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Utility of Wastage Material as Steel Fibre in Concrete Mix M-20

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ABSTRACT

Fiber Reinforced Concrete (FRC) is a composite material consisting of cement based matrix with an ordered or random distribution of fiber which can be steel, nylon, polythene etc. The addition of steel fibre increases the properties of concrete, viz., flexural strength, impact strength and shrinkage properties to name a few. A number of papers have already been published on the use of steel fibres in concrete and a considerable amount of research has been directed towards studying the various properties of concrete as well as reinforced concrete due to the addition of steel fibres. Hence, an attempt has been made in the present investigations to study the influence of addition of Lathe Machines waste material as fibers at a dosage of 5% to 30% by weight of cement. The properties studied include compressive strength. The studies were conducted on a M20 mix and tests have been carried out. The results are compared and conclusions are made.

Keywords: Fiber Reinforced Concrete, Mix, compressive strength, Waste material,

1 INTRODUCTION

Concrete is the most important construction material, which is manufactured at site. Concrete required for extensive construction activity can always be made available since all the ingredients of concrete are materials of geological origin. Various research and efforts have been made to obtain a durable, strong and economical concrete mix.

The investigation reported in this project was carried out to study the feasibility of using industrial waste fibres in fibre reinforced concrete. Waste fibre from lathe industry were collected and used in this investigation. A total of 63 number of concrete cube specimens were casted with and without fibres and were tested under compression as per relevant Indian standard specifications. Test result indicated that addition of waste fibres from lathe increases the compressive strength and many other properties of concrete but up to certain limit of percentage.

The Concrete mix design can be defined as the art of obtaining a concrete of the required properties, at the lowest cost, by suitable choice and proportions of available materials. Needless to say, a property designed concrete mix for the specified strength requirement, should have the minimum cement content to make mix economical. It should, however, be stressed that the precise relationship falls between the properties of concrete and the specific characteristics such as water cement ratio, aggregate cement ratio and grading, apart from such elusive quantities as aggregate-particle shape and texture. Hence, concrete mix design cannot be mechanically done and is likely to remain an art, rather than a science, for some time to come.

The purpose of concrete mix design is to ensure the most optimum properties of the constituent materials to meet the requirements of the structure being built. Mix design should ensure that the concrete:

- Complies with the specifications of structural strength laid down, which is usually stated in terms of the compressive strength of standard test specimens.
- Complies with the durability requirements to resist the environment in which the structure will serve its functional life.
- Be capable of being mixed, transported, and compacted as efficiently as possible without undue labour.
- And last, but not least, be as economical as possible.

The design of concrete is science that can be described here only in its broad outlines. The starting point of any mix design is to establish the desired workability characteristics of wet concrete, the desire physical properties of the cured concrete and the acceptable cost of the concrete.

2.1: VARIABLES IN MIX PROPORTIONING

With the given materials, the four variable factors to be considered for the specifying a concrete mix are:

i) Water cement ratio.
ii) Cement content or cement aggregate ratio.
iii) Gradation of aggregate.
iv) Consistency.

2.2 METHODS OF CONCRETE MIX PROPORTIONING

A large number of methods are available for concrete mix proportioning. Some of them are listed below:

1) ACI method
2) Indian Standard Method
3) Rapid Method
4) Road note no.4 Method
5) Surface area Method
6) IRC-44 Method
7) Trial and error Method
8) High strength concrete mix design
9) DOE (British) mix design Method

2.3 STATISTICAL QUALITY CONTROL OF CEMENT CONCRETE:

In concrete, it is very difficult to assess the strength of final product. It is not possible to have a large number of destructive tests for evaluating the strength of end product. The aim of quality control is to limit the variability as much as practicable. Limited variability means, ensuring the probability test result falling below the design strength is not more than specified tolerance level. Statistical quality control method provides a scientific approach to the concrete designer to understand the realistic variability of the material so as to lay down design specification with proper tolerance. Cement is a binding material, which is used in construction work. There are varieties of cement available in the market and each type is used under certain condition due to special properties.

