibre is an anisotropic material, and its transverse modulus is greater than longitudinal modulus in an order of magnitude.

Physical and mechanical properties of carbon fibres

Typical properties	High strength	High modulus	Ultra-high modulus
Density (g/cm3)	1.8	1.9	2.0-2.1
Young's modulus(GPa)	230	370	520-620
Tensile strength (GPa)	2.48	1.79	1.03-1.31
Tensile elongation (%)	1.1	0.5	0.2

The characteristics of carbon fibre reinforced concrete (CFRC) includes,

- High tensile strength – smaller cross section, earth quake resistance;
- Higher durability – corrosion free and less running cost;
- Eco-friendly – less material needed for maintenance and construction;
- Low weight – easy to handle;
- High flexibility;
- High abrasion resistance – suitable for highway construction;
- Low co-efficient of thermal expansion – high fire resistance;
- Increase of flexural strength and toughness;
- High compressive strength;
- Decrease of electrical resistance;
- Decrease of dry shrinkage;
- High split tensile strength.

MATERIAL PREPARATION AND MIXTURE DESIGN

The design of any concrete mix widely depends on the structure to be constructed, the conditions that prevail at the site, and in particular the exposure conditions of the
structure. Hence a complete knowledge of the constituent materials is very important for the design of any concrete mix. Mix design can be defined as the process of selecting suitable ingredients of the concrete and determining their relative proportions with the objective of producing concrete with the stipulated minimum strength and durability in the most economical manner. Then, the mix design of the rubberized concrete is done by choosing the appropriate raw materials and by replacing partially the coarse aggregate by tyre fibres.

RAW MATERIAL

The materials used for the mix design are fly ash based Grade 53 cement, Fine River sand, coarse aggregate of sizes 20mm (60%), 10mm (40%) and cut tyres in fibre form. Preliminary investigations like setting time and fineness had been conducted on Fly Ash based G53 Portland cement, Bulk modulus and Sieve analysis had also been done on sand. The impact strength on coarse aggregate gravel was also done. The carbon fibres were used for the partial replacement of coarse aggregates. Tyres from light vehicles such as cars and light weight trucks were used for the tyre fibres. Nylon threaded tyres were used instead of steel belted tyres because it was difficult to make holes in steel belted tyres and also there would be a possibility of rusting of steel belts which might affect the strength. A simple machine was used in the production of the tyre fibre. Initially, the tyres were cut by a saw into fibres and a simple method was used to put the holes in the fibre manually by drilling. 1Using this method the quantity of carbon fibres produced in a day was only a kilo.

To investigate the effect of fibre aspect ratio on the strength and stiffness of the rubberised concrete, as suggested by Gregory fibres were cut in to different lengths, 25mm, 50mm, with diameters of holes, via, 4mm, 5mm on them. The diameter of holes on a single fibre is the same. The dimensions of the tyre fibres were calculated from the aspect ratio procedure developed by the Cox.

Figures 2 show the samples of tyre fibre specimens cut in to different dimensions L25-D4, D5, , L50-D4, D5,

If "L" denotes the length of the tyre fibre and "D" denotes the diameter of the hole in millimetres (mm) then, 'L25-D4, D5, denotes Fibre length of 25mm and holes of 4 or 5 mm diameter on the tyre fibre. 'L50-D4, D5, denotes Fibre length of 50mm and holes of 4 or 5 or diameter on the tyre fibre. '

Fig 2. Carbon fibre specimen

Literature Review

Prof S. S. Vidhale' Vidhale work on her project Mix Design of Fibre Reinforced Concrete (FRC) Using Slag & Steel Fibre. FRPs are very much suitable for structural applications mainly to repair concrete reinforced elements, pre-stressed concrete, masonry and wood structural elements. The cement in concrete is replaced accordingly with the percentage of 10 %, 20%, 30%, and 40% by weight of slag and 0.5%, 1%, 1.5%, 2% by weight of steel fibre. Concrete cubes are tested at the age of 3, 7, and 28 days of curing. . From the experimental investigations, it has been observed that, the optimum replacement of Ground Granulated Blast Furnace Slag Powder to cement and steel fibre without changing much the compressive strength is 20 % & 1.5 % respectively for M20, M30&M40 grade respectively. The principal reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength, and improve the cracking deformation characteristics of the resultant composite.

