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Significance of Micro Steel Fibred Self-Compacting concrete with Cement, GGBS and Fly ash

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ABSTRACT: Concrete is a mixture of cement, fine aggregates, coarse aggregate and water . As known, with addition of fibers to concrete the properties of concrete are altered. Micro Steel fiber is one of the steel fiber used in concrete. Using self compacting concrete we can avoid vibrations for compacting of concrete. In High rise buildings it is difficult to place the normal vibrating concrete; SCC is the best answer for the Builders. Micro-steel fibers provide extra strength to the concrete and also provide some tensile support from plain concrete. The present technical report investigates the significant effects of Micro steels fibers present in the Self compacting concrete. Here Micro steels fibers of ranges from 0%, 0.5%, 0.75%, 1%, 2% and 3% are added to the concrete. From 0% to 1% there is an increase of strength for 7, 14 and 28 days. Optimal compressive strength is obtained at 1% of Micro steel fibers and from there increase in fiber content decrease in compressive strength, the increased compressive strength is +34.79% for 7 days, +40.00% for 14 days and +42.64% for 28 days of curing. There is a sudden reduction of -10.64% for 7 days, -30.07% for 14 days and -31.29% for 28 days with 2% of fibers added. Another one observed is 90% of the Micro steel fiber concrete strength is obtained within 14 days of curing the specimens. Therefore the optimal range of Micro steel fibers can be used is 1% with +42.64% increase in compressive and +23.58% increase in Splitting tensile strength.

KEYWORDS: Micro steel fibers, compressive strength, SCC, Splitting tensile strength.

1. INTRODUCTION

In worldwide, concrete is the most efficient and ordinarily used construction material these days with well known combination of cement, water and aggregates. Now a day’s fibers are most effectively used material in the concrete to reduce crack repair, reduction in shrinkage of concrete and improve the strength properties of concrete. In high rise buildings it is difficult to place the manual concrete to such heights and proper observation should be there. To rectify all these self compacting concrete is the best solution, which reduces the labor usage in the field.

Replacement of OPC with supplementary cementing materials such as Fly ash and GGBS is on the promising way to mitigate thermal cracking due to temperature difference in mass concrete. This paper deals with the study of effects on concrete behavior made up of partial replacement of cement in numerous ratios with micro steel fibers, GGBS and fly ash all together totally different proportions. Concrete is probably the most extensively used construction material in the world with about six billion tones being produced every year. It is only next to water in terms of per capita consumption. However, environmental sustainability is at stake both in terms of damage caused by the extraction of raw material and CO2 emission during cement manufacture. This brought pressure on researchers for the reduction of cement consumption by partial replacement of cement by supplementary materials. These materials may be naturally occurring, industrial wastes or by-products that are less energy intensive. These materials (called pozzolonas) when combined with calcium hydroxide, exhibits cementitious properties. Most commonly used pozzolonas are fly ash, silica fume, Metacolin, ground granulated blast furnace slag (GGBS). This needs to examine the admixtures performance when blended with concrete so as to ensure a reduced life cycle cost. There are competing reasons, in the long term, to extend the practice of partially replacing cement with waste by products and processed materials possessing pozzolanic properties. Lately some attention has been given to the use of natural pozzolonas like Fly ash and GGBS as a possible partial replacement for cement. Amongst the various methods used to improve the durability of concrete, and to achieve high performance concrete, the use of GGBS is a relatively new approach. The chief problem is with its

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extreme finesse and high water requirement when mixed with ordinary Portland cement. The present paper investigates on strength variation of fibred concrete along with the replacement of cement with fly ash and GGBS.
Steel fibers are short, discrete lengths of steel wires having an aspect ratio (ratio of length to diameter) from about 20 to 100. They are manufactured in several different cross sections, and are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual concrete mixing procedure. Steel fibers are produced by various processes, in various shapes and geometries. Most of steel fibers however, are round in cross-section with an equivalent diameter ranging between 0.15 and 2mm and lengths from 7 to 75 mm. for fibers that are not circular the equivalent diameter is the diameter of a circle having the same area as that of the average cross sectional area of an actual fiber. The fibers used in the early times were round and smooth and obtained by cutting or chopping wires to the required lengths. Here the fibers used are Micro steel fibers of length 6mm and diameter of 0.2-0.25mm with an aspect ratio of 50.