3. CEMENT

3.1 TYPES OF CEMENT

Ordinary Portland cement

Ordinary Portland cement is the most commonly used form of cement. Prior to 1987, there was only one grade of OPC, which was governed by IS 269-1976. After 1987 higher-grade cements were introduced in India. The oxide composition of ordinary Portland cement is:

Type of Oxide	Percentage
Ca O	60-67
SiO2	17-25
Al2O3	3-8
Fe2O3	0.5-6
MgO	2.5
SO3	1

3.2 AGGREGATE

The aggregate is the matrix or principal structure consisting of reltively inert, fine and coarse material. The aggregate for concrete varies in sizes, but in any mix the particles of different sizes are used. The particles size distribution is called the grading of the aggregate. While producing good quality concrete the aggregate is used at least from two size groups.

3.2.1 FINE AGGREGATE

IS:-383-1963 destines the fine aggregate as the aggregate which will pass through 4.75 mm IS sieve. The fine aggregate is often termed a sand size aggregate.

3.2.2 COARSE AGGREGATE

Coarse aggregate shall consist of crushed or broken stones and be hard, strong, dense, durable, clean or proper gradation and free from skin and coating likely to prevent proper adhesion of mortar. The aggregate shall generally be cubical in shape as far as possible flaky, elongated pieces shall be avoided. Unless special stone of particular quarries are mentioned in the special provisions, aggregate shall be broken from the best trap/granite/quartzite/geness stones in that order available in the region and approved by the Engineer.

The maximum size may be up to 80 mm and well graded between the size 5mm to 80mm in such proportion as to give maximum density to the concrete. The maximum size should be as large as possible within the above limit but should not exceed 1/4 of minimum thickness of the member provided. However, this size presents no difficulty in the case of R.C.C. to surround the reinforcement thoroughly and fill up the corners of the formwork satisfactorily.

In the case of general concrete work, maximum size of 40 mm is used and in R.C.C. work a maximum size of 20 mm (about 3/4) will be found satisfactory but it should be restricted to 6 mm (about 1/4) less than the minimum lateral cleat distance between bars or 6 mm (about11/4) less than the cover whichever is smaller. The crushing strength of aggregate will be such as to allow the concrete in which it is used to build up the specified strength of concrete.

To know more about the concrete it is very essential that one should know about aggregate, which constitute major volume in concrete. For testing the study of aggregates has been done under the following subheadings:

Size
Specific Gravity
Moisture Content
Sieve Analysis
Grading

3.3 SIZE

The largest maximum size of aggregate practicable to handle under a given set of condition should be used. Using the largest possible maximum size will result in:

- Reduction of cement content
- Reduction in water requirement
- Reduction of drying shrinkage

However, the maximum size of aggregate that can be used in any given condition may be limited by the following condition:

- Thickness of section
- Spacing of reinforcement
- Clear cover
- Mixing, handling and placing techniques

Generally, the maximum size of aggregate should be as large as possible within limits specified, but in any case not greater than one-fourth of the minimum thickness of the member provided.

3.4 SPECIFIC GRAVITY

Specific gravity of aggregate is made use of, in design calculations of concrete mix. With the specific gravity of each constituent known its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Average specific gravity of the rock varies from 2.6 to 2.8.

3.5 MOISTURE CONTENT

Some of the aggregate are porous and absorptive. Porosity and absorption of aggregate will affect the water cement ratio and the workability of concrete and sometimes also affect the durability of concrete.

3.6 Sieve analysis

Sieve analysis is the name to the operation of dividing a sample of aggregate into various fraction each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in sample of aggregate, which is called gradation. In this connection a term known as "Fineness Modulus" is being used. The fineness modulus is a numerical index of fineness, giving some ideas of the mean size of the particles present in the entire body of the aggregate.

