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Experimental Study on Strength of Self Compacting Concrete by Incorporating Metakaolin and Polypropylene Fibre

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***Abstract*— concrete is the most commonly used material for construction. Production of cement results in a lot of environmental pollution as it involves the emission of CO_2 gas. Supplementary cementitious materials are finely ground solid materials that are used to replace a portion of the cement in a concrete mixture. These supplementary materials maybe naturally occurring, manufactured or manmade waste. Various types of pozzolanic materials that improve cement properties have been used in cement industry for a long time. Metakaolin is a dehydroxylated aluminium silicate. It is an amorphous non crystallized material, constituted of lamellar particles. From the recent research works using Metakaolin, it is evident that it is a very effective pozzolanic material and it effectively enhances the strength parameters of concrete. The main objective of the paper is to investigate the strength of Self Compacting Concrete by fibrous material Polypropylene fibre with varying percentages of Metakaolin (mineral admixture). The mix design which was carried out in the study is Nan su method .Investigations are made to study the Flexural, Compressive and Tensile properties of concrete for 7 days and 28 days of curing and optimum result is obtained for different percentages of Metakaolin 10%, 20% and 30%. The investigation carried out in this work shows that the introduction of 20% of Metakaolin (MK) in concrete will yield better strength compared to other percentages of Metakaolin added. The addition of Metakaolin and polypropylenes results to higher strength. This paper reviews the properties of hardened state of self-compacting concrete.**

Keywords— Self Compacting concrete, Metakaolin, Polypropylene fibre, Hardened properties.

I. INTRODUCTION

The Self Compacting Concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. It is environmental-friendly, as industrial wastes are used .It reduces equipment and labor costs and concrete is noise free. The cement content is partially replaced with mineral admixture, Metakaolin and fibrous material Polypropylene fibre. Metakaolin which is manufactured from selected kaolins, after refinement and calcination under specific conditions. It is a highly efficient pozzolana and reacts rapidly with the excess calcium hydroxide resulting from OPC hydration, via a pozzolanic reaction, to produce calcium silicate hydrates and calcium aluminosilicate hydrates. The use of Metakaolin becomes ample ingredients in the production of concrete of more than 40MPa or where service environments, exposure conditions or life cycle cost considerations dictate the use of Self Compacting concrete. Metakaolin is used in oil well cementing to improve the compressive and flexural strength of the hardened cement. Metakaolin also reduces the hardened cement permeability to liquids and gases. Hence by partially replacing Portland cement with Metakaolin not only reduces carbon dioxide emissions but also increases the service life of building. Metakaolin used in recent years as cement replacement material for developing SCC, improves workability, strength and durability with reduced permeability. It is a relatively new material in the concrete industry, which is effective in reducing sulphate attack and improving air-void network. When load is applied to the concrete matrix, a part of load is transferred to fibre along its surface. Because of the difference in stiffness between the fibre and matrix ,shear helps to transfer some applied load to the fibre .If the fibre modulus is lesser than the matrix modulus ,then the deformation around the fibre will be higher .This occurs with polymeric fibres. One such fibre is Polypropylene Fibre plays many roles in the concrete and prevents shrinkage cracks developed during curing the structure inherently stronger and prevents water or moisture from entering and migrating throughout the concrete.

II.EXPERIMENTAL PROGRAM

In this work an attempt has been made to study the various properties of self compacting concrete when cement is replaced by different proportions of Metakaolin which can act as cementitious material. The flow characteristics of SCC are measured from slump flow, L-box, V-funnel test apparatus. Also the strength characteristics of SCC like compressive strength, tensile strength, flexural strength are found.

