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# EXPERIMENTAL STUDIES OF COMPACTING IN CONCRETE USING STEEL FIBER

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## ABSTRACT

Conventional concrete tends to present a problem with regard to adequate compaction in this sections or areas of congested reinforcement, which leads to a large volume of entrapped air voids and compromises the strength and durability of the concrete. It is proposed to use of fine materials in the fresh concrete M30 grade such as fly ash (40% replacement of cement), super-plasticizer (viscocrete – 1%) and viscosity modifying agent (stabilizer 4R – 0.2%) and studied the concrete properties of self-compacting concrete. Self-compacting concrete with steel fiber compressive and flexural strength was more than M30 grade concrete with 1.0% of steel fiber have 45.24 N/mm$^2$ which is about 16.69% more than M30 grade control concrete without steel fiber and flexural strength of self-compacting concrete with 1.5% of steel fiber have 27.45 N/mm$^2$ which is about 2.66% more than OCC with 1.5% of steel fiber.

## I. INTRODUCTION

**General**

The term fiber reinforced concrete (FRC) is defined as the concrete containing a hydraulic cement, water, fine and coarse aggregate and discontinuous discrete fibers called fiber-reinforced concrete (FRC).

Fibers of various shapes and sizes produced from steel, plastic, glass and natural materials are being used; however, for most structural and non-structural purposes, steel fiber is the most commonly used of all the fibers.

The steel fibers of different shapes and sizes are shown below:
Typical fiber types used in concrete:

(a) Straight, smooth, drawn wire steel fibers
(b) Deformed (crimped) wise steel fibers
(c) Variable – cross section steel fibers
(d) Glued bundles of steel fibers with crimped ends

**Function of steel fibers in concrete**

Unlike welded wire reinforcement or rebar, which is specifically located in a single plane, steel fibers are distributed uniformly throughout the concrete matrix. The primary function of steel fibers is to modify micro and macro cracking.

**Admixtures for concrete**

An admixture is a material added to the batch of concrete before or during its mixing to modify its freshly mixed, setting or hardened properties.

**Groups**

There are two main groups of admixtures.

1. Chemical
2. Mineral

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**Chemical admixtures**

Chemical admixtures reduce the cost of construction, modify the properties of concrete and improve the quality of concrete during mixing, transportation, placing and curing.

1. Air-entrainment
2. Water-reducing
3. Set-retarding
4. Accelerating
5. Super-plasticizers
6. Corrosion-inhibitors
7. Shrinkage-reducers
8. Alkali-silica reactivity reducers

**Mineral admixtures**

Mineral admixtures reduce cost, reduce permeability, increase strength and change other concrete properties. There are three main mineral admixtures.

1. Supplementary Cementations Materials (SCM),
2. Silica fume and
3. Ground granulated blast furnace slag

**Functions**

The reasons to use admixtures are:

- Increase slump and workability;
- Retard or accelerate initial setting;
- Reduce or prevent shrinkage;
- Modify the rate or capacity for bleeding;
- Retard or reduce heat evolution during early hardening;
- Accelerate the rate of strength development at early ages;
- Increase strength (compressive, tensile or flexural);
- Increase durability or resistance to severe conditions of exposure, including application of de-icing salts and other chemicals (air-entraining);
- Decrease permeability of concrete;
- Increase bond between existing and new concrete;
- Improve impact and abrasion resistance (hardness);
- Inhibit corrosion of embedded metal;
- Gas-forming;
- Anti-washout;
- Foaming and
- Produce colored concrete
- Reduce segregation and Improve pump ability and finish ability

**Objective and research significations**

To minimize the time period of urgent repair works and also increase the strength by using of FRC with admixtures.

Since systematic laboratory study on the simultaneous use of combination of admixtures is lacking, it is found necessary to study the properties of fiber reinforced concrete containing combination of admixtures.

By using the SFRC can reduce the requirement of steel reinforcement in concrete.