MuhammetUzun, (Conventional Polypropylene Random Short Fibre Reinforced Composites) ,In this study, prior to the production of composites, auxetic and conventional polypropylene (PP) fibres were produced by the melt spinning technique. The fibres were tested and analysed in terms of Poisson's ratio, linear density, elongation at break and tenacity. The auxetic and conventional PP stable fibre reinforced composites were fabricated by the hand layup method. Several mechanical properties of the composites were examined, including tensile strength, Young's modulus, elongation at break, energy absorption, impact velocity and damage size. SEM analysis was also conducted to identify microscopic changes to the overall composite structures. It was found that the auxetic fibre reinforced composites (7.5% and 10%) had the highest tensile strength and the auxetic fibre reinforced composite (5%) had the highest Young's modulus.

Khashayar Jafari, This paper studies the mechanical behaviour of the rubberized polymer concrete. Crumb and chipped rubber were used to replace fine and coarse aggregates in PC, respectively. A complete series of destructive tests including impact test, compression and splitting tensile tests and non-destructive methods including ultrasonic test, digital signal processing, electrical conductivity, and microstructure analysis was performed to demonstrate the various potential applications of the rubberized PC. The results indicated that the rubberized PC reduced the workability and increased the porosity and air content of the mixture; however, reduced the cost and density, and improved ductility. Scanning electron microscope was used to analyse the interface between aggregates and adhesive materials. The correlation between the compressive strength and ultrasonic pulse velocity was determined and proposed for the rubberized PC. PC containing crumb rubber had a lower pulse velocity and higher damping properties than that of chipped rubber

Conclusion

The following conclusions were drawn from the study.

1. Use of waste tire rubber particles as polymer concrete aggregates reduced workability. Also, the density of PC significantly decreased by using waste tire rubber instead of natural aggregates. By replacing 10–30% crumb rubber with fine aggregates, density decreased 8.5–23.9%. Also, by substituting 10–30% chipped rubber with coarse aggregates, density decreased 6.7–21.4%.
2. The compressive strength testing it was observed that both plain and rubberized concrete developing similar strength over the curing period as expected. For all concrete mixtures, the rate of compressive strength developed was high between 7 and 14 days and slow between 14 and 28 days.
3. Some experimental investigation observed that high percentage carbon fibre mixed cylinders took longer time to crack down because of the elastic nature of the fibres when bearing the loading.
4. The toughness and tensile strength, and improve the cracking deformation characteristics of the resultant composite.
5. Rubberized concrete beams exhibited more deflection capacity compared with conventional concrete.
6. While it is shown that adding rubber to concrete increases the damping ratio and kinetic energy, rubber has an adverse impact on the dissipated hysteretic energy.

REFERENCES

- Thomas BS, Gupta RC. A comprehensive review on the applications of waste tire rubber in Cement concrete. Renewable and Sustainable Energy Reviews. 2016; 54:1323-33.

- Ganjian E, Khorami M, Maghsoudi AA. Scrap-tyre-rubber replacement for aggregate and filler in concrete. Construction and building materials. 2009;23:1828-36.

- Khatib ZK, Bayomy FM. Rubberized Portland cement concrete. Journal of materials in civil engineering. 1999;11:206-13.

- Nehdi M, Khan A. Cementitious composites containing recycled tire rubber: an overview of engineering properties and potential applications.

- Thomas BS, Chandra Gupta R. Properties of high strength concrete containing scrap tire rubber.Journal of Cleaner Production. 2016;113:86-92.

- Christopher Zmuda ,Design of Structural Composite with Auxetic Behavior (2017), http://www.wpi.edu/Academics/Projects.

- **http://silver.neep.wisc.edu/~lakes/PoissonEnd.html.**

- Mr. Nikhil A. Gadge1, Prof. S. S. Vidhale,International Journal of Modern Engineering Research (IJMER), Mix Design of Fiber Reinforced Concrete (FRC) Using Slag & Steel Fiber (2013)