The following limits may be taken as guidance:-

Type of sand	Fineness Modulus
Fine sand	2.2 - 2.6
Medium sand	2.6 - 2.9
Coarse sand	2.9 - 3.2

3.7 Gradation

The particle size distribution of an aggregate as determine by sieve analysis is termed as grading of aggregate. The grading of aggregate is expressed in term of percentage by weight retained on or passing through a series taken in order, 80mm, 40mm, 20mm, 10mm, 4.75mm, for coarse aggregate and 10mm,4.75mm, 2.36mm, 1.18mm, 600 microns, 300microns, for fine aggregate. The grading of aggregate affects the workability, which in turn, controls the water and cement requirements, segregation and influences the placing and finishing of concrete. There is no universal ideal grading curve. However, IS:383-1970 has recommended certain limits within which the grading must lie to produce satisfactory concrete, subjected to the fulfillment of certain desirable properties of aggregate, such as shape, surface texture, type of aggregate and amount of flaky and elongated materials.

4. FIBRE REINFORCED CEMENT CONCRETE

Fibre reinforced concrete is a composite material consisting of cement, sand, coarse aggregate, water and fibres. In this composite material, short discrete fibres are randomly distributed throughout the concrete mass. The behavioral efficiency of this composite material is far superior to that of plain concrete and many other construction material of equal cost. Due to this benefit, the use of FRC has steadily increased during the last two decades and is current field of application includes: airport and highway pavements, earthquake resistant and explosive resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, rock slope stabilization .

Figure 4.1. Steel Fibre from Laths Machines

4.1 Steel Fiber-Reinforced Concrete Design Considerations

Length, diameter, configuration, tensile strength and aspect ratio can be used to specify steel fiber. The range in fiber length available is 5 mm to 50mm. The 25mm length provides both macro-micro crack reinforcement and hardened concrete benefits. Configuration can be straight, continuous-deformed, or end-deformed. Initially, straight fibers were the only configuration of steel fibers available. It was quickly learned that their bonding potential was limited which restricted their expected contribution to the engineering properties of concrete. New products were developed to increase the bond between the fiber and concrete and two configurations emerged as the two best configurations: A hooked-end, drawn-wire fiber and a continuously-deformed, slit-sheet steel fiber. It was determined that the continuous-deformed, slit-sheet fiber provided better micro-macro cracking performance, as well as flexural strength enhancement; whereas, the end-deformed, drawn-wire steel fibers performed best post-first-crack.

To provide optimum performance, steel fibers should be clean and free from rust, oil and deleterious materials. They should be introduced in a continuous stream to the mixing system which must be rotating at mixing speed. Calcium chloride and chlorides in general, should not be used with steel fibers. Although steel fibers do not exhibit the same rusting problems as continuous-steel reinforcement, it makes good engineering sense to avoid chlorides. To improve consistency and mobility, low-, medium- and high-range water reducers are recommended for use with steel-fiber reinforced concrete. Typically, medium- and high-range water reducers are used as standard practice.

4.2 ADVANTAGES OF STEEL FIBRE REIN FORCED CONCRETE (SFRC)

1) FLEXURAL STRENGTH: 1.5 to 3 times increase in first crack and flexural bending strength can be achieved over plain concrete using Steel Fibre.

2) FATIGUE RESISTANCE: The fatigue strength of steel fibre concrete is 1.5 times that of conventional concrete.

3) IMPACT RESISTANCE: Steel fibres greatly increase concrete's resistance to damage from heavy impact. Highly recommended in use where heavy impacts are expected.

4) CORROSION: Steel Fibre being a discontinuous, corrosion will be arrested to the damaged portion and will not be transported.

5) SHRINKAGE: Steel fibres themselves do not affect the shrinkage rate but they do minimize and help eliminate shrinkage cracks.

6) ABRASION RESISTANCE: Steel Fibres offer a high degree of protection against abrasion.

7) PERMEABILITY: By effectively reducing the micro cracking SFRC (Steel Fibre Reinforced Concrete) will reduce the

overall porosity of the matrix, making the concrete less permeable.

