International Journal of Engineering Research and General Science Volume 5, Issue 1, January-February, 2017
ISSN 2091-2730