II . LITERATURE REVIEW

Ozawa et al. (1989) focused on the influence of mineral admixtures, like fly ash and blast furnace slag on the flowing ability and segregation resistance self- compacting concrete. They found out that on partially replacement of OPC by fly ash and blast furnace slag the flowing ability of the concrete improved remarkably. He concluded that the best flowing ability and strength characteristics 10-20% of fly ash and 25-45% of slag cement by mass.

Domone and His-wen (1997) performed a slump test for high workability concrete. A beneficial correlation the slump values and flow was obtained from the laboratory test. It showed satisfying value of the slump.

Bertil Persson (2001) carried out an experimental and numerical study on mechanical properties, such as strength, elastic modulus, creep and shrinkage of self-compacting concrete and the corresponding properties of normal compacting concrete. The study included eight mix proportions of sealed or air-cured specimens with water binder ratio (w/b) varying between 0.24 and 0.80. Fifty percent of the mixes were SCC and rests were NCC. The age at loading of the concrete in the creep in the studies varied between 2 and 90 days. Strength and relatively humidity were also found. The results indicated that elastic modulus, creep and shrinkage of SCC did not differ significantly from the corresponding properties of NCC [1].

Nan Su et al (2001) proposed a new mix design method for self-compacting concrete. First, the amount of aggregates required was determined, and the paste of binders was then filled into the voids of aggregates to ensure that the concrete thus obtained has flow ability, self-compacting ability and other desired SCC properties. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength tests were carried out to examine the performance of SCC, and the results indicated that the proposed method could be used to produce successfully SCC of high quality. Compared to the method developed by the Japanese Ready-Mixed concrete Association (JRMCA), this method is simpler, easier for implementation and less-time consuming requires a smaller amount of binders and saves cost [2].

Surabhi c.s, Minisoman, Syam Prakash V carried out an experimental study on cement content in the SCC mix is replaced with various percentage of limestone powder and the fresh and hardened properties were studied. It is observed that limestone powder can be effectively used as a mineral additive in SCC. Then conclude that result the 7 day and 28 day compressive strength with increases with increase in content of limestone powder. But further addition of limestone powder reduces the strength. All the hardened properties like cylinder compressive strength, split tensile strength, flexural strength and modulus of elasticity improves with the addition of limestone powder.

Mayur B. Vanjare, ShriramH.Mahure (2012) carried out an experimental study on to focus on the possibility of using waste in a preparation of innovative concrete. One kind of waste was identified. Glass Powder (GP). The use of this waste (GP) was proposed indifferent percentage as an instead of cement for production of self-compacting concrete. The addition of glass powder in SCC mixes reduces the self-compatibility characteristics like filing ability, passing ability and segregation resistance. The flow value decreases by an average of 1.3%, 2.5% and 5.36% for glass powder replacement of 5%, 10% and 15% respectively.

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Suraj N. Shweta S.Sutar, Yogesh Bhagwat carried out an experimental study onto find out the effect of addition of red mud, which is a waste product from the aluminum industries, and foundry waste sand, which is a waste product from foundry, on the properties of self-compacting concrete containing two admixtures experimentation combination of admixtures which is taken Super plasticizer & VMA. It can be concluded that maximum compressive strength of self-compacting concrete with the combination of admixtures (SP+VMA) may be obtained by adding 2% foundry waste sand which is a waste material of ferrous industry.

Miao (2010) conducted a research on developing a SCC with cement replacement up to 80% in all the mixes and examining its fresh properties. Result show that the fly ash acts as a lubricant material. It does not react with super plasticizer and produce a repulsive force and the super plasticizer may only act on the cement. As a result, the larger the amount of fly ash contained, lesser the super plasticizer needed.

Heba (2011) presented an experimental study on SCC with two cement contents; the work involved three types of mixes, the first considered different percentage of fly ash and silica fume. It was concluded that higher the percentage of fly ash the higher the values of concrete compressive strength until 30% of FA, however the values of concrete compressive strength is obtained from mix containing 15% FA.