5. LABORATORY TEST OBSERVATION

TABLE 5.1:- Average compressive Strength of concrete mix made by using OPC with 5 % Steel Fibres

STRENGTH → DAYS ↓	CONCRETE MIX DESIGN	5 % STEEL FIBRE IN CONCRETE
	Comp. Strength (N/mm2)	Comp. Strength (N/mm2)
3 Days	14.44 15.55 14.22	13.33 16.00 16.66
7 Days	16.67 17.78 18.89	17.78 22.22 22.66
28 Days	24.44 24.89 26.67	27.78 23.33 24.44

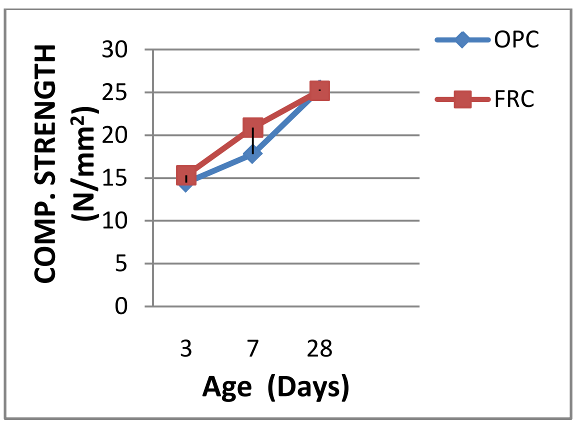

Figure 5.1. Average compressive Strength ofconcrete mix made by using OPC with 5 % Steel Fibres

TABLE 5.2:- Average compressive Strength of concrete mix made by using OPC with 10 % Steel Fibres

STRENGTH → DAYS ↓	CONCRETE MIX DESIGN	10 % STEEL FIBRE IN CONCRETE
	Comp. Strength (N/mm^2)	Comp. Strength (N/mm^2)
3 Days	14.44 15.55 14.22	16.67 16.89 16.44
7 Days	16.67 17.78 18.89	20.00 23.33 15.55
28 Days	24.44 24.89 26.67	20.89 24.00 24.44

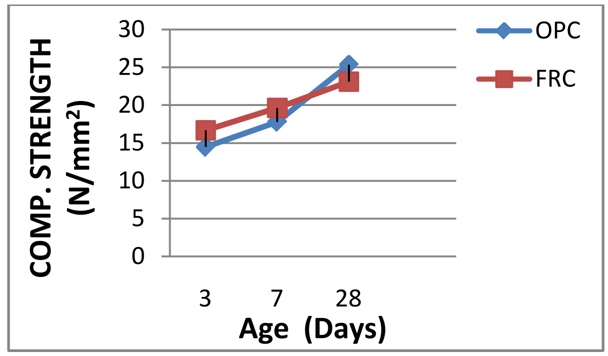

Figure 5.2. Average compressive Strength ofconcrete mi made by using OPC with 10 % Steel Fibres

TABLE 5.3 Average compressive Strength of concrete mix made by using OPC with 15 % Steel Fibres

STRENGTH DAYS → ↓	CONCTRETE MIX DESIGN	15 % STEEL FIBRE IN CONCRETE
	Comp. Strength (N/mm^2)	Comp. Strength (N/mm^2)
3 Days	14.44 15.55 14.22	19.55 16.89 18.67
7 Days	16.67 17.78 18.89	20.44 17.78 23.33
28 Days	24.44 24.89 26.67	25.33 25.78 21.33

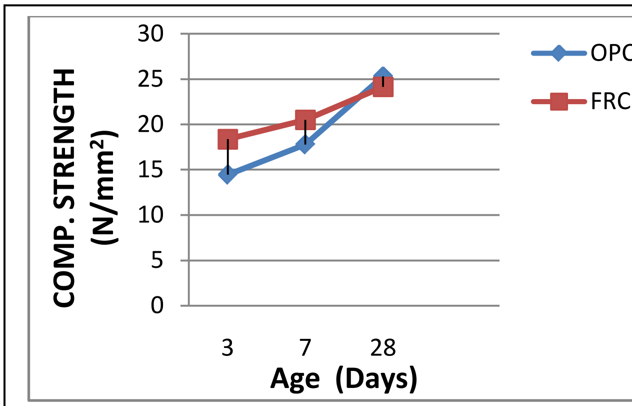

Figure 5.3. Average compressive Strength of concrete mix made by using OPC with 15 % Steel Fibres

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TABLE 5.4 Average compressive Strength of concrete mix made by using OPC with 20 % Steel Fibre

