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Design & Analysis of Scrap Steel Fibre Reinforced Concrete

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Abstract— This research work describe the use of scrap fibres which comes from the various industries & institutes as steel fibres are much costly and their cost is increased as increasing the percentage of steel fibres in the given concrete mix. so the concept is to design a suitable concrete mix and to analyze the various properties of this particular design mix as all know the function of the fibre based concrete is to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking but by using these scrap fibres I wish to maintain the cost of the mix and obtain the improved values of the different properties related to concrete mix. However concrete has some deficiencies as listed below:

Low tensile strength
Low post cracking capacity
Brittleness and low ductility
Limited fatigue life
Incapable of accommodating large deformations
Low impact strength

Key Words: Scrap Fibres, Fibre, Aggregate, Cement
Sub Area : Construction Technology & Management
Broad Area :Civil Engineering

I. INTRODUCTION

Concrete is a composite material composed mainly of water, aggregate, and cement. Usually there are additives and reinforcements included to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

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FIGURE 1.1Ingredients of Concrete

Concrete is universally used as a construction material which can be molded into any shape that man desires can be provided at a reasonable cost a material that can be designed to ensure high compressive strength. Concrete is a most widely used construction material with present estimated annual consumption of more than 6 billion tons a year all over the world. From the present trend, the future of cement concrete application looks brighter not only because of its better engineering properties but also on accounts of its better ecology and environmental acceptance for the reasons that :

1. It is usually the cheapest and most readily available construction material.
2. It is plastic in nature when in green state and can be molded in desired shapes and sizes.
3. It has good resistance against water passage.
4. It has better ecological acceptance.

II. TYPES OF FIBRES

1. **STEEL FIBER REINFORCED CONCRETE-**

steel fibre reinforce concrete is a composite material which is made up from cement concrete mix and steel fibres as a reinforcing. The steel fibres, which are uniformly distributed in the cementations mix .This mix, have various volume fractions, geometries, orientations and material properties. It has been shown in the research that fibres with low volume fractions (<1%), in fibre reinforced concrete, have an insignificant effect on both the compressive and tensile strength.
The types of steel fibers are defined by ASTM A820:-
Type I: cold-drawn wire
Type II; cut sheet
Type III: melt-extracted
Type IV: mill cut
Type V: modified cold-drawn wire.

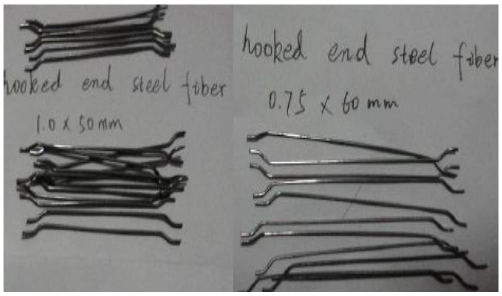


FIGURE 1.2-Steel Fibres

2. **GLASS FIBER REINFORCED CONCRETE** –

Glass fibre–reinforced concrete is (GFRC) basically a concrete composition which is composed of material like cement, sand, water, and admixtures, in which short length discrete glass fibers are dispersed. Inclusion of these fibres in these composite results in improved tensile strength and impact strength of the material. GFRC has been used for a period of 30 years in several construction elements but at that time it was not so popular, mainly in non-structural ones, like facing panels (about 80% of the GRC production), used in piping for sanitation network systems, decorative non-recoverable formwork, and other products.

At the beginning age of the GFRC development, one of the most considerable problems was the durability of the glass fiber, which becomes more brittle with time, due to the alkalinity of the cement mortar. After some research, significant improvement have been made, and presently, the problem is practically solved with the new types of alkali-resistant (AR resistance) glass fibers and with mortar additives that prevent the processes that lead to the embrittlement of GFRC.

FIGURE 1.3-Glass Fibres

3. **POLYMER FIBER REINFORCED CONCRETE:-**

Civil structures made of steel reinforced concrete normally suffer from corrosion of the steel by the salt, which results in the failure of those structures. Constant maintenance and repairing is needed to enhance the life cycle of those civil structures.

There are many ways to minimize the failure of the concrete structures made of steel reinforce concrete. The custom approach is to adhesively bond polymer fiber composites onto the structure. This also helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite. But this method adds another layer, which is prone to degradation. These fiber polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the de-lamination of the composite. A uniform distribution of fibers throughout the concrete improves the homogeneity of the concrete matrix. It also facilitates reduced water absorption, greater impact resistance, enhanced flexural strength and tensile strength of concrete. The use of polymer fibers with concrete has been recognized by the Bureau of Indian Standards (BIS) and Indian Road Congress and is included in the following Standard documents:-

FIGURE 1.4-Polymer Fibres

IS: 456:2000 – Amendment No.7, 2007
IRC: 44-2008 – Cement Concrete Mix Designs for Pavements with fibers
IRC: SP: 76:2008 – Guidelines for Ultra-Thin White Topping with fibers Vision: 2021 by Ministry of Surface Transport, New Delhi.