**Scope**

Manufacturing methods for steel fiber are explained. Effects of steel fiber inclusion on concrete in the hardened and fresh states are overviewed.

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## II. INGREDIENTS

**Cement**
The binding materials used in concrete are Portland Pozzolana cement. This cement is of 53grades conforming to IS 456-2000 and is having desired properties. The compressive strength of cement is checked by casting cube and testing under compressive testing machine and the tensile strength of cement is checked by casting beam and testing under tensile testing machine.

This cement should be cool and stored in dry cool place. The specific gravity of cement should be determined by adopting standard procedure.

**Coarse aggregates**
The coarse aggregate for the works should be river gravel or crushed stone. Angular shape aggregate of size 20 mm and below. The aggregate which passes through 75 mm sieve and retain on 4.75 mm are known as coarse aggregate.

After 24-hrs immersion in water, a previously dried sample of the coarse aggregate should not gain in weight than 5%. Aggregate should be stored in such a way as to prevent segregation of sizes and avoid contamination with fines.

**Fine Aggregates**
Aggregate which is passed through 4.75 IS sieve and retained on 75 micron (0.075mm) IS sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture.

Usually, the natural river sand is used as fine aggregate. The moisture content of fine aggregate is determined to apply field corrections in design mixes. Ordinary river sand conforming IS 383-1970.

**Steel fibers**

About two decades back, steel fiber rein-forced short Crete (SFRS) and steel fiber reinforced concrete (SFRC) were considered a new technology for the construction industry. However today this technology has found wider acceptance among the construction industry. Currently, steel fibers are used in varies segments in many application areas across different segments in the construction industry, especially in tunneling, airport, warehouses, etc.

The most important aspect controlling the performance of steel fibers in short Crete (and concrete) is the aspect ratio, volume concentration, geometrical shape.

**Admixtures**
Super plasticizers are High Range Water Reducers and use lower W/c ration. This is a liquid type is SUPAFLO SP and brown color. Air entrainment in concrete is normally limited to a maximum of 4 to 5 percent as it reduces the strength of concrete to some extent.

Calcium chloride is the most commonly used accelerator. Color of accelerator is Dark Blue. This is liquid type i.e. FORMATES. This is liquid type i.e. GLUCONATES. Color of retarder is water color. This is liquid from i.e. SETCRETE RMW and color of the admixtures is Brown color.

**Combination of admixtures**
- Super plasticizers + Air-Entraining agent + Accelerator (SP+AEA+ACC)
- Super plasticizers + Air-Entraining agent + Retarder (SP+AEA+RET)
- Super plasticizers + Air-Entraining agent + Water proofing compound (SP+AEA+WPC)

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| Details of admixtures used | | | |
|---|---|---|---|
| **Admixtures** | **Abbreviation** | **Chemical Content** | **Dosage used (by weight of cement) per cent** |
| Super plasticizer | SP | SUPAFLO SP | 1.1 % |
| Air-Entraining agent | AEA | Vinsol Resin | 0.1 % |
| Accelerator | ACC | Gluconates | 0.4 % |
| Retarder | RET | Formats | 0.8 % |
| Water proofing compound | WPC | SETCRETE RMW | 0.4 % |

## III. MATERIAL PROPERTIES

**Specific gravity of cement**
The specific gravity of cement is to be found in the laboratory by using pyconometer and other accessories. Value of specific gravity of cement is obtained as 3.05.

**Specific gravity of coarse aggregate**
The specific gravity of coarse aggregate usually called coarse aggregates is the ration of the weight in air of the giver volume of dry coarse aggregate at a stated temperature to the weight in air is equal volume of distilled water at a stated temperature.

**Specific gravity of fine aggregate**
The specific gravity of soil grains (or solids) usually called soil is the ration of the weight in air of the given volume of dry soil solids at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature.

The specific gravity of sand is to be found in the laboratory by using pyconometer and other accessories. Value of specific gravity of sand is 2.63.

**Water Absorption of coarse aggregates**
The water absorption of aggregate is determined by measuring the increase in weight of a dry sample when immersed in water for 24 hours.

