STRENGTH AND BEHAVIOUR OF FLEX FIBER REINFORCED CONCRETE

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ABSTRACT— With the rising quantity of waste generation from numerous processes, there has been growing attention in the consumption of waste materials in the production of construction materials to attain possible advantages. Over the last decades, the efficient management of several sorts of waste productions is getting more attention to maintain sustainability in construction. The consumption of waste materials rather than natural resources is one of the fundamental concerns of waste management strategies. Reduction in environmental pollution, decreasing land filling and discarding of wastes, and preserving raw materials are the main advantages of recycling. Now a day's synthetic plastic wastes are plenty and cause several environmental hazards. Recycling or reusing plastic wastes as fibers in concrete is an innovative solution to this problem. This work aims at investigating the mechanical properties of concrete made using fibers from flexwastes.

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Keywords—concrete, fibers, durability, mechanical properties, plastic, RC beams.

1INTRODUCTION

The plastic production has risen massively around the world, and various types and forms of plastics have come to be a vital part of our modern lifestyle. The overall manufacture of plastics is given an account to have raised to 288 million tons in 2012, worldwide. Approximately half of these products are a one-use consumer, which caused critically to the generation of different sorts of plastic wastes. The amount of synthetic plastic flexes consumed annually has been steadily increasing, and the mismanage of these type of waste plastics leads to severe environmental concerns such as human's health hazards, effects on animal's life, water and air pollutions, and soil impurities. Currently, the main ways of disposal of such a considerable amount of waste plastics are limited to incineration and landfill. Therefore, reliable and sustainable discarding substitutions to the existing methods have become essential. Therefore, one of the alternatives is to recycle synthetic wastes and use them as fiber reinforcement for concrete. The fiber reinforced concrete (FRC) is relatively a new construction material developed through extensive research during the last two decades. It has already found a wide range of practical applications and has proved reliable in construction and is a materialhaving superior performance characteristic. The addition of fibers into the concrete has been found to improve several of its properties like tensile strength, cracking resistance, impact, wear and tear, ductility, fatigue resistance etc. Many types of fibers like steel fibers, carbon fibers, GI fibers, glass fibers, asbestos fibers etc. can be used in fiber reinforced concrete. Waste plastics can also be used as fibers. The disposing of waste plastic is causing environmental pollution. The plastic is a non-biodegradable material, neither decays nor degenerate it either in water or in soil. In turn it pollutes the water and soil. The plastic if burnt releases many toxic gases, which are very dangerous for the health. Such plastic, which is non-biodegradable material, can be used in concrete in the form of fibers to impact some additional desirable qualities to the concrete. Reduction in environmental pollution, decreasing landfilling and discarding of wastes, and preserving raw materials are the main advantages of recycling. Therefore, in the construction and building industries, the concept of sustainability persuades the utilization of waste materials to substitute raw resources. This leads to green environment, eco-friendly and sustainable construction.

Concrete can be modified to perform in a more ductile form by the addition of randomly distributed discrete fibers in the concrete matrix. The concrete containing fibrous material which increase its structural integrity. It contains short discrete Fibers that are uniformly distributed and randomly oriented. Fiber reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and fibers. In this composite material, short discrete fibers are randomly distributed throughout the concrete mass. The behavioral efficiency of this composite material is far superior to that of plane concrete and many other construction materials. Due to this benefit, the use of FRC has steadily increased during the last decades and its current field of application includes, airport and highway pavements, earthquake resistant and explosive resistant structures, mine and tunnel linings, bridge deck overlays, hydraulicstructures, rock-slope stabilization. Extensive research work on FRC has established that addition of various types of fibers such as steel, glass, synthetic and carbon in plain concrete improves strength, toughness, durability, ductility, post cracking resistance andetc.

Synthetic plastic flex is used as a fiber reinforcing material in concrete to study its effects on the compressive, tensile, flexural strength and durability to economize concrete and to reduce environmental problems created by the wastes. The waste plastic flexes produce negative impact on the environment since it is a non-biodegradable in nature. Disposal of such wastes are the major cause of environmental pollutions. A solution of the issue is that can be proposed to add in concrete to improve mechanical and durability properties. The usefulness of fiber reinforced concrete in various civil engineering applications is thus indisputable. Hence this study explores the feasibility of plastic flex fiber reinforcement; aim is to do parametric study on compressive strength, flexural strength, tensile strength, and durability study etc.…, with given grade of concrete, proportions and percentage of fibers.

