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Experimental Investigation and Comparison of Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre Concretes

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ABSTRACT

Fibre-reinforced concrete (FRC) contains fibrous material which upsurges its structural integrity. The use of irregular arrangement of fibres to concrete altogether upgrades its essential characteristics, for instance, influence quality, static flexural strength, elasticity and flexural stiffness. Filaments are further added to cement to control breaking because of plastic shrinkage and to drying shrinkage. This research paper shows and compare the use of electrical waste copper wire fibre and electrical waste glass fibre of various percentages of volume fractions such as 0.25%, 0.5%, 0.75%, 1.0%, 1.25%, 1.5%, 1.75%, and 2.0% incorporated in concrete. We investigate and compare the mechanical properties such as compressive strength, splitting flexural strength and tensile strength tests were conducted for ordinary concrete and fibre reinforced concrete for a curing period of 28 days. The test results of electrical waste copper wire fibre reinforced concrete with electrical waste glass fibre reinforced concrete were compared to determine the influence of fibres used.

1.0 Introduction

Fibre reinforced concrete may be well-defined as the composite materials prepared with Portland cement, aggregate, and combining short discrete discontinuous fibres. Plain reinforced concrete is a brittle material due to this the structure having low tensile strength, low ductility and a low strain capacity. The addition of steel fibres in concrete significantly improves the tensile strength, durability, static flexural strength, Impact strength, Fatigue and Shear strength, failure toughness and shock resistance ductility. However the degree of these developments depends on the type, shape, size and aspect ratio of the steel fibre. In the modern years, the several fibres were developed and used in the construction activities but some electronic waste fibres can also be used in concrete [1]. Electronic waste (E-Waste) is measured more toxic than municipal waste. When E-waste used in concrete, it decreases the environmental pollution and reduces the solid waste problem [2]. Electronic waste in concrete is the new innovative concept of sustainable concrete. When electrical waste plastic type fibres are used at small size the results obtained are virtuous when compared with the larger size [3]. In this research paper, the extracted outer casting of electronic copper wire was used for making electronic waste fibre [4]. Fibre reinforced concrete advantages to decrease the crack propagation and raise the mechanical properties related to the normal concrete [5]. The strength and the resultant deflection was increase linearly with increasing steel fibre content in concrete[6].This research paper shows influence of mechanical properties of concrete by use of electrical waste glass fibre and electrical waste copper wire fibre of different percentages of volume portions in concrete.

2.0 Materials and Methods

The materials used for this research paper work are cement, sand, water and electrical waste copper fibre and electrical waste glass fibre.

2.1 Cement

Cement is a binder that hardens, sets and can bind extra materials together. Ordinary Portland Cement (OPC) 53 grade is used in this work. A powdery material made by claiming clay, lime and mixed with water to make mortar or mixed with sand, gravel and water to form concrete. Specific gravity was cement is to be 3.14 [7].Initial and final setting times of cement is 200 and 270 minutes

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correspondingly. Properties of the cement as show in below.

Table 1: Properties of Cement

Test		Result
Fineness		220 m^2/Kg
Soundness		10 mm
Setting time	1. Initial	31 min
	2. Final	580 min
Compressive strength		[illegible]
	1. 7 days	[illegible]
	2. 14 days	[illegible]
	3. 28 days	[illegible]

2.2 Fine aggregate

Locally existing river sand with good quality was used as a fine aggregate. The sand was meeting the requirements of zone II [8]. Aggregate passing through 4.75 mm sieve and retained on the 75 µm sieve. Specific gravity of the fine aggregates is found to be 2.64. Properties of fine aggregates as show in below.

Table 2: Properties of Fine Aggregates

Physical tests	Fine aggregates
Specific gravity	2.64
Fineness modulus	2.34
Bulk density (kg/m^3)	1780

2.3 Coarse Aggregate

The Crushed granite stone aggregate was used from the local quarry. In this experiment the aggregate was used of 20 mm down and Specific gravity of the fine aggregates is found to be 2.6. Properties of coarse aggregates as show in below.

Table 3: Properties of Course Aggregates

Physical tests	Course aggregates
Specific gravity	2.6
Fineness modulus	4.38
Bulk density (kg/m^3)	1550

2.4 Steel Fibres

2.4.1 Electrical waste copper wire fibre

Electrical waste consists of all waste from electronic and electrical usages. It includes computer and its equipment, monitors, printers, power supply cables, internet cables, electrical machines windings, central processing units, mobile phones and remotes, chargers, headphones, compact discs, batteries, LCD/Plasma TVs, refrigerators, air conditioners and other household appliances. The span of the fibre used was 30 mm shown in Figure 1. Properties of the electrical waste copper wire fibre as shown in Table 4.

