ISSN 2348 – 8034
Impact Factor- 3.155

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

EXPERIMENTAL STUDY ON PROPERTIES OF TERNARY BLENDED SELF COMPACTING CONCRETE BY ADDING FIBRE REINFORCEMENT AND REPLACING QUARRY DUST AS SAND

ABDUL RAOOF AHMED RAZVI[*1] and ABDUL NAEEM ANSARI[2]
[*1]Assistant Professor, Department of Civil & Environmental Engineering, Nawab Shah Alam Khan College of Engineering & Technology
[2]Department of Civil Engineering Nawab Shah Alam Khan College of Engineering & Technology

ABSTRACT

Self Compacting Concrete (SCC) which flows under its own weight and does not require any external vibration for compaction has revolutionized concrete placement. It is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding, and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability.

Concrete is most widely used construction material because of ease of construction and its properties like compressive strength and durability. It is difficult to point out another material of construction which is versatile as concrete. It is well known that plain concrete is very good in resisting compressive strength but possesses low specific modulus, Limited ductility and little resistance to cracking. Internal micro cracks inherently present in the concrete and its poor tensile strength is due to propagation of such micro cracks eventually leading to brittle failure of concrete.

To ensure its high filling ability, flow without blockage and to maintain homogeneity, SCC requires a reduction in coarse aggregate content and hence a high cement content which can increase cost and also cause temperature rise during hydration as well as possibly affect other properties such as creep and shrinkage. Therefore significant quantities of additions are often incorporated to replace some of the cement, to enhance the fresh properties and reduce heat generation.

Several admixtures have been developed to improve the strength and workability properties of concrete. Of all admixtures used in concrete, Metakaolin occupies a special position for quite a few reasons. The improvement of durability, resistance to chloride, sulphate, freezing and thawing, alkali silica reaction, frost attack, and increase in compressive strength reduces the permeability and bleeding. Metakaolin effectively improve the structure of interface eliminates the weakness of the interfacial zone.

The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to sand as fine aggregates in the production of concretes especially in Self Compacting Concrete. Quarry dust, a by-product from the crushing process during quarrying activities is one of such materials. Granite fines or rock dust is a by-product obtained during crushing of granite rocks and is also called Quarry dust. In recent days there were also been many attempts to use Fly Ash, an industrial by product as partial replacement for cement to have higher workability, long term strength and to make the concrete more economically available.

SCC or Self Compacting Concrete that is not only workable at lesser water to binder ratio but also cohesively flow able like a viscous fluid without yielding to segregation, rendering compaction by self weight, ultimately resulting to superior engineering properties. Due to these characteristics, SCC is ideally suited for concreting structures, which have heavily congested reinforcement or difficult access condition.

The present experiment is carried out to investigate the fresh and hardened properties of ternary blended Self Compacting Concrete with 10% of Metakaolin and 30% of fly ash by weight of cement as partial replacement of cement tests were conducted by adding crimped fibres and addition of 0%, 20%, 40% and 60% quarry dust as fine replacement. Compressive strength of SCC is measured by testing standard cubes (150mmx150mmx150mm) at age of 7 and 28 days, Flexural strength of SCC is measured by testing beams(100mmx100mmx500mm) at the age of 28 days and split tensile strength of SCC is measured by Testing standard cylinders(150mm dia, 300mm height) at the age of 7 and 28 days.

Metakaolin and Fly Ash along with Quarry dust, tested with fibre reinforcement in SCC has shown decrease in the compressive strength, flexural strength and split tensile strength of ternary blended SCC. However, the combination of quarry dust with fly ash metakaolin and crimped fibres in place of river sand and cement shall be very economical and also can help in the utility of industrial wastes and in maintaining the ecological balance thus reducing the consumption of cement and river sand.

Keywords- *Self Compacting Concrete, Quarry dust, Ternary blends, Metakaolin, Fly ash, Steel crimped fibres.*

I. INTRODUCTION

The importance of concrete in modern society cannot be underestimated. There is no escaping from the impact of concrete on everyday life. Concrete is a composite material which is made of filler and a binder. Typical concrete is a mixture of fine aggregate (sand), coarse aggregate (rock), cement, and water. Nowadays the usage of concrete is increasing from time to time due to the rapid development of construction industry. The usage of concrete is not only in building construction but also in other areas such as road construction, bridges, harbor and many more. Thus technology in concrete has been developing in many ways to enhance the quality and properties of concrete. One of the technological advances in improving the quality of concrete is Self Compacting Concrete.