M.A. Mansur, M.S. Chin and T.H. Wee (1997) the authors developed experimental stress-strain curves for high strength plain and fiber concrete with confinement in the form of lateral ties duly considering test parameters of the diameter of the tie, spacing, core area of concrete and specimen casting direction. The results obtained do not affect Initial Tangent Modulus and Poisson's Ratio of the concrete due to confinement. Vertically cast fiber concrete specimen with confinement exhibits larger strain at peak stress and has higher post peak ductility when compared to a similar specimen cast horizontally. However, improvement of ductility remains more or less the same for both horizontal and vertically cast specimen. An analytical model has been developed (presented in section 3.5 of mathematical models of stress-strain behavior of concrete) based on the experimental data for Stress-Strain curves for confined high strength concrete and found it to tally well with the experimental Stress-Strain curves.

Valeria Corinaldesi and Giacomo Moricoin (2011) the authors have investigated the properties of SCC using three types of fibers, namely steel, Poly-Vinyl-Alcohol and Poly Propylene high tough fibers. They have added limestone powder as mineral additions. The fresh and hardened concrete properties like workability, strength and shrinkage were evaluated and they found that SCC with the above fibers and additions behaved well with improved durability.

III . EXPERIMENTAL PROGRAMMING

Test series consisted of 54 cubes and 54 cylinders of 6 different mixes at 6 different ratios. The dimensions of cube specimens are 150x150x150 mm and cylinder specimen having dimensions of 300mm height, 150 mm diameter. The main parameter of concrete is different ratios of fibers at single grade (M40) of concrete. Tests were conducted after curing the specimens for 7, 14 and 28 days. Different percentages of fibers added to concrete at 5 ratios (0.5%, 0.75%, 1%, 2% and 3%). Each ratio of fiber is compared with normal grade (M40) of concrete on three days.

A. MATERIALS USED

Cement: - Ordinary Portland cement of 53 grade conforming to Indian standard codes is used. Specific Gravity of cement is 3.15.
Fly ash: - Fly ash which is obtained from the thermal plants nearby thermal plant from Vijayawada is used in here. Specific Gravity of Fly ash is 2.3.
GGBS: - Ground Granulated Blast Furnace Slag (GGBS), which is obtained from the Iron industries is grounded to fine powder which is finer than cement. Specific Gravity of GGBS is 2.8.
Fine aggregate: - River sand available locally is used, which is free from silt content and waste materials. Specific Gravity of river sand is 2.65.
Coarse aggregate: - crushed stone aggregate of maximum size 12.5mm is adopted for mix and a supporting aggregate of 10mm are used. Specific Gravity of concrete is 2.78.

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Metacolin: - which is used as binder for cementitious products. Give extra strength and good bonding for the materials. Specific Gravity of Metacolin is 2.5.
Super plasticizer: - It is used for reducing the water-cement ratio of concrete. Specific Gravity of super plasticizer is 1.02.
Micro steel fibers: - Micro steel fibers of specifications 6mm length, 0.2-0.25 mm diameter, aspect ratio of 50 and tensile strength of >2800 Mpa is used in the paper to investigate the changes.

A.1. **MIX PROPORTION**

For Self-compacting concrete the method approached is conforming to ASTMC standards. The slump-cone, flow table, V-funnel, U-box, L-box, J-ring andT_{50} tests are done for the fresh concrete properties. Below table shows mix proportion for Self-compacting concrete. For one cubic meter volume of Self-compacting concrete the mix proportions are given.

S no	Cement	GGBS	Fly ash	Fine aggregate	Coarse aggregate	W/C ratio	Super plasticizer
1	280	150	100	854.916	897.455	159	3.71
	1	0.53	0.35	3.05	3.20	0.30	0.7%

For Self-compacting concrete, fresh concrete properties are tested and tabulated in the results.

IV. RESULTS AND DISCUSIONS

A. SCC TESTS

Here we have given the detailed fresh concrete properties in below table.

Test conducted	Results obtained
Slump cone (flow test)	700 mm (650-750mm)
Flow table (flow test)	9 (0-10)
V-funnel (filling ability)	8 seconds (6-12 sec)
U-box (confined flow)	20 (0-30)
L-box (passing and filling ability)	0.87 (0.8-1.0)
J-ring (confined flow)	9 (0-10)

A.1 COMPRESSIVE TESTS

Compressive strength of Micro steel fiber self-compacting concrete is tested and compared with the normal self-compacting concrete and compared for each ratio of Micro steel fibers added.