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2 LITERATURE REVIEW

N. Ganesan, Bharati Raj. J and A.P. Shashikala (2012) conducted a research on Strength and durability studies of self-compacting rubberized concrete. In this study, the addition of fine rubber was 15% by volume replacing the fine aggregates and the addition of crimped steel fibers was 0.5% by volume (diameter 0.45 mm, length 30 mm and aspect ratio 66). The durability properties such as water permeability, chloride ion permeability, water absorption, abrasion resistance, sorptivity, and resistance to seawater attack and acid attack were investigated. Thee durability of SCRC was found to be ideal under the conditions of evaluations, except the sorptivity index. The reduction in compressive strength due to the incorporation of scrap rubber in SCC could be compensated to some extent by the addition of steel fibers. They concluded that Self Compacting Rubberized Concrete may be a useful cementitious composite with better durability characteristics than conventional Self Compacting Concrete.

J.M. Irwan, R.M. Asyraf et al (2013) conducted a research to investigate the performance of concrete containing Polyethylene Terephthalate (PET) bottle waste as fiber. The study was conducted using cylindrical mold of concrete to investigate the performance of the concrete in term of mechanical properties. A total of four batches of concrete were produced namely, normal concrete and concrete containing PET fiber of 0.5%, 1.0% and 1.5% fraction volume. The results show that the compressive strength, tensile splitting strength and modulus of elasticity value have increase with 0.5% PET fiber content in the concrete mix in compare to normal concrete. Concrete containing 1% and 1.5% PET fiber is lower than the normal concrete in compressive and splitting tensile strength and elastic modulus. Therefore, it is concluded that, the fiber content will affect the strength of the concrete. The strong fibers are desired and used to improve concrete strength and ductility, but may lead to loss in segregation, increased porosity, and overall reduction in concrete strength. In addition, high dosages of fiber will cause workability problems because of their relatively surfacearea.

Soon Poh Yap, Chun Hooi Bu (2014) In this work, the effect of steel, polypropylene (PP) and steel-PP hybrid fibers on the compressive strength, tensile strength, flexural toughness and ductility of oil palm shell fiber reinforced concrete (OPSFRC) was studied. The experimental results showed that the highest compressive strength of about 50 MPa was produced by the mix with 0.9% steel and 0.1% PP hybrid fibers. The highest increments in the splitting tensile and the flexural strengths of the OPSFRC were found up to 83% and 34%, respectively. However, the mixes with 1% PP fibers produced negative effects on both the compressive and tensile strengths. The mixes with 0.9% steel and 0.1% PP hybrid fibers reported the highest improvement in toughness index and residual strength factor

N. Ganesan, Ruby Abraham, S. Deepa Raj (2015)conducted a study on durability characteristics of steel fiber reinforced geopolymer concrete. Here they used hooked end steel fires of diameter 0.5 mm and 30 mm length with anaspect ratio of 60.The volume fractions ofsteel fires used were 0.25% (19.32 kg/m3), 0.50% (38.64 kg/m3), 0.75%(57.96 kg/m3) and 1% (78.28 kg/m3). The result obtained was the properties such as water absorption,effective porosity, and sorptivity of GPC were found to be lowerthan that of NC, and GPC specimens show excellent resistance to acid and sulphate attack. From the study they conclude that GPC possessbetter durability characteristics.

Ashwini Manjunath B T (2016) conducted an experimental study made on the utilization of E-waste particles as fine and coarse aggregates in concrete with a percentage replacement ranging from 0 %, 20% to 30% i.e. (0%, 10%, 20% and 30%) on the strength criteria of M20 Concrete. The e plastic waste consists of discarded plastic waste from the old computers, TVs, refrigerators, radios; these plastics are non-biodegradable components of E plastic waste as a partial replacement of the coarse or fine aggregates. As the use of E plastic waste will reduces the Aggregate cost and provides a good strength for the structures and roads. Compressive strength, Tensile strength and Flexural strength Concrete with and without E- waste plastic as aggregates was observed which exhibits a good strength. The feasibility of utilizing E-waste plastic particles as partial replacement of coarse aggregate were presented. In the present study, compressive strength was investigated for Optimum Cement Content and 10% E-plastic content in mix yielded stability and very good in compressive strength of 53 grade cement.