**Abrasion value of coarse aggregates**
The abrasion value is to be found in the laboratory by using Deval's abrasion machine and other accessories. Abrasion value of coarse aggregate is 8.6%

Fineness modules are a ready index of coarsenessor fineness of material. Fineness modules is an empirical fact or obtained by adding the cumulative percentage of aggregate retained on standard sieves ranging from 80 mm to 150u and dividing thus sum by an arbitrary number 100 and coarse is the material by means of sieve analysis. We can find out fineness modules of aggregates.

**Initial setting time and final setting time**

***Initial Setting Time:***
The period elapsed between the times when is water added to the cement and the time that the paste starts losing its plasticity. The needle may penetrate only to a depth of 33-35 mm from the top is taken as initial setting time.

***Final Setting Time:***
The period elapsed between the instant of addition of water and the paste has completely lost its plasticity.

***Setting of cement***
When water is mixed with cement, the paste so formed remains pliable and plastic for a short time. During this period it is possible to disturb the paste and remit it without any deleterious effects.

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**Bulk density and percentage of voids**

Bulk density of aggregate is of interest when we deal with light weight aggregate and heavy weight aggregate. The parameter of bulk density is also in concrete mix design for converting the proportions by weight into proportions by volume when weigh batching equipment is not available at the site.

**Moisture content**

Free moisture is both fine and coarse aggregate affects the quality of concrete in more than one way. In case of weight batching, determination of free moisture content of the aggregate is necessary and the correction of w/c ration to be effected in this regard.

**Properties of cement**

The properties of cement tested were listed below

| Properties of cement | | |
|---|---|---|
| **Sl. No.** | **Particulars** | **Values** |
| 1 | Specific Gravity | 3.00 |
| 2 | Initial Setting Time | 3 min |
| 3 | Final Setting Time | 5hrs 20min |

| Compressive strength of cement grade | | | |
|---|---|---|---|
| **Types of Cement** | **7 Days** | **14 Days** | **28 Days** |
| 53 grade ordinary Portland Cement | 30 $N/mm^2$ | 40 $N/mm^2$ | 55 $N/mm^2$ |

**Properties of coarse aggregate**

The properties of coarse aggregate tested were listed below

| Properties of coarse aggregate | | |
|---|---|---|
| **Sl. No.** | **Particulars** | **Values** |
| 1 | Specific Gravity | 2.80 |
| 2 | Water Absorption | 0.5 % |
| 3 | Deval's Abrasion | 8.7 % |
| 4 | Fineness Modules | 7.15 |
| 5 | Bulk Density | 1.42 x $10^3$ $Kg/m^3$ |
| 6 | % of voids | 50 % |
| 7 | Moisture Content | 0 % |

**Properties of fine aggregate**

The properties of fine aggregate tested were listed below

| Properties of fine aggregate |
|---|

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| Sl. No. | Particulars | Values |
|---|---|---|
| 1 | Specific Gravity | 2.60 |
| 2 | Bulk Density | 1.21 x $10^3$ Kg/$m^3$ |
| 3 | Fineness Modules | 2.45 |
| 4 | % of voids | 54 % |
| 5 | Water Absorption | 1.0 % |
| 6 | Moisture Content | 1.5 % |

**The properties of steel fibers**

The properties of steel fibers tested were listed

| The properties of steel fibres | | |
|---|---|---|
| **Sl. No.** | **Fibre Properties** | **Steel Fibre Details** |
| 1 | Shape | Hooked ends |
| 2 | Length (mm) | 30 |
| 3 | Size / Diameter (mm) | 0.5 |
| 4 | Density (Kg / $M^3$) | 7850 |
| 5 | Tensile Strength (MPa) | 532 |
| 6 | Young's Modulus (GPa) | 207.3 |

The above properties shall be used during mix design.