S no	Days of curing	% of fibers added	Normal self-compacting concrete (N/mm^2)	Micro steel fiber self-compacting concrete (N/mm^2)	% difference in compressive strength
1	7 days	0.5%	32.95	35.15	+6.25%
2	7 days	0.75%	32.95	40.51	+22.94%
3	7 days	1%	32.95	50.56	+34.79
4	7 days	2%	32.95	45.18	+27.06
5	7 days	3%	32.95	36.42	+9.25%

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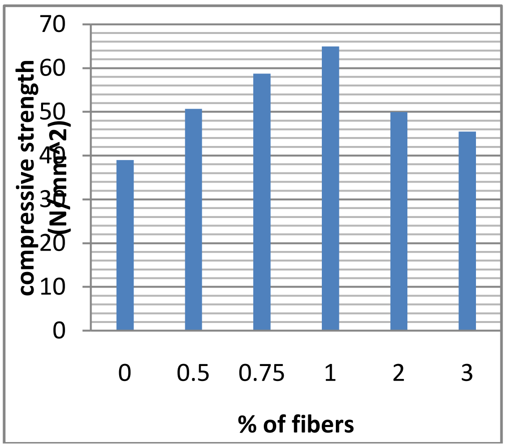
Compressive strength for 14 days of curing the specimens

S no	Days of curing	% of fibers added	Normal self-compacting concrete (N/mm^2)	Micro steel fiber self-compacting concrete (N/mm^2)	+% difference in compressive strength
1	14 days	0.5%	38.98	44.77	+12.93
2	14 days	0.75%	38.98	58.76	+38.76
3	14 days	1%	38.98	64.97	+40.00
4	14 days	2%	38.98	49.95	+21.96%
5	14 days	3%	38.98	45.77	+14.27%

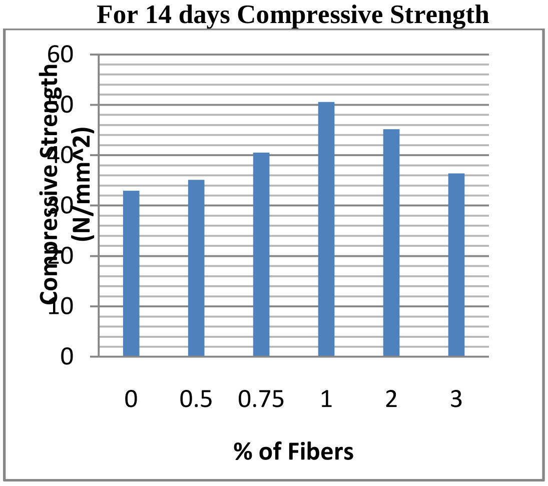
Compressive strength for 28 days of curing the specimens

S no	Days of curing	% of fibers added	Normal self-compacting concrete (N/mm^2)	Micro steel fiber self-compacting concrete (N/mm^2)	% difference in compressive strength
1	28 days	0.5%	45.77	53.75	+14.84%
2	28 days	0.75%	45.77	61.80	+25.93%
3	28 days	1%	45.77	79.8	+42.64%
4	28 days	2%	45.77	60.78	+24.69%
5	28 days	3%	45.77	54.83	+16.52%