4. **NATURAL FIBER REINFORCED CONCRETE –**

The first use of fibers in reinforced concrete has been dated to 1870"s. Since then, researchers around the world have been interested in improving the tensile properties of concrete by adding, iron and other wastes. Local interest has been demonstrated through research work performed. In addition to industrial fibers, natural organic and mineral fibers have been also investigated in reinforced concrete. Wood, sisal, jute, bamboo, coconut, asbestos and rockwool, are examples that have been used and investigated.

FIGURE 1.5-Natural Fibres

5. **SYNTHETIC FIBRE-**

Synthetic fibres are no substitute for primary reinforcement in concrete because they add little or no strength. But structural reinforcement doesn't provide its benefits until concrete hardens. That's why some contractors add synthetic fiber to concrete as secondary. Unlike structural reinforcement, synthetic fibers provide benefits while concrete are still plastic. They also enhance some of the properties of hardened concrete.

III. EFFECT OF FIBRES ON CONCRETE

The findings of the past studies indicate that the addition of fibers to concrete improve not only the strength characteristics but also the ductility. Research over the years have shown that fiber reinforcement has sufficient strength and ductility to be used as a complete replacement to conventional steel bars in some types of structures; foundations, walls, slabs.
The technology that is available today has made is possible to consider fiber reinforcement without the use of conventional steel bars in load carrying structures.
For this to be a reality, the fibers must be distributed and oriented as expected, which is difficult. If fibers can be used without the need of steel reinforcement bars, the reinforcement part of the construction work will be eliminated. Hence, the construction costs will be significantly reduced.
From the past test results of compressive strength, split tensile strength and flexural strength, it can be seen that, in the presence of steel fiber there is an increase in compressive strength, split tensile strength and flexural strength. The crack formation is also very small in fiber specimen compared to the non fiber specimens.

Concrete made from Portland cement, is relatively strong in compression but weak in tensionand tends to be brittle (Banthia N (2012).The weakness in tension can be overcome by the use of conventional steel bars reinforcement and to some extent by the mixing of a sufficient volume of certain fibers. The use of fibers also recalibrates the behavior of the fiber-matrix composite after it has cracked through improving its toughness (Nataraja M.C., Dhang N).This thesis is aims to provide information on the properties and applications of the more commonly available Scrap Steel fibers and their uses to produce concrete with certain characteristics. A new kind of fibre reinforced concrete is developed which is made from cellulose fibers. A fibre is a small discrete reinforcing material produced from various materials like steel, plastic, glass, carbon and natural materials in various shapes and size (ACI Committee 440. 1996).
The plain concrete fails suddenly when the deflection corresponding to the ultimate flexural strength is exceeded, on the other hand fiber-reinforced concrete continue to sustain considerable loads even at deflections considerably in excess of the fracture deflection of the plain concrete.

TESTING OF SPECIMEN

Compressive strength and splitting tensile strength was conducted for 0, 1 & 2 % of SSFRC. A set of 3 specimens were tested for each % change in Scrap fibre for 14, 21 & 28 Days for both cubes and cylinders and the change in compressive strength and splitting tensile strength was observed.

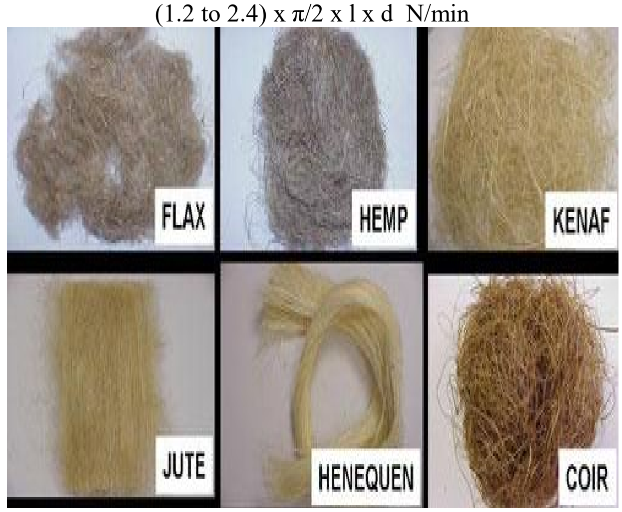
(A) COMPRESSIVE STRENGTH TEST

The test was conducted on cubes and cylinders according to IS code 516-1959. Specimens were taken out from curing tank at the age of 14, 21 & 28 days of pond curing and were then tested. Specimens were tested on Compression testing machine (CTM).The position of the cube while testing was at right angles to that of casting position. Axis of specimens was carefully aligned with the center of thrust of the spherically seated plates. The load was applied gradually without any shock and increased at constant rate of 14 N/mm²/minute until failure of specimen takes place, thus the compressive strength of specimens was found out before for all the cubical and cylindrical blocks.