STRENGHT → / DAYS ↓	CONCTRETE MIX DESIGN	20 % STEEL FIBRE IN CONCRETE
	Comp. Strength (N/mm^2)	Comp. Strength (N/mm^2)
3 Days	14.44 15.55 14.22	16.89 18.89 18.22
7 Days	16.67 17.78 18.89	23.22 22.22 22.22
28 Days	24.44 24.89 26.67	18.89 22.22 25.55

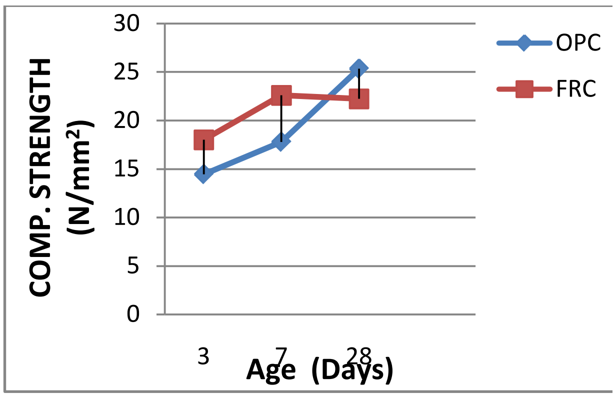


Figure 5.4. Average compressive Strength of concrete mix made by using OPC with 20 % Steel Fibre

TABLE 5.5 Average compressive Strength of concrete mix made by using OPC with 25 % Steel Fibre

STRENGHT → / DAYS ↓	CONCTRETE MIX DESIGN	25 % STEEL FIBRE IN CONCRETE
	Comp. Strength (N/mm^2)	Comp. Strength (N/mm^2)
3 Days	14.44 15.55 14.22	18.89 17.78 15.11
7 Days	16.67 17.78 18.89	26.67 18.89 20.00
28 Days	24.44 24.89 26.67	20.00 22.22 20.00

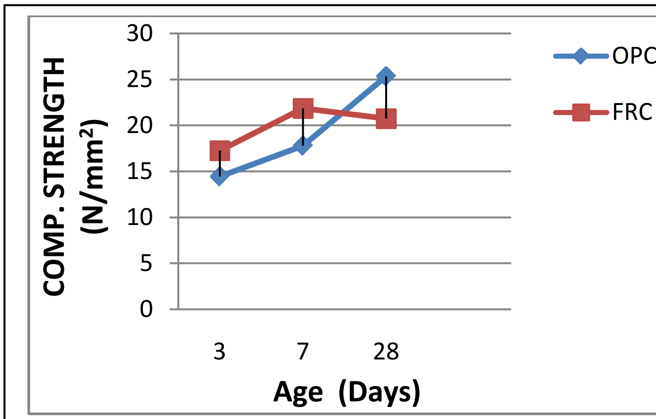


Figure 5.5. Average compressive Strength of concrete mix made by using OPC with 25 % Steel Fibre

TABLE 5.6 Average compressive Strength of concrete mix made by using OPC with 30 % Steel Fibres

STRENGTH → / DAYS ↓	CONCTRETE MIX DESIGN	30 % STEEL FIBRE IN CONCRETE
	Comp. Strength (N/mm2)	Comp. Strength (N/mm2)
3 Days	14.44 15.55 14.22	10.00 14.22 14.22
7 Days	16.67 17.78 18.89	16.67 18.22 20.00
28 Days	24.44 24.89 26.67	21.11 20.44 20.00

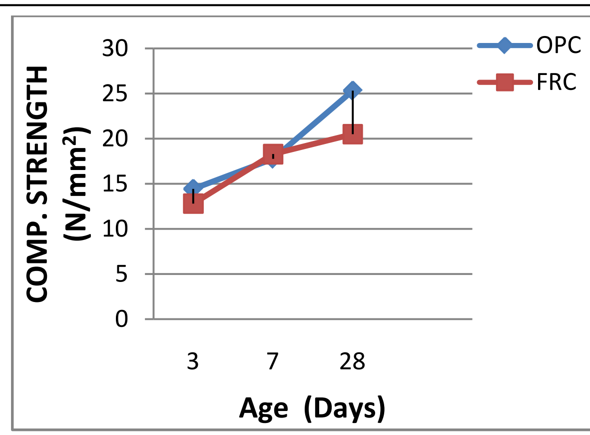


Figure 5.6 Average compressive Strength of concrete mix made by using OPC with 30 % Steel Fibres