The following are the steps included in this phase:

A. Design of concrete Mix
B. Mixing of concrete
C .Preparation of specimen
D. Hardened properties of SCC
E. Results and Discussion

A. Design of Concrete Mix

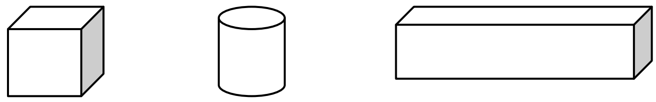
As the development of SCC started since long no codes and standards are available particularly in India. SCC is one type of trial and error method. General purpose Portland Cement 53 grade and Metakaolin from Astra chemicals, Chennai were used as binding materials in making the concrete mixes. Crushed stones size of 12.5mm down and retained 10mm were used in equal weight proportion combination as coarse aggregate .This retained to 10mm is fixed for every mix. River sand passing through 4.75 mm sieve was used as fine aggregate. A high performance Superplasticizer of Conplast SP340 manufactured by BASF chemicals is used and the dosage level was 1.2% of the binder content. In concrete mix, the Metakaolin was varied by 10%, 20% and 30%.The Percentage of Polypropylene fibre was kept constant i.e 0.35% for all the mixes.The mix proportion of 1:2.25:2.80 was obtained .

B. Mixing of Concrete

The coarse and fine aggregate with sufficient water to wet the aggregate and mixed for 30 seconds in a pan type mixer .The cement and Metakaolin were added together with 70% of the mixing water and mixed for further 2 minutes. Finally the remaining water mixed with Superplasticizer was added and the mixing was continued for one minute .then the mixing was halted for 2 minutes and the mixing was continued for another 2 minutes .

C. Preparation of Moulds:

Three types of element have been used in these investigation namely the cubes, prisms and cylinder .The cubes used are of size 150x150x150 mm, prisms of size 100x100x500mm and cylinder of 150 dia x 300mm.The compressive strength was determined by Cubes, Flexural strength by prisms and Split tensile by cylinder specimens.



CUBE CYLINDER PRISM

After conducting the flow characteristics experiments, the concrete mix was poured in the moulds required for strength assessment .After pouring the concrete into the moulds no compaction was given either through vibration or through hand compaction. Even the concrete did not require any finishing operation .After 24 hours of casting the specimens were demoulded and were transferred to the curing tank. After the curing period of 7 and 28 days specimen were removed from curing tank and taken for testing

D. Hardened Properties of SCC

Description	**Tests to be performed**		
	Compressive Strength	**Split Tensile strength**	**Flexural Strength**
Specimen Size (mm)	Cube (150x150x150)	Cylinder (150Dia.&300Ht)	Prism (100x100x500)
No. of Specimen	3	3	3
Days of Testing	7,28	7,28	7,28
Total nos. of Specimen	18	18	18
Volume (m^3)	0.003375	0.0053	0.005

	Quantity of Material				
Metakaolin %	**Cement Kg/m3**	**Metakaolin Kg/m3**	**Fine Aggregate Kg/m3**	**Coarse Aggreg-ate Kg/m3**	**Super Plasticizer in %**
10	350	35	787.4	979.9	1.2
20	350	70	787.4	979.9	1.2
30	350	105	787.4	979.9	1.2

Compressive Strength test:

For compressive strength test, cubes were cast for M40 grade of concrete .Superplasticizer (1.2%) was added .The specimens were filled with 0.35% of Polyproplyene fibre. After 28 days of curing, cubes were tested on Compression testing machine .The failure load was noted. The specimens are tested after 7 and 28 days, using a calibrated compression testing machine of 2,000 KN capacity. In each category three cubes were tested and their average value is reported. The compressive strength is calculated as follows

Compressive strength (MPa) = P/A

Where P= failure load

A= Cross Sectional area

Fig 1.Testing of Compressive strength

Split Tensile Strength

For Split tensile strength test, cylinder specimen of dimension 150mm diameter and 300mm length were cast. The specimens were demoulded after 24 hours and were transferred to curing tank where in they were allowed to cure for 7and 28 days .After 7 and 28 days curing , cylinders were tested on Compression testing machine .Three specimens for each category were casted and average value is reported .Split tensile strength is calculated as follows.

The Split Tensile strength was calculated using the relation:

Split Tensile Strength $=2P/\pi DL$
Where P= failure load, D=diameter of cylinder
L=Length of cylinder.

Fig 2 Split Tensile testing

Flexural Strength test:

The specimens of size 100x100x500 mm were casted for different percentages of Metakaolin for each category three numbers. The prisms were demoulded after 24 hours of casting and transferred to the curing tank. They were tested after 7 and 28 days of curing. Flexural strength specimens were tested under two point loading.