(B) SPLITTING TENSILE STRENGTH TEST

The test was conducted on cubes and cylinders according to IS code 5816-1999 Specimens when received dry shall be kept in water for 24 h before they are taken for testing. Unless other conditions are required for specific laboratory investigation specimen shall be tested immediately on removal from the water whilst they are still wet. Surface water and grit shall be wiped off the specimens and any projecting fins removed from the surfaces which are to be in contact with the packing strips.
The bearing surfaces of the testing machine and of the loading strips shall be wiped clean. The test specimen shall be placed in the centering jig with packing strip and/or loading pieces carefully positioning along the top and bottom of the plane of loading of the specimen. The jig shall then be placed in the machine so that the specimen is located centrally. In the case of cubic specimens, the load shall be applied on the molded faces in such a way that the fracture plane will cross the trowelled surface. For cylindrical specimen it shall be ensured that the upper platen is parallel with the lower platen.
The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2 N/ (mm^2/min) to 2.4 N/ (mm^2/min). Maintain the rate, once adjusted, until failure. On manually controlled machines as failure is approached the loading rate will decrease; at this stage the controls shall be operated to maintain as far as possible the specified loading rate. The maximum load applied shall then be recorded. The appearance of concrete and any unusual features in the type of failure shall also be noted. The rate of increase of load may be calculated from the formula:

$$(1.2 \text{ to } 2.4) \times \pi/2 \times l \times d \text{ N/min}$$



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The technology that is available today has made is possible to consider fiber reinforcement without the use of conventional steel bars in load carrying structures.

FOR COMPRESSIVE STRENGTH

Fibres do little to enhance the static compressive strength of concrete, with increases in strength ranging from essentially nil to perhaps 15% for cubical blocks and upto 30% for cylindrical blocks however fibres contributes a little in compressive strength for 2% fibre but gives good results for 1% scrap steel fibres & all these values are shown in Table 1,2,3,4,5,6 & variation is shown in Figure 3 & in Figure 4 .

Table-5.1-Compressive strength of Cubes for 0% Scrap fibre

Mix Designation	Fibre content	Curing Time (Days)	Area (mm^2)	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
M-25	0%	14	22500 22500 22500	659 643 679	17.11 16.66 16.88	29.34
		21	22500 22500 22500	735 768 744	32.66 34.13 33.07	33.29
		28	22500 22500 22500	854 890 766	37.95 39.55 34.04	37.18

Table-5.2-Compressive strength of Cubes for 1% Scrap fibre

Mix Designation	Fibre content	Curing Time (Days)	Area (mm^2)	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
M-25	1%	14	22500 22500 22500	558 574 552	24.80 25.51 24.53	24.94
		21	22500 22500 22500	663 714 660	29.46 31.73 29.33	30.17
		28	22500 22500 22500	983 1017 894	43.69 45.20 39.73	42.87

Table-5.3-Compressive strength of Cubes for 2% Scrap fibre

Mix Designation	Fibre content	Curing Time (Days)	Area (mm^2)	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
M-25	2%	14	22500 22500 22500	570 608 595	25.33 27.02 26.44	26.26

		21	22500 22500 22500	750 667 656	33.33 29.64 29.15	30.70
		28	22500 22500 22500	825 810 894	36.67 36.00 39.73	37.46

Table-5.4-Compressive strength of Cylinders for 0% Scrap fibre

Mix Designation	Fibre content	Curing Time (Days)	Area (mm^2)	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
M-25	0%	14	17671 17671 17671	316 320 327	17.88 18.10 18.50	18.16
		21	17671 17671 17671	463 430 492	26.17 24.29 27.84	26.10
		28	17671 17671 17671	542 563 548	30.66 31.86 31.02	31.18

For this to be a reality, the fibers must be distributed and oriented as expected, which is difficult. If fibers can be used without the need of steel reinforcement bars, the reinforcement part of the construction work will be eliminated. Hence, the construction costs will be significantly reduced.

From the past test results of compressive strength, split tensile strength and flexural strength, it can be seen that, in the presence of steel fiber there is an increase in compressive strength, split tensile strength and flexural strength. The crack formation is also very small in fiber specimen compared to the non fiber specimens.

Fibre content(%)	**Compressive Strength (N/mm^2)**					
	Cubes			**Cylinders**		
	14 days	**21 days**	**28 days**	**14 days**	**21 days**	**28 days**
0	29.34	33.29	37.18	18.16	26.10	31.18
1	24.94	30.17	42.87	20.53	26.64	34.42
2	26.26	30.7	36.60	23.73	24.11	30.10

CONCLUSIONS:

The present investigation was undertaken to study the effect of fire on characteristic strength of concrete. To achieve the objectives of the present study, nine specimens were prepared. with different of grade M-25 and with different proportion of scrap steel fibres for different time periods. The results of the testing compared to check the percentage gin in compressive strength and splitting tensile strength of concrete after inclusion of scrap steel fibres into it. The compressive strength was determined for the design mix of grade M-25 at the curing age of 14, 21 & 28 days for 0, 1, & 2% scrap steel fibres.. The results obtained for the above mixes were compared to investigate the effects of these fibres on mechanical properties.

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