Figure 1: Electrical Waste Copper Wire Fibres

Table 4: Properties of Electrical Waste Copper Wire Fibre

Fibre properties	Electrical waste copper wire fibre values
Fibre diameter (mm)	0.65
Fibre length (mm)	30
Fibre shape	Straight
Tensile strength of fibre (N/mm^2)	960
Aspect ratio	50

2.4.2 Electrical waste glass fibres

Electrical waste glass fibres confirming to ASTM D3517-14 were used [9]. The dried fibres were then cut to the necessary lengths to reach the preferred aspect ratio of 50 as shown in Figure 2. Properties of electrical waste glass fibres were shown in Table 5.

Figure 2: Electrical Waste Glass Fibre

Table 5: Properties of Electrical waste glass fibre

Fibre properties	Electrical waste glass fibre values
Fibre diameter (mm)	0.95
Fibre length (mm)	50
Fibre shape	Straight
Tensile strength of fibre (N/mm^2)	1900
Aspect ratio	50

2.4.3 Workability

The property of concrete which defines the amount of useful internal work, necessary to yield full compaction so workability is the quantity of energy to overwhelmed friction while compacting. Also defined as the relative comfort with which concrete can be mixed, transported, moulded and compacted. The slump test was done for all the concrete mix to check the workability of concrete and is shown in Table 6. The slump values of electrical waste copper wire fibre reinforced concrete and electrical waste glass fibre reinforced concrete with different percentage of volume of fibres added are as shown in a graphical representation of figure 3.

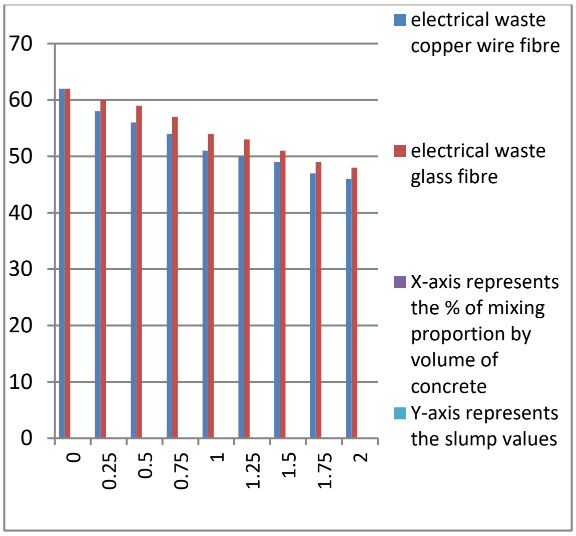
Table 6: Slump Values

% of mixing proportion by volume of concrete	Electrical waste copper wire fibre reinforced concrete (mm)	Electrical waste glass fibre reinforced concrete (mm)
0	62	62
0.25	58	60
0.5	56	59
0.75	54	57
1.0	51	54
1.25	50	53
1.5	49	51
1.75	47	49
2.0	46	48

2.4.4 Preparation and testing of specimen

Preparation and testing of concrete cubes, beams and cylinders were done as per IS code references. The concrete mix implemented was M20 concrete [10] with different percentage of fibres ranging from 0%, 0.25%, 0.5%, 0.75%, 1.0%, 1.25%, 1.5%, 1.75%, and 2.0%. Nominal concrete cubes (150 mm x 150 mm x 150 mm), concrete cylinders are 300 mm long and 150 mm diameter and prism (100 mm×100 mm × 500 mm) were casted.

Figure 3: Comparison of Slump Values



A blend of fibres were mixed with the aggregate while casting the specimens, it was confirmed that fibres were uniformly distributed throughout the mix. Tests were conducted on concrete cubes using various percentages of fibres to check for differences in compressive, flexural strength and splitting tensile. Three sets of nine cubes, nine cylinders and nine prisms of M20 mix were cast with fibre content ratio as 0.25%, 0.5%, 0.75%, 1.0%, 1.25%, 1.5%, 1.75% and 2.0%. The specimens were then shifted to curing tank for the essential period of curing and tested.

