Effect of Partial Replacement of Cement by Meatakaolin in SIFCON Made from Manufactured Sand

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Abstract - *Slurry-infiltrated fibrous concrete (SIFCON) can be considered as a special type of fibre concrete with high fibre content. It is different from normal fibre reinforced concrete (FRC) in two aspects, viz., the fibre content and method of production. The matrix usually consists of cement slurry or flowing mortar. This slurry-based matrix must consist of fine particles to infiltrate the fibre network. SIFCON has excellent potential for application in areas where high ductility and resistance to impact are needed. Msand in Slurry infiltrated fibrous concrete which is a new addition to the high performance concrete will help in maintaining the ecological balance. cement is partially replaced by metakaolin in SIFCON. Metakaolin (MK) is a pozzolanic material, which blends with Portland cement to improve the durability and it, reduces the porosity of concrete as the particle size of MK is very less. This experimental work focuses on strength development of Metakaolin in SIFCON on partial replacement by 5%, 7.5%, and 10% MK in cement with 5% and 10% fibre content by volume.*

Key Words: SIFCON , Cement concrete, Metakaolin, M.Sand Compressive Strength, Split tensile strength, Flexural Strength.

1. INTRODUCTION

Slurry Infiltrated Fibrous Concrete (SIFCON), is a high performance cement based composite which contains a high content of steel fibres. Fibres are preplaced in the form and then the fibre bed is infiltrated with cement-based slurry. SIFCON is a type of fibre concrete with high percent of steel fibres, the high amount of steel fibres makes SIFCON stronger in tension, though not strong enough to replace the steel and not economical to concrete, it enhances the cracking load considerably. Excellent energy absorption capacity, Highly ductile and Greater strength. Increase in demand and decrease in supply of aggregates for the production of concrete results in the need to identify new sources of aggregates. SIFCON gains importance because eliminates the use of coarse aggregate. The principle of sustainable construction development requires prudent use of natural resources with best quality. SIFCON could be the one better solution. Generally, fibre-reinforced concrete contains 1– 3% of fibres by volume, but SIFCON contains 6–20% of fibres.

In recent years, there has been a great interest in the exploitation of metakaolin (MK) as a supplementary cementitious material in concrete to improve its properties. MK is an ultrafine pozzolana, produced by calcinations of pure or refined kaolin tic clay. Moreover, the use of MK in concrete in present form is a new concept . Recent researches have shown that the inclusion of MK greatly influenced the mechanical and ductility properties of concrete.The utilization of MK as a replacement material is also environmentally friendly since it helps in reducing the CO2emission to the atmosphere by the minimization of the Portland cement (PC) consumption. Blending metakaolin with Portland cement improves the properties of concrete by increasing compressive and flexural strength, providing resistance to chemical attack, reducing permeability substantially preventing alkali silica reaction, reducing efflorescence and shrinkage preventing corrosion of steel.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1 Cement: OPC 43- grade confirming to Indian Standards is used in the present study and the test is conducted to determine specific gravity. The specific gravity of cement was found to be 3.15 by proper experimentation.

2.1.2 Fine aggregates: Manufactured sand passing through 4.75 mm sieve was used. The specific gravity was found as 2.83.

2.1.3 Water: Fresh water available in the local sources was used for the mixing and curing of SIFCON.

2.1.4 Metakaolin: The particle size of Metakaolin is 2µm, which is very small compared to cement. The colour of Metakaolin is ivory to cream, whereas cement colour is grey.

2.1.5 Steel Fiber: SIFCON is made from waste coiled steel fibres obtained from lathe machine shop. In this study, fibres having aspect ratios like 80, 90, 100, 110 and 120 are used.

Table 2.1: Significant properties of materials used

Materials	Specific gravity
Cement	3.12
Fine aggregates	2.83
Metakaolin	2.4

Table 2.2: Mineral Composition of metakaolin

Major Minerals	Percentage
Lime (Cao)	1.2
Silica (SiO2)	51.92
Alumina (Al2O3)	42.0
Iron oxide (Fe2O3)	0.93
Magnesium oxide (MgO)	0.06
Sodium oxide (Na2O)	0.04

2.2 Mix Proportion

A fibre content of 5% was adopted initially and a Water cement ratio of 0.5 was used. Slurry consisted of cement and Msand mixed in the proportion of 1:1 by weight is prepared. Compaction is done by table vibrator to ensure complete penetration of slurry into the fibre pack. 24 hours after casting, the cubes were taken out from the mould and cured in water for 28 days. The fibre content was changed as 5%, and 10% and metakaolin content changed as 5%, 7.5% and 10% respectively. A super plasticizer of 1% was added to improve the flowability of the slurry.

3. Experimental Program

3.1 Specimen

The experimental program consisted of casting and testing of specimens of cylinder (150 X 300 mm) and beam of size 100 X 100 X 500 mm.

3.2 Compressive strength

Three numbers of cylinders were cast for each mix and tested using 200T capacity Compression Testing Machine (CTM).