Self compacting concrete (SCC), which flows under its own weight and does not require any external vibration for compaction has revolutionized concrete placement. It is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. Such concrete should have a relativity low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding, and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability.

II. TERNARY BLENDED CONCRETE

It means Metakaolin or other cement replacement additives are to be used with OPC only. That is not strictly true and ternary mixtures comprise efficient -systems. The primary incentive of adding limited amount Metakaolin –for example 5 percent with Fly-ash cement mixes was to ensure high early strength research has however, shown that Ternary mixtures of OPC, Metakaolin and Fly-ash result in synergic action to improve the micro structure and performance of concrete. When both Metakaolin and Fly-ash are used, the resultant enhancement of strength or pozzolanic activity was greater than super position of contributions of each, for the respective proportions. Such synergic effect results from strengthening the weak transition zone in aggregate cement interface, as well as segmentation and blocking of pores.

Depending upon the service environment in which it is to operate, the concrete structure may have to encounter different load and exposure regimes. In order to satisfy the performance requirements, different ternary compounds required. Such as cement, Fly-Ash, Metakaolin, silica fume. Greater varieties are introduced by the corporation of additives like pozzolona, granulated slag are inert fillers this leads to different specifications of cements in national or international.

Fly Ash

Metakaolin

III. FIBERS

Steel Fibers reinforce in three dimensions throughout the entire matrix. They restrain micro-cracking and act as tiny reinforcing bars. The earlier a crack is intercepted and its growth inhibited, the less chance it will develop into a major problem. Compared to plain or conventional reinforced concrete the most noticeable differences are improved ductility and post crack performance. Shorter fibers with a high fiber count offer superior first crack strength and better fatigue endurance.

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers, and natural fibers. Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Crimped fibers

Concrete is the most widely used structural material in the world is prone to cracking for a variety of reasons. These reasons may be attributed to structural, environmental or even economics factors, but most of the cracks are formed due to the inherent weakness of the material of resist tensile forces. When concrete shrinks, and it is restrained, it will crack.

Steel fiber reinforcement offers solution to the problem of cracking by making concrete tougher and more ductile. R&D and filed trails over three decades have proved that addition to steel fibers to conventional plan or reinforced and pre-stressed concrete member at the time of mixing / production in parts strength, performance and durability of concrete.

Table 1.chemical properties of Fly ash

S.No	Characteristics	Percentage (%)
1	Loss of ignition	4.17
2	Silica (sio_2)	58.55
3	Iron Oxide(Fe_2O_3)_	3.44
4	Alumina(al_2o_3)|	28.20
5	Calcium oxide (CaO)	2.23
6	Magnesium oxide (MgO)	0.32
7	Total sulphur (SO_3)	0.07
8	Insoluble residue	-
9	Alkalis -Sodium Oxide(Na2o) -Potassium Oxide (K_2O)	 0.58 1.26

Table 2.Chemical composition of Metakaolin

S.No	Compound	Percentage (%)
1	Sio_2+Al_2O_3+ Fe_2O_3	96.88
2	CaO	0.39
3	MgO	0.08
4	TiO2	1.35
5	Na2O	0.56
6	K2O	0.06
7	Li2O	Nil
8	Loss of ignition	0.68

Slump test

V funnel test

Test specimens

L-Box test

Flexural strength test

IV. TEST RESULTS AND DISCUSSIONS

Compressive strength

The effect of replacement of Metakaolin in different proportions with cement on compressive strength for M40 grade SCC was investigated by preparing cube specimens of dimensions 150x150x150mm. The replacement of Metakaolin was 6%, 8%, 10%, 12%, and15%. Specimen were cured in water and tested at age of 7 and 28 days. Test results are given below

Table 4.1 **Compressive strength of various concrete mixtures with constant fly ash FBR and different percentages of Metakaolin at 7 and 28 days curing**

S.No.	Mix ID	Compressive Strength (MPa)	
		7 days	28 days
1	F0MK0	39.05	54.79
2	F30MK6	39.82	55.22
3	F30MK8	40.87	56.02
4	F30MK10	42.18	57.33
5	F30MK12	40.06	54.97
6	F30MK15	38.77	53..02