2.5 Compressive strength of concrete

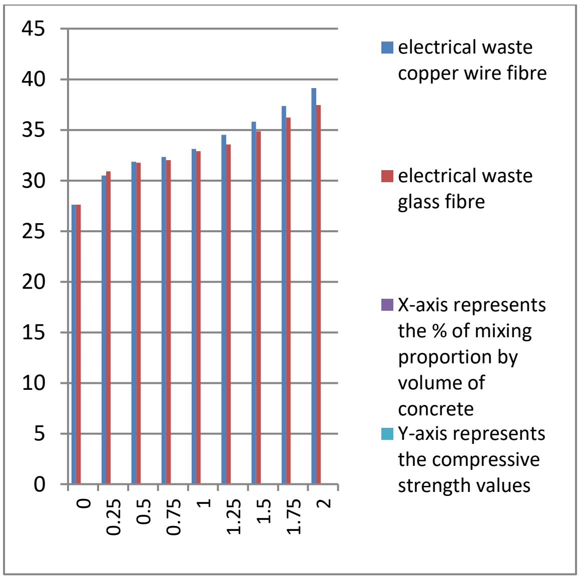
Compressive strength of concrete cubes (150 mm×150 mm ×150 mm) were made according to IS516 [10]. No packing material was filled in between the cube and loading frame. The load was applied progressively without any shock. Compressive strength of cubes was determined at a curing age of 28 days. The outcomes were tabulated in Table 7 and the compressive strength values of electrical waste copper wire fibre reinforced concrete and electrical waste glass fibre reinforced concrete with different percentage of volume of fibres added is as shown in a graphical representation of figure 4. The Compressive strength was calculated from the equation-1.

Equation 1: Compressive strength (N/mm2) = Failure load / cross sectional area

Table 7: 28 Days Compressive Strength of Concrete Cube with Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre in N/mm2

% of mixing proportion by volume of concrete	Electrical waste copper wire fibre reinforced concrete	Electrical waste glass fibre reinforced concrete
0	27.60	27.60
0.25	30.50	30.90
0.5	31.86	31.76
0.75	32.34	32.00
1.0	33.12	32.90
1.25	34.50	33.56
1.5	35.81	34.87
1.75	37.37	36.21
2.0	39.12	37.45

Figure 4: Graphical Representation Compressive Strength of Concrete Cube with Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre



2.6 Splitting tensile test of concrete

The Splitting tensile strength of cylinders (150 mm diameter and 300 mm length) were prepared according to IS 5816 [11]. Diametric lines on each of cylinder were drawn to confirm that they were in the same plane. The splitting tensile strength was determined at curing periods of 28 days. The results were tabularized in Table 8 and the splitting tensile strength of electrical waste copper wire fibre reinforced concrete and electrical waste glass fibre reinforced concrete with different percentage of volume of fibres added is as shown in a graphical representation of figure 5. The Splitting tensile strength (T) was determined from the equation-2.

Equation 2: Splitting Tensile strength (N/mm2) = 2P / π DL

where, P = failure load,

D = diameter of cylinder,

L = length of cylinder.

Table 8: 28 Days Splitting Tensile Strength of Concrete Cube with Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre in N/mm2

% of mixing proportion by volume of concrete	Electrical waste copper wire fibre reinforced concrete	Electrical waste glass fibre reinforced concrete
0	2.66	2.66
0.25	2.90	3.21
0.5	3.19	4.17
0.75	3.52	4.92
1.0	4.05	5.06
1.25	4.97	5.84
1.5	5.54	6.98
1.75	6.21	7.67
2.0	7.03	8.08

2.7 Flexural strength of concrete

Flexural strength of prisms (100 mm ×100 mm×500 mm) were prepared and tested at a curing age of 28 days [12] respectively as per IS516 [10].The load is applied progressively without any vibration or shock. The results were tabulated in Table 9 and the flexural tensile strength of electrical waste copper wire fibre reinforced concrete and electrical waste glass fibre reinforced concrete with various percentage of volume of fibres added is as shown in a graphical representation of figure 6. The flexural strength (F_b) was determined from the equation-3.

Equation: Flexural strength F_b (N/mm2) = PL /bd2

Where, P = Failure load,

L = Centre to centre distance between the support = 400 mm,

b = width of specimen=150 mm,

d = depth of specimen= 100 mm.