ShehdehGhannamaet.al (2016)conducted anexperimental study on concrete made with granite and iron powders as partial replacement of sand. Here an experimental investigation has been carried out using the granite powder and iron powder (byproducts generated from the granite polishing and milling industry in powder form) as a partial replacement of sand in concrete. Twenty cubes and ten beams of concrete with GP and twenty cubes and ten beams of concrete with IP were prepared and tested. The percentages of GP and IP added to replace sand were 5%, 10%, 15%, and 20% of the sand by weight. It shows the better performance in the compressive and tensile and flexural strength, good workability and fluidity, etc.

José A. Fuente-Alonso a, Vanesa Ortega-López (2017) In this work, fiber reinforcements were addedto the concrete. The properties of several mixes, reinforced with 0.6% metallic and 0.4% synthetic fibers in volume, were studied both in the fresh and in the hardened state. The metallic fiber used was steel of length 50mm and 1.05mm diameter and synthetic fiber used was polylefin of length 48mm and 0.93mm diameter. In this work, the concrete mixes that showed the best performance contained 45 kg of metallic fiber per cubic meter (volume of fibers at 0.6% by volume of concrete), and 3.5 kg of synthetic fiber per cubic meter (volume of fibers at 0.4% by volume of concrete). The water penetration and the tensile test results (in terms of strength and ductility) were satisfactory for the use of these concretes in industrial pavements; the compressive results were close to the requirements for high-performance concretes. Impact strength and abrasion resistance yielded better results in mixes containing EAFS as aggregate than in mixes with naturalaggregates.

Yashida Nadir, Sujatha A (2017) conducted a study on the durability properties of coconut shell aggregate concrete. They prepared a Control mix, mix with18.5% coarse aggregate replaced by CS (12.5mm size) by weight,30% cement replaced by fly ash, and 15% cement replaced by GGBFS. Experimental investigation was carriedto determine the fresh properties, hardened and durabilityproperties of concrete. Test resultsshowed that durability properties of all the mixes were comparable to normal concrete and some durability properties were enhancedby the addition of mineral admixtures.

AbdulazizAlsaif , Susan A. Bernal et al (2018) conducted a study to assesses the durability and transport properties of low water/binder ratio (0.35) steel fiber reinforced rubberised concrete (SFRRuC) mixes. SFRRuC mixes having different substitutions of rubber aggregates (0, 30 and 60% by volume) were used for the study. The test results show that, although water permeability (e.g. volume of permeable voids and sorptivity) and chloride ingress increase with rubber content, this increase was minor and water and chlorides permeability are generally within the rangeof highly durable concrete mixes. No visual signs of deterioration or cracking (except superficial rust) were observed on the surface of the concrete specimens subjected to 150 or 300 days of accelerated chloride corrosion exposure and a slight increase in the mechanical properties was observed. This study shows that the examined low water/binder SFRRuC mixes promote good durability characteristics, making these composite materials suitable for flexible concrete pavement applications.

Emad Booya et.al (2018) conducted a study on durability of cementitious materials reinforced with various Kraft pulp fibers. The average fiber lengths was 0.8, 1.8, and 2.1 mm for unmodified fibers (UM), mechanically modified fibers (MMF) and chemically treated fibers (CTF), respectively and with average diameter (or width) of 18 mm, a density of 1.55 g/cm3. They conducted some tests on compressive strength, durability tests such as water absorption test, chloride ion penetration test, sorptivity tests etc. The results show that, these fibers reduced the compressive strength and durability. However, the two engineered fibers performed better than the unmodified fiber in terms of compressive strength, chloride ion permeability and water sorptivity.

3MATERIAL CHARACTERISATION

3.1 CEMENT

Portland Pozzolana Cement (53 Grade)

Table 1: Properties of cement

Properties	Observations
Fineness	5%
Consistency	34%
Initial Setting Time	47 min
Final Setting Time	480 min
Specific gravity	3.2

3.2 AGGREGATES

Table 2: Aggregates properties

	F A	C A
Bulk Density (g/cc)	1.83	1.51
Specific Gravity	2.59	2.91
Porosity	29.18%	48.13%
Void ratio	0.412	0.928

3.3 FLEXFIBER

Size of the flex =240 gsm

Specific gravity =0.7

Volume fractions used in mixing 0.5% and 1%

Aspect ratios used: 15,30,45,60

Fig 3.1: Flex fibers

Fig 3.1 shows the shredded flex sheet in the form of fibers corresponding to the aspect ratios.