## IV. METHODOLOGY

**Selection of W/c Ratio**

From figure-1 IS 10262-1982
W/c ratio = 0.5

**Section of water and sand content**

From table-4 IS 10262-1982 for 20mm nominal maximum size aggregate and sand conforming to grading zone water content / cubic meter of concrete = 186Kg and sand content as percentage of total aggregate by absolute volume = 35 % for change in value in W/c, compacting factor and sand belonging to zone III, the following adjustment is required.

## V. TEST FOR CONCRETE

**Comparison on test results**

**Compression strength test as per is code method**

| Test results of the specimens FRC without admixtures and FRC with combination of admixtures (SP+AEA+ACC) | | | | |
|---|---|---|---|---|
| **Different percentage of Steel Fibre** | **Compressive strength of FRC without any admixture (Ref. mix) (MPa)** | | **Compressive strength of FRC with combination of admixture ( SP+AEA+ACC ) (MPa)** | |
| | **7 Days** | **28 Days** | **7 Days** | **28 Days** |
| 0 | 24.20 | 36.12 | 32.10 | 43.00 |
| 0.1 | 25.51 | 39.33 | 34.35 | 45.1 |
| 0.2 | 27.11 | 40.33 | 35.12 | 45.4 |
| 0.3 | 28.31 | 41.2 | 35.80 | 45.6 |

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| Test results of the specimens FRC without admixtures and FRC with combination of admixtures(SP+AEA+RET) | | | | |
|---|---|---|---|---|
| Different percentage of Steel Fibre | Compressive strength of FRC without any admixture (Ref. mix) (MPa) | | Compressive strength of FRC with combination of admixture ( SP+AEA+RET ) (MPa) | |
| | 7 Days | 28 Days | 7 Days | 28 Days |
| 0 | 24.20 | 36.12 | 30.95 | 42 |
| 0.1 | 25.51 | 39.33 | 31.12 | 43.3 |
| 0.2 | 27.11 | 40.33 | 33.18 | 44 |
| 0.3 | 28.31 | 41.2 | 33.85 | 44.7 |

| Test results of the specimens FRC without admixtures and FRC with combination of admixtures (SP+AEA+WPC) | | | | |
|---|---|---|---|---|
| Different percentage of Steel Fiber | Compressive strength of FRC without any admixture (Ref. mix) (MPa) | | Compressive strength of FRC with combination of admixture ( SP+AEA+WPC ) (MPa) | |
| | 7 Days | 28 Days | 7 Days | 28 Days |
| 0 | 24.20 | 36.12 | 28.22 | 40.10 |
| 0.1 | 25.51 | 39.33 | 29.85 | 42.22 |
| 0.2 | 27.11 | 40.33 | 31.55 | 43.80 |
| 0.3 | 28.31 | 41.2 | 32.11 | 44 |

The following results are obtained by the above compression test results.

The compressive strength of M20 grade concrete mix using FRC with combination of admixtures (SP+AEA+ACC ) the values of compressive strength will be more than other two combination of admixtures like (SP+AEA+RET ) and ( SP+AEA+WPC )

## VI. RESULT AND DISCUSSION

1. There is an increase in the compressive strength by adding FRC with different admixtures (SP + AEA + ACC) up to 45.6 MPa.
2. There is an increase in the compressive strength by adding FRC with different admixtures (SP + AEA + RET) up to 44.7 MPa.
3. There is an increase in the compressive strength by adding FRC with different admixtures (SP + AEA + WPC) up to 44 MPa.

## VII. SCOPE OF FURTHER WORK

Use M30 grade concrete and adding the FRC with combination of admixtures to find the compressive strength for cubes 7 days and 28 days. After comparison of that M20 and M30 grade mixes.

Similarly use M20 and M30 grade concrete and adding the FRC with combination of admixtures to find the flexural for beam 7 days and 28 days and values are compared.

## VIII. CONCLUSION

It gives good strength of the concrete. By using this can able to recycle the steel waste material. Increasing the percentage of fibre the strength of the concrete also increased. So it can use as a admixture and this recycled material used to reduce the steel wastage

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