For 7 days compressive strength



For 14 days Compressive Strength



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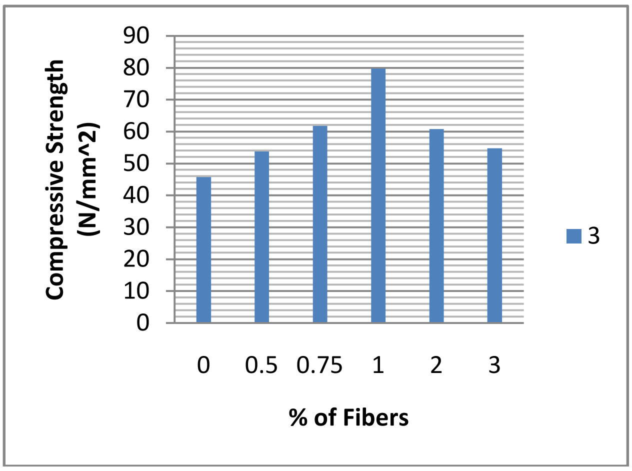
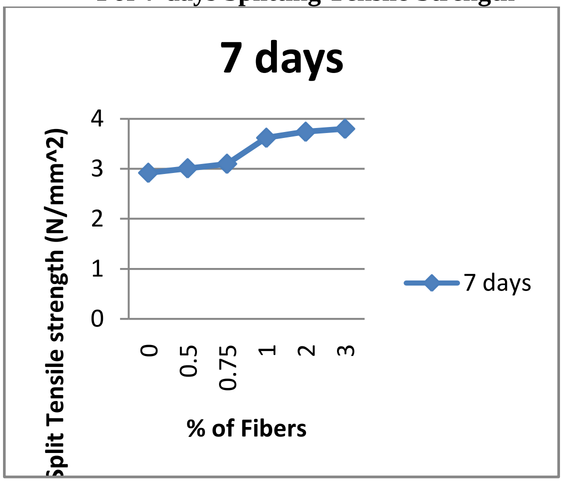
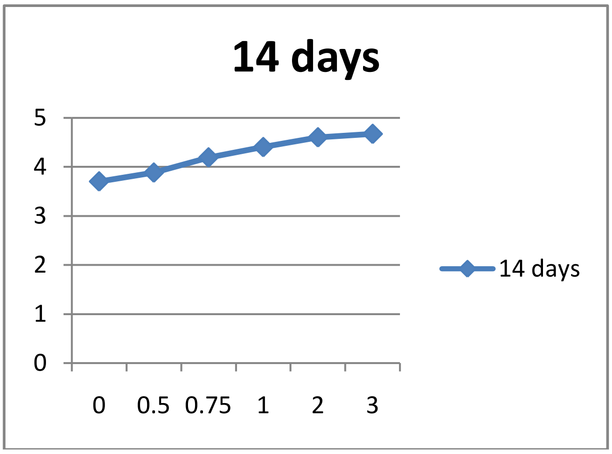
For 28 days compressive strength



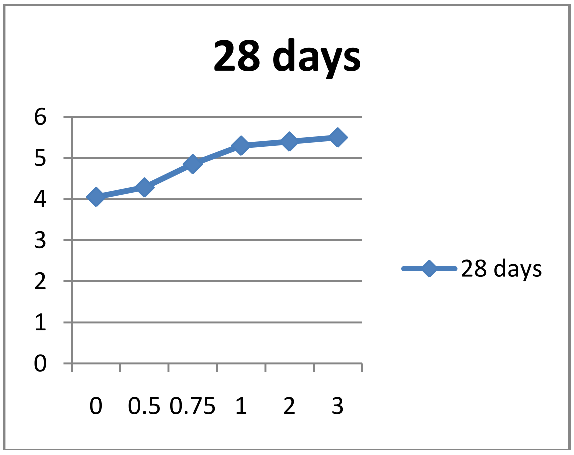
For 7 days Splitting Tensile Strength



For 14 days splitting tensile strength



For 28 days splitting tensile strength



V. CONCLUSION

The following conclusions can be drawn from the experimental behavior of Micro steel fiber Self-compacting concrete with different ratios added for the same mix proportion.

I. The Self-compacting properties of fresh concrete has passed all the tests and after hardening also there were no honey comb like structures with smooth finishing.

II. Fibers are added to the concrete from percentages of 0%, 0.5%, 0.75%, 1%, 2% and 3% of all these percentages 1% of Micro steel fiber gives best results in terms of compressive strength.

III. There is abnormal increase in the compressive strength of concrete at 1% of fibers added to concrete. When compared with Normal Self-compacting concrete +42.64% increases in strength.

IV. Split tensile strength of concrete increases gradually for 3% of fibers added but economical more for the consumer since it is not recommended.

V. While increase in fiber content little raise in the water content.

VI. As we have used GGBS and Fly ash there will be less heat of hydration and resulting in less shrinkage and temperature cracks in the concrete.

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