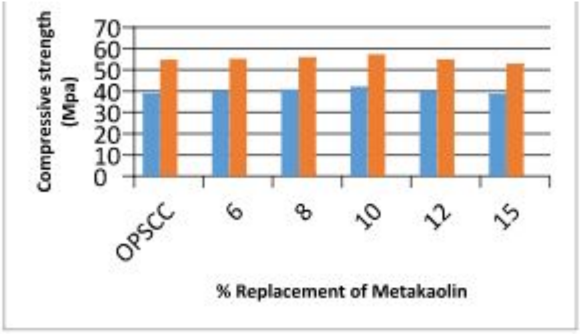

Figure 4.1 compressive strength Vs % replacement of Metakaolin with % constant of Fly ash (30%)

There is a considerable improvement in the compressive strength of SCC with replacement of cement by 30% replacement of Fly ash and 10% Metakaolin with FBR, because of the high pozzolanic nature of condense Metakaolin, Fly ash and its void filling ability. The test results indicate that with 30% Fly ash and 6 to 12% Metakaolin as replacement of cement gives better strength

Table 4.2

S.No.	%REPLACEMENT OF QUARRY DUST	Compressive Strength (MPa)	
		7 days	28 days
1	OPSCC	34.65	49.2
2	F30MK10Q0	31.41	48.15
3	F30MK10Q20	29.52	47.55
4	F30MK10Q40	28.88	46.11
5	F30MK10Q60	26.45	44.1

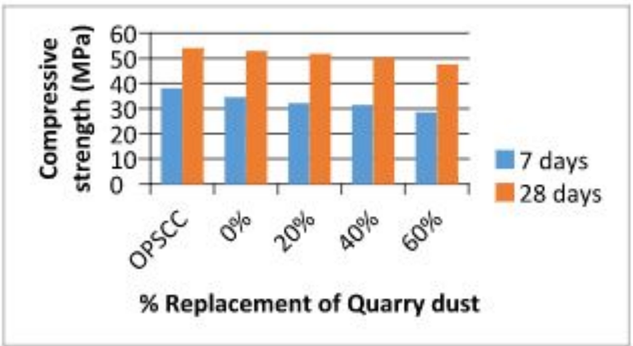

Figure 4.2 Compressive strength vs. age of mixes with different percentage replacements of quarry dust

Flexural strength

The effect of replacement of quarry dust in different proportions with river sand on flexural strength of M40 grade SCC was studied by preparing beam specimens of dimensions 100x100x500mm.

ISSN 2348 – 8034
Impact Factor- 3.155

Table 4.3 – Flexural strength of ternary blended SCC mixtures with various percentage replacement of quarry dust at 28 days curing

S.No	**Mix ID**	**Flexural strength (MPa)**
1	OPSCC	7.66
2	F30MK10Q0	7.63
3	F30MK10Q20	7.49
4	F30MK10Q40	7.45
5	F30MK10Q60	7.35

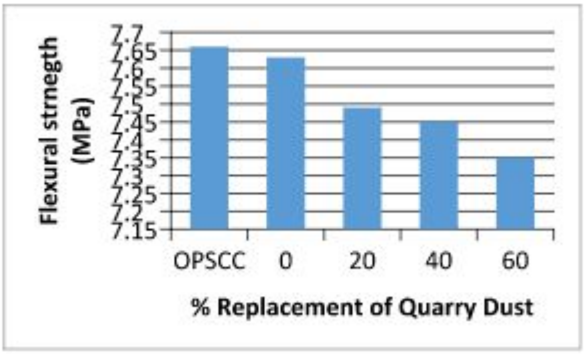

Figure 4.3 Flexural strength vs. different percentage replacement of quarry dust at the age of 28 days.

The percentage increase in the Compressive strength of TBSFRC when 1% fibre content was used was found to be optimum which varies from 8%-12%

Table 4.4 – Split tensile strength of ternary blended SCC mixtures with various percentage of quarry dust at 28 days curing

S.No	Mix ID	Split Tensile Strength (MPa)
1	OPSCC	4.96
2	F30MK10Q0	4.88
3	F30MK10Q20	4.56
4	F30MK10Q40	4.17
5	F30MK10Q60	3.94