Flexural Strength $= (PxL)/(bxd^2)$

Where P= failure load,
L=Length of the specimen
b = width of specimen, d = depth of specimen

Fig 3 .Flexural Strength testing

III . EXPERIMENTAL RESULTS

Following graphs give results of Compressive strength , Flexural strength , Split Tensile Strength for M40 grade of concrete with 10 % , 20 % and 30 % replacement of cement by Metakaolin .

SI no	**Metakaolin %**	**Average Compress -ive Strength SCC MPa-7 days**	**Normal Concrete Compress -ive Strength MPa -7days**	**Average Compress -ive Strength SCC Mpa- 28days**	**Normal Concrete Compress -ive Strength MPa-28 days**
1	10	33.25	30.75	47.73	42.57
2	20	36.52	31.48	49.46	46.91
3	30	34.09	29.58	48.25	43.26

Table 2 –Compressive strength of M40 grade

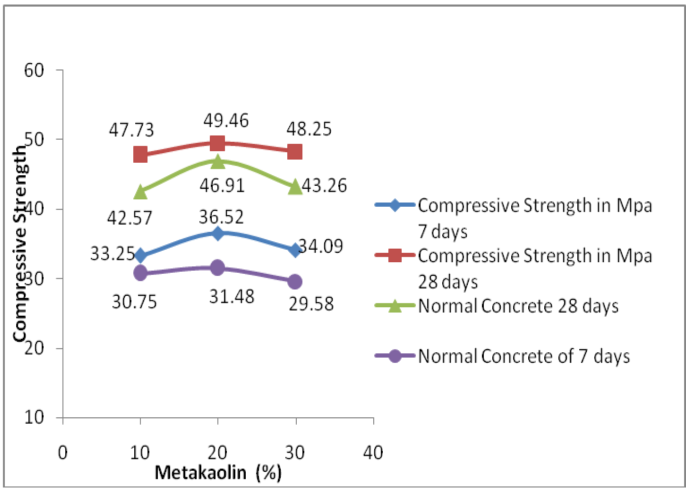


Fig 4 Compressive Strength for M40 grade for different percentage of Metakaolin

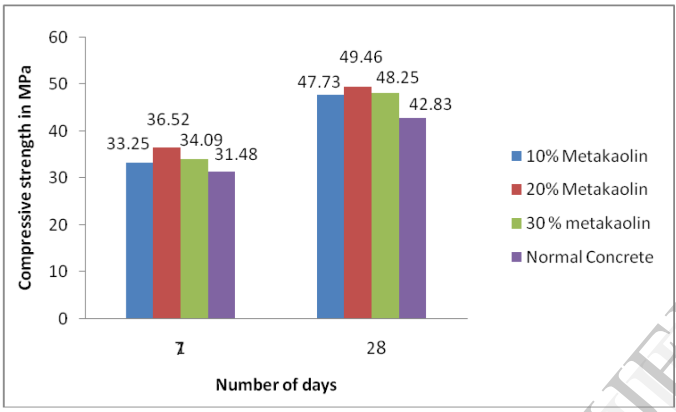


Fig 5 Comparsion ofCompressive strength Normal concrete and Self Compacting concrete for 7 days and 28 days

SI no	Metakaolin %	Average Split Tensile Strength SCC MPa-7 days	Normal Concrete Split Tensile Strength MPa -7days	Average Split Tensile Strength SCC Mpa-28days	Normal concrete Split Tensile Strength MPa-28 days
1	10	2.48	2.16	3.48	2.95
2	20	2.8	2.27	3.64	3.26
3	30	2.68	2.09	3.41	3.18