Figure 5: Graphical Representation of Splitting Tensile Strength Concrete Cube with Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre

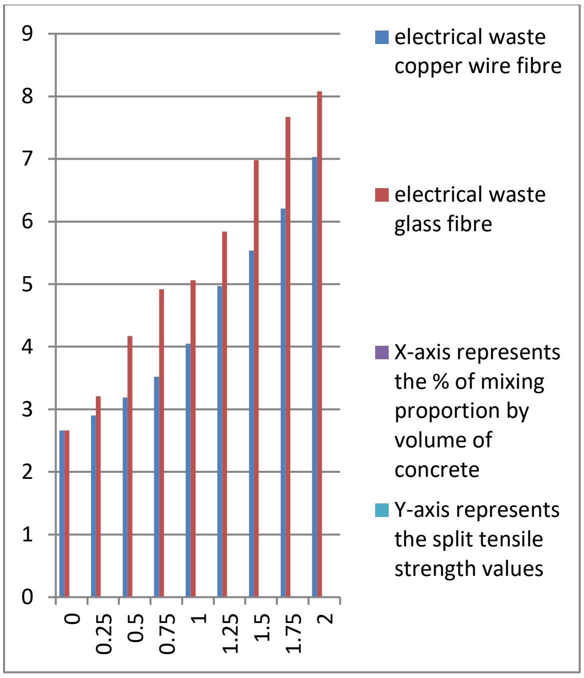


Figure 5: Graphical Representation of Flexural Strength Concrete Cube with Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre

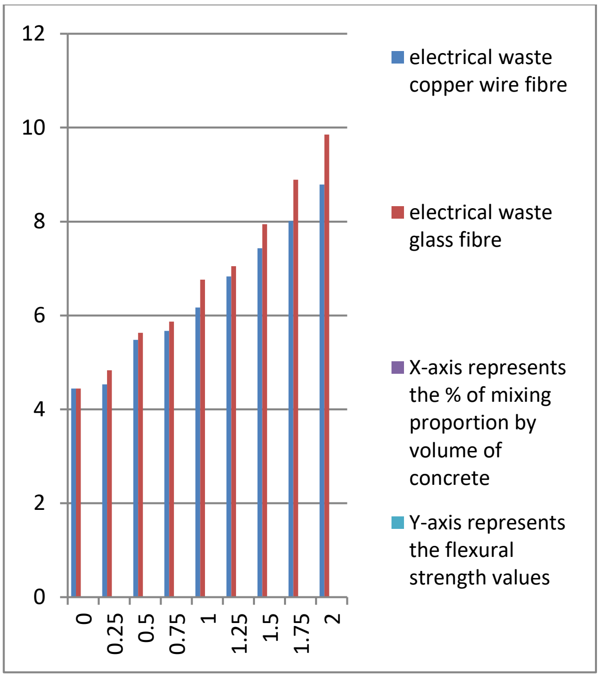


Table 9: 28 Days Flexural Strength of Concrete Cube with Electrical Waste Copper Wire Fibre and Electrical Waste Glass Fibre in N/mm2

% of mixing proportion by volume of concrete	Electrical waste copper wire fibre reinforced concrete	Electrical waste glass fibre reinforced concrete
0	4.44	4.44
0.25	4.53	4.83
0.5	5.48	5.63
0.75	5.67	5.87
1.0	6.17	6.76
1.25	6.83	7.05
1.5	7.43	7.94
1.75	8.01	8.89
2.0	8.79	9.85

3.0 Conclusion

The following conclusions could be drawn from the present analysis.

- Compressive strength of electrical waste copper wire fibre reinforced concrete values are slightly more at all percentage of fibre mixing proportion by volume of concrete except 0.25% compare to electrical waste glass fibre reinforced concrete values.
- Splitting tensile strength of concrete is quite different from compressive strength because here electrical waste glass fibre reinforced concrete values are higher at all percentages of fibre mixing proportion by volume of concrete compare to electrical waste copper wire fibre reinforced concrete values.
- Flexural strength values of an electrical waste glass fibre reinforced concrete values are higher at all percentages of fibre mixing proportion by volume of concrete compare to electrical waste copper wire fibre reinforced concrete values.
- Compressive strength, Splitting tensile strength and Flexural strength values at 2% of fibre mixing proportion by volume of concrete gives a

higher value comparing to other proportions so from this we conclude that if increasing of percentage of fibre content increase the strength at some extent.

Hence in this paper finally I concluded that the addition of copper fibre and electrical waste glass fibre integrated at 0.25, 0.5%, 0.75 %, 1.0%, 1.25%, 1.50%, 1.75% and 2.0% by volume of concrete improve the compressive strength, splitting tensile strength, flexural strength of the concrete and it also decreases the crack width under various loading conditions that was witnessed in concrete testing conditions.

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