3.3 Split Tensile strength

Three numbers of cylinders were cast and tested using 200T capacity Compression Testing Machine (CTM).

3.4 Flexural strength

Three numbers of beams were cast and tested using 200T capacity Universal Testing Machine (UTM).

4. Results and discussions

4.1 Compressive strength: The compressive strength was determined after normal 28 days. The results are presented in Table 4.1 and are also depicted graphically in figure 4.1.

Table 4.1 : Compressive Strength Test results

specifications	Compressive Strength (N/mm^2)
Steel fiber 5% MK 5%	33.7
Steel fiber 5% MK 7.5%	35.2
Steel fiber 5% MK 10%	36.8
Steel fiber 10% MK 5%	39.1
Steel fiber 10% MK 7.5%	35.3
Steel fiber 10% MK 10%	37.4

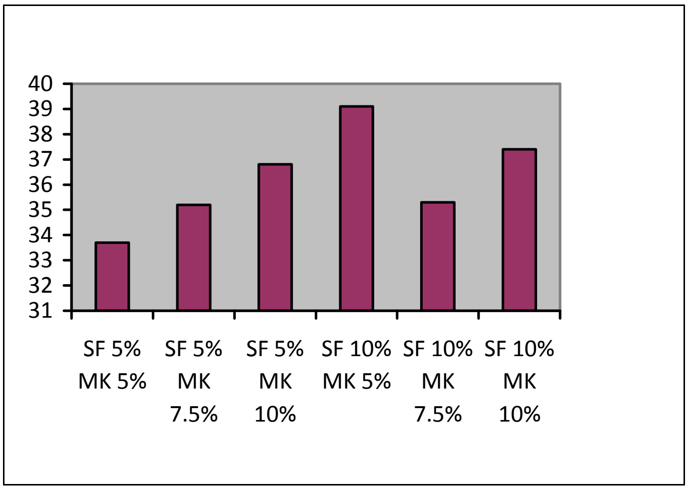

Fig. 4.1 Compressive Strength Test results

4.2 Split Tensile strength

The split tensile strength was determined after normal curing for 7 days and 28 days. The results are presented in Table 4.2.

Table 4.2 : Split tensile Strength Test results

specifications	Split tensile Strength (N/mm^2)	
	7 days	28 days
Steel fiber 5% MK 5%	2.6	3.92
Steel fiber 5%	2.7	4.1

MK 7.5%		
Steel fiber 5% MK 10%	3.3	4.6
Steel fiber 10% MK 5%	3.8	6.3
Steel fiber 10% MK 7.5%	3.1	4.9
Steel fiber 10% MK 10%	3.8	5.55

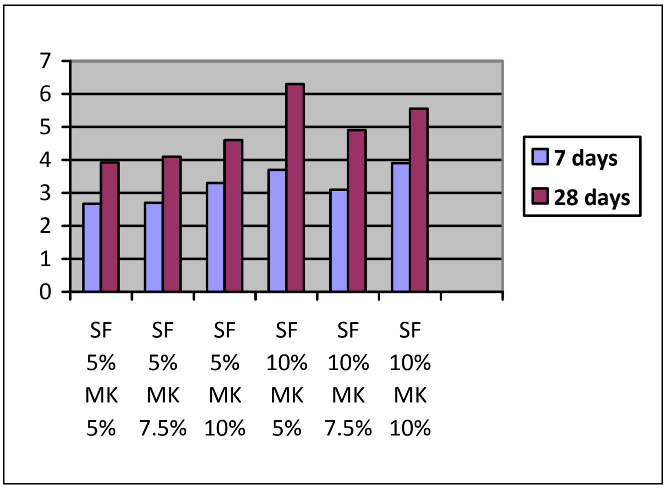

Fig. 4.2 Split tensile Strength Test results

4.3 Flexural strength

The Flexural strength was determined after normal curing for 7 days and 28 days. The results are presented in Table 4.3.

Table 4.3 : Flexural Strength Test results

specifications	Flexural Strength (N/mm^2)	
	7 days	28 days
Steel fiber 5% MK 5%	3.8	5.8
Steel fiber 5% MK 7.5%	4.7	7.3
Steel fiber 5% MK 10%	5.8	8.3
Steel fiber 10% MK 5%	7.3	12.1
Steel fiber 10% MK 7.5%	6.5	10.3
Steel fiber 10% MK 10%	6.4	9.2

5. Conclusions

The present study led to the following conclusions.

1. Addition of Metakaolin has resulted in enhanced early strength and ultimate strength of concrete
2. It is observed that utilisation of Msand in SIFCON is well accepted because of its strength properties.
3. Thus Msand can be a better replacement to river sand in Slurry infiltrated fibrous concrete.
4. The inclusion of MK as a partial cement replacement material provided an excellent improvement in development of strength compared to conventional SIFCON.

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10. Shanmugapriya, Uma. 2012. optimization of partial replacement of m-sand by natural sand in high performance concrete with silica fume, International Journal of Engineering Sciences & Emerging Technologies, 2, 73-80. Figure 2 Graph showing the tensile strength comparision 537.