Table 3 –Split Tensile strength of M40 grade

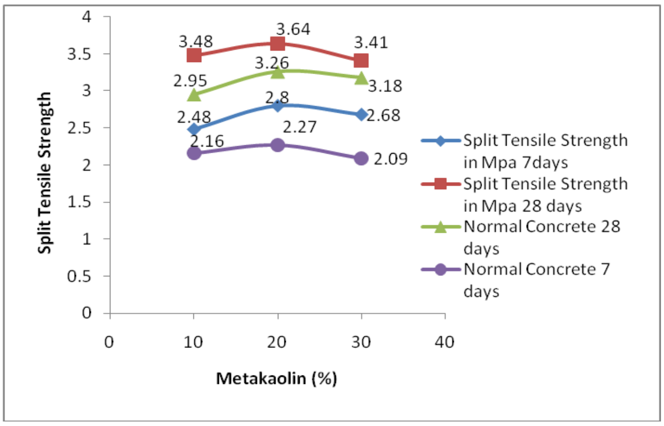


Fig 6 Split tensile Strength for M40 grade for different percentage of Metakaolin

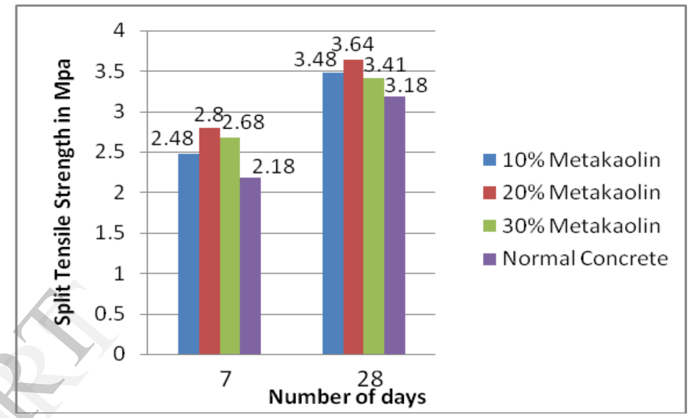


Fig 7 Comparsion of Split Tensile strength Normal concrete and Self Compacting concrete for 7 days and 28 days

SI no	Metakaolin %	Average Flexural Strength of SCC MPa-7 days	Normal Concrete Flexural Strength MPa -7 days	Average Flexural Strength of SCC MPa-28days	Normal Concrete Flexural Strength MPa -28 days
1	10	5.82	5.44	7.23	6.89
2	20	6.01	5.51	7.69	6.97
3	30	5.57	5.38	7.51	6.68

Table 4–Flexural strength of M40 grade

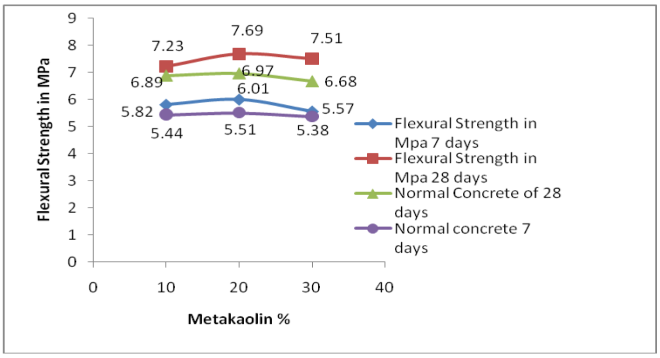


Fig 8 Flexural Strength for M40 grade for different percentages of Metakaolin

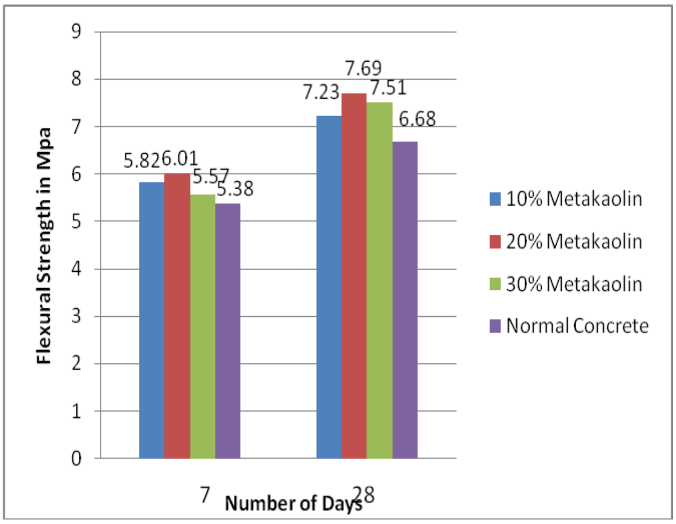


Fig 9 Comparsion of Flexural strength Normal concrete and Self Compacting concrete