4 EXPERIMENTALSTUDY

4.1 TESTS ON FRESH CONCRETE-WORKABILITY

The concrete mix in the proportion arrived at in the previous section was prepared in the laboratory and its properties in fresh state were determined. Mainly workability was measured by means of four tests-slump test, compaction factor test, flow test and vee bee consistometer. Table 3 shows the specimen designation for corresponding aspect ratios and volume fractions and the Table 4 shows the combined workabilityvalue.

Table 3:Specimen designation

Designation	Volume fraction (%)	Aspect ratio
NC (normal concrete)	0	0
S1	0.50%	15
S2	0.50%	30
S3	0.50%	45
S4	0.50%	60
S5	1%	15
S6	1%	30
S7	1%	45
S8	1%	60

Table 4: Combined workability

Sample	Slump value	Compaction Factor	Flow of concrete in %	Vee Bee degree
NC	70	0.803	81.7	11
S1	70	0.85	84.5	12
S2	80	0.833	81.5	12.5
S3	75	0.814	84.2	12
S4	100	0.882	87.2	11
S5	70	0.845	84.4	11.5
S6	105	0.862	85.2	13
S7	90	0.831	82.1	12.5
S8	95	0.845	86.5	12

In general, almost all specimens were found to be more workable than control mix except some specimen which shows similar values and less values for workability. When aspect ratios and volume factions increase then workability also increases.

4.2 TESTS ON HARDENED CONCRETE

The Compressive strength of concrete is the most important of all the properties. It is determined by casting and testing cubes. The compressive strength of concrete is defined as the load which causes the failure of a standard specimen divided by the area of cross-section. In the field a random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested i.e., the sampling should be spread over the entire period of concreting and cover all mixingunits. After the mix design mix proportion taken as 1:1.78:3. The volume fraction of flex fiber is taken as 0.5% and 1% .And the aspect ratios was 15, 30, 45 and 60.

4.2.1 COMPRESSIVE STRENGTH OFCONCRETE

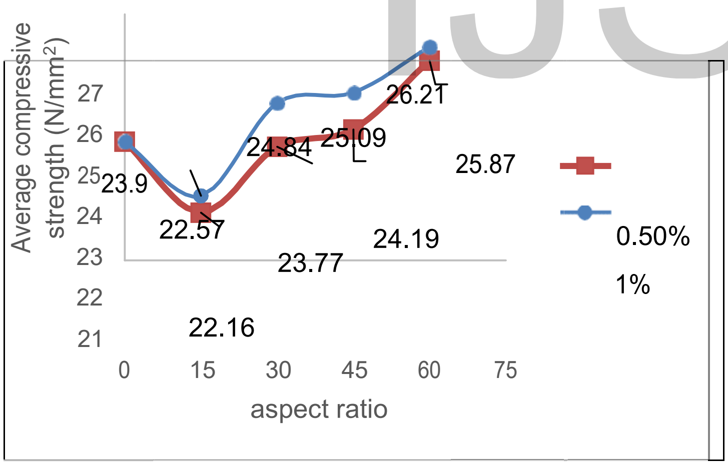

Fig: 4.1.28-day Average compressive strength value

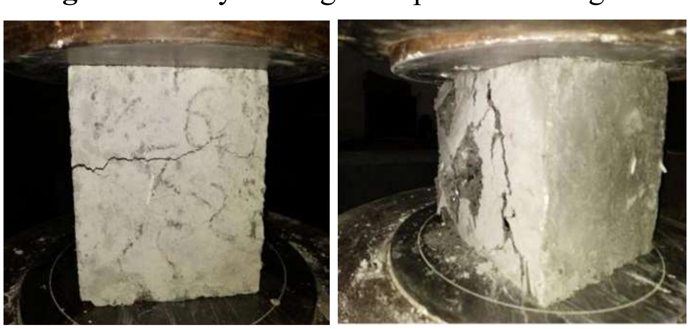

Fig:4.2. Compression testing

Fig 4.1 and Fig 4.2 shows the compressive strength graph of the all concrete specimen after 28 day and compression testing correspondingly.

Table 5: compression test results

Samples	Aspect ratio	Volume fraction	Average compressive strength (N/mm^2)
NC	0	0	23.9
S1	15	0.50%	22.16
S2	30	0.50%	23.77
S3	45	0.50%	24.19
S4	60	0.50%	25.87
S5	15	1%	22.57
S6	30	1%	24.84
S7	45	1%	25.09
S8	60	1%	26.21

Initially, there is slight decrease in compressive strength value. Also, the aspect ratio and volume fractions increase, the compressive strengthincreases.