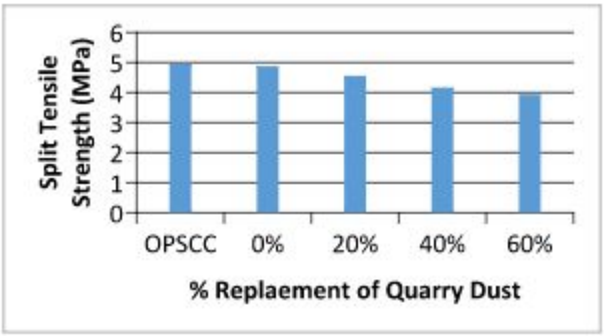

Figure 4.4 Percentage Increase in the Compressive Strength of TBSFRC with increase in fibre content compared with TBC

V. CONCLUSIONS

- Optimum percentage of SCC mix containing Metakaolin and Fly ash as partial replacement of cement with FBR was found to be 10% and 30% respectively.
- The use of Metakaolin along with Fly ash as partial replacement of cement with FBR enhances the properties of fresh and hardened SCC mixes.
- There is a slight improvement in properties of fresh ternary blended SCC with quarry dust as sand replacement with FBR up to 40% after that there is decrease in the properties.
- Replacement o f river sand with quarry dust ranging from 0% to 60% decreases the compressive strength. It decreased by 2.1% to 10.4% as the % replacement of quarry dust is increased from 0% to 60% at the age of 28 days when compared with OPSCC. When compared with ternary blended SCC, the strength decreased by 8.41% for 60% replacement of river sand.
- The Flexural strength and Split Tensile strength of concrete mix also decreases with increase in quarry dust percentage replacement.
- The optimum usage of Quarry dust is 40% with respect to self compactibility.
- The combination of Quarry dust with Fly ash and Metakaolin in place of river sand and cement with FBR respectively shall be very economical and can also help in the utility of Industrial wastes and in maintaining the ecological balance thus reducing the consumption of Cement and River sand.

REFERENCES

1. *Cengiz Duran Atis and OkanKarahan, (2009), "Properties of steel fiber reinforced fly ash concrete", Construction and Building Materials, Volume 23, issue 1, pages 392–399.*
2. *Charles. H. Henage &Doberty. T.J. (1976) : "Analysis of reinforced fibrous concrete", Journal of ASCE, Structural Division, Vol-2,. No.ST.1, pp.177-188. 7 Kukreja, C.B. and Chawla, Sanjeev. (1989), "Flexural characteristics of steel fibre reinforced concrete", Indian Concrete Journal, March , pp. 246-252.*
3. *Faisal.,Wafa & Samir, (1992) "Mechanical properties of high strength fibre reinforced concrete", ACI Materials Journal, September , pp. 449-454.*
4. *IS 12269-1987 "Specifications for 53 Grade Ordinary Portland Cement", Bureau of Indian Standards, New Delhi.*
5. *IS 2386-1963 "Method of Test for Aggregate for Concrete", Bureau of Indian Standards, New Delhi.*
6. *IS 383-1970 "Specifications for Coarse and Fine Aggregate from Natural Source of concrete", Bureau of Indian Standards New Delhi.*
7. *IS 456-2000 "Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards New Delhi.*
   IS 516-1959 "Method of Tests for Strength of Concrete", Bureau of Indian Standards, New Delhi.
8. *Jian-Tong Ding and Zongjin Li, (2002) "Effects of Metakaolin and silica fume on properties on concrete "ACI Materials Journal, PP-393-398.*
9. *Kukreja, C.B. and Chawla, Sanjeev. (1989), "Flexural characteristics of steel fibre reinforced concrete", Indian Concrete Journal, March , pp. 246-252.*
10. *Nagarkar, P.K., Tambe, S.K. and Pazare, D.G. (1987) , "study of fibre reinforced concrete", Proceedings of the International symposium on fibre reinforced concrete, Dec. 16-19, Madras, India, pp.2.131-2.141.*

11. *ParvizSoroushian&ZiadBayasi. (1991), "Fibre-Type Effects on the performance of steel fibre reinforced concrete", ACI Materials Journal, March-April, pp. 129-134.*
12. *Ramakrishanan, V. et al. (1980), "A comparative evaluation of concrete reinforced with straight steel fibres and fibres with deformed ends glued together in to bundles", ACI journal, May-June , pp. 135-143.*
13. *S.Ezeldin and S.R. Lowe, (1991) Mechanical properties of steel fibre reinforced rapid-set materials. ACI Materials Journal, Jul-Aug, Vol.88 No.4 , pp. 384-389*
14. *superplasticized cement pastes containing Metakaolin", Cement & Concrete Research 28, No.5, pp. 629-634.*