Table 5.7 – Averege compressive strength of cement of different percentage of Steel Fibre with OPC

Curing Age in Days	Mix WF	5% Steel Fibre	10% Steel Fibre	15% Steel Fibre	20% Steel Fibre	25% Steel Fibre	30% Steel Fibre
	Compressive Strength in N/mm^2						
3	14.73	15.33	16.67	18.37	18.00	17.26	12.82
7	17.78	20.89	19.63	20.52	12.59	21.85	18.30
28	25.33	25.18	23.11	24.15	22.22	20.74	20.52

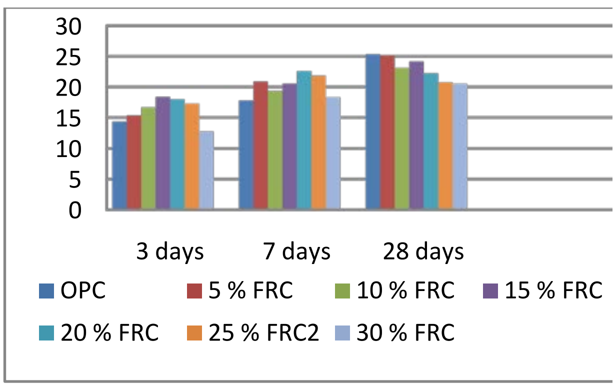
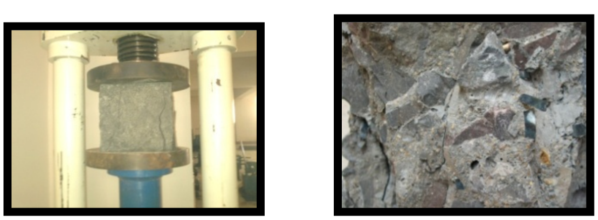


Figure 5.7. Averege compressive strength of Concrete mix of different percentage of Steel Fibre with OPC

(a) (b)

Figure5.8 – Addition (a) and Mixing (b) of Steel Fibres



(c) (d)

Figure5.9 – Compression Test of Cube© & Bond between Fibre and Concrete (d)

6. CONCLUSION

The aim of Mix Design is to make a concrete of desirable strength, durability and economy. In Present study, the waste product "steel fiber from lath" was used in place of reducing percentage of cement has been studied in terms of effect on strength of concrete and following results were obtained-

1. When 5% cement replaced by Steel Fibre was allowed to mix on OPC for making concrete, its strength increased up to 7 days as compare plain cement concrete but strength decreased in 28 days curing.
2. When 10% cement replaced by Steel Fibre was allowed to mix on OPC for making concrete, its strength increased up to 7 days as compare plain cement concrete but strength decreased in 28 days curing.
3. When 15% and 20% cement replaced by Steel Fibre was allowed to mix on OPC for making concrete, its strength increased up to 7 days as compare plain cement concrete but strength decreased in 28 days curing.
4. When 25% and 30% of cement was replaced by Steel Fibre, added the strength of concrete consistently decreased as compared to Plain Cement Concrete.

Thus from above study we concluded that the 28 days compressive strength of concrete mixed (M 20), containing Steel Fiber in varying percentage viz.(5,10,15,20) was slightly less than the Plain Cement Concrete. The project report shows that strength increased upto 20 % when cement was replaced by 20 % Steel Fibre. But strength decreased when 25 % and 30 % cement was replaced by Steel Fibre. Strength reduced due to decreasing quantity of cement; on other hand adding steel fibre in place of cement did not act as a binding material which affected the bond strength of concrete hence strength of concrete reduced. In practical aspect it is very essential that concrete gained its maximum strength in the age 7 days. In the above study the trend of the curve of cement concrete mix with steel fiber obtained is high or nearly same as that of Plain Cement Concrete, so it mainly used for field work.

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