4.2.2 SPLITTING TENSILE STRENGTH OFCONCRETE

For determining the split tensile value of concrete, cylinder of diameter 150mm and height 300mm were casted and tested in compression testing machine. And the value of split tensile strength can be calculated using the equation.

$$\square\square\square\square\square\ \square\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square = \frac{2\square}{\pi\square\square}$$

Were D, L are the diameter and length of the cylinder correspondingly.

Table 6: Split tension test results

Samples	Aspect ratio	Volume fraction	Average splitting tensile strength (N/mm^2)
NC	0	0	2.54
S1	15	0.50%	2.42
S2	30	0.50%	2.51
S3	45	0.50%	2.66
S4	60	0.50%	2.82
S5	15	1%	2.52
S6	30	1%	2.69
S7	45	1%	2.99
S8	60	1%	2.98

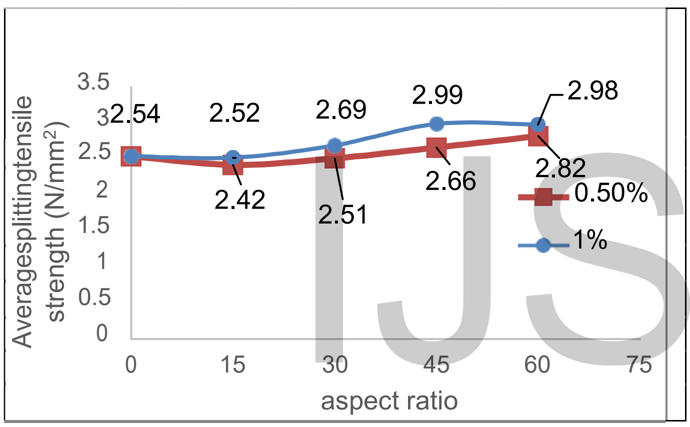

Fig:4.3. Split tension test

Here also there is a slight decrease in split tensile strength value initially, after that this value increases up to 45 aspect ratios then decrease when aspect ratio increases to 60 for 1% aspectratio.

Fig:4.4. Split tension test

4.2.3. FLEXURAL STRENGTH ON PRISM

The flexural strength of concrete is the another most important property. It is determined by casting and testing prism of dimension 500x10x10 mm. And it is calculated by the equation □ =□□/□□2

Table 7: Flexural strength test results

Sample	Aspect ratio	Volume fraction	Modulus of rupture (Mpa)
NC	0	0	3.825
S1	15	0.50%	3.825
S2	30	0.50%	4.1202
S3	45	0.50%	4.2183
S4	60	0.50%	5.1012
S5	15	1%	3.924
S6	30	1%	4.26735
S7	45	1%	4.46355
S8	60	1%	5.2974

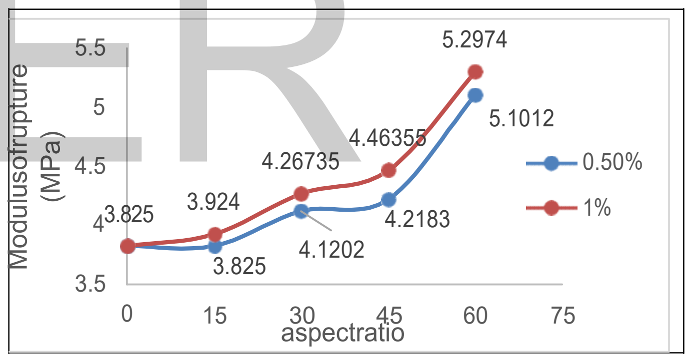

Fig:4.5. Modulus of rupture value

From the Fig 4.5. it is clear that modulus of rupture increases with increase in both aspect ratio and volume fraction. Fig 4.6 shows the flexural testing of prism and crack pattern of the same.

Fig:4.6. Flexural test on prism

5 CONCLUSIONS

The synthetic plastic flex fibers can be added to the concrete and it will give good results in mechanical properties of concrete like compressive strength, tensile strength, flexural strength.

Following are the conclusion of the work:

- Initially, there is slight decrease in compressive strength value i.e. for aspect ratio 15. Also, the aspect ratio and volume fractions increase, the compressive strengthincreases.
- In split tensile strength there is also a slight decrease value initially, after that this value increases up to 45 aspect ratios then decrease when aspect ratio increases to 60 for 1% aspect ratio.
- The flexural strength of flex fiber reinforced concrete is increases with increase in both aspect ratio and volumefraction.

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