E. Results and Discussion

SCC satisfying the hardened properties is selected as an optimum mix as a result of several trials .The Mineral admixture Metakaolin replacing cement by 20% improves the mechanical properties of SCC. Polypropylene fibres are added to mix in the percentage of 0.35% .From the experiment and predicted values, the following results arrived:

- Slump test , L-box, V-funnel is done to find the optimum mix for SCC as per EFNARC guidelines
- Addition of Mineral admixture, Compressive increases the strength at 20 % Metakaolin replacement by cement compared to 10 % and 30% of Metakaolin. The average compressive strength of 28 days for 10%,20% and 30% is 47.73N/mm^2 , 49.64N/mm^2, 48.23N/mm^2 respectively which is higher than the conventional concrete
- Addition of fibres increases the split tensile strength. It can been seen from the Fig 7 , the average split tensile strength of SCC is 2.8 N/mm^2 greater than conventional concrete 2.18 N/mm^2 at 7 days and also for Split tensile strength of SCC at 28 days is 3.64 N/mm^2 which is greater than conventional concrete 3.18 N/mm^2 for 20% Metakaolin replacement. Increase in Split tensile strength was known at 20 % of Metakaolin compared to 10% and 30%.
- The flexural strength of concrete increases at 20 % of Metakaolin replacement. At 7 days, flexural strength is 6.01N/mm^2 for SCC at 20 % of Metakaolin is high than conventional concrete which is 5.38 N/mm^2. For 28 days there is increase of flexural strength than conventional concrete.
- Hence from the above results, it shows that strength increases at 20% of Metakaolin for Compressive, Flexural and tensile strength than 10 % and 30 % Metakaolin replacement.

IV . CONCLUSION

- SCC gives good finishing as compared to ordinary concrete without any external mean of compaction. SCC gives good durability properties as compared to the ordinary concrete.
- Studies indicate that there is a good compatibility between mineral combination Metakaolin and Polypropylene fibre along with the chemical admixtures such as Superplasticizer when used in SCC.
- The brittleness of concrete is improved by addition Polypropylene fibre. Since concrete is very weak in tension, the fibres are beneficial in axial-tension to increase tensile strength.
- The 7 day compressive strength, split tensile strength and flexural strength of concrete generally increases with 20%Metakaolin content compared to 10% and 30 %.
- The 28 day compressive strength, split tensile strength and flexural strength of concrete generally increases with 20% Metakaolin content up to its optimum content and thereafter declines.
- At 7 days, 75% compressive strength is achieved due to addition of Metakaolin and Superplasticizer

REFERENCES

[1] Timo Wustholz "Fresh Properties of Self Compacting Concrete", Ott-o-Graf Journal vol. 14, 2003.
[2] K.H Khajat, "Workability, Testing and Performance of Self Compacting Concrete ", ACI Materials Journals/May- June 1999.
[3]] N. R Gaywala, D.S Rajiwala, " Self Compacting Concrete: A journal of next Decade", JE/RS vol. II Issues IV/ Oct-December 2011,/213-218.
[4] Aiswarya S, Prince Arulraj G, "A Review on Use of Metakaolin in concrete", an International Journal (EST/J), ISSN: 2250-3498, vol. 3 No.1 June 2013.
[5] Sanjay N Patil, Anil K Gupta, Subhash S Deshpande, "Metakaolin-Pozzolonanic Material for Cement in High Strength Concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-IMCE) ISSN 2278-1684, pp.46-49.
[6] G Murali, P Sruttee, "Experimental Study of Concrete with Metakaolin as Partial Replacement of Cement", International Journal of Engineering trends in Engineering and Developments, Issue 2, vol. 4(May 2012), ISSN 2249-614
[7] M. S Shetty, Concrete technology, S Chand and company limited New- Delhi, 6th Edition 2005.
[8] Hajime Okamura and Masahiro Ouchi "Self Compacting Concrete" Journal of Advanced C T, vol. 1, No 1, 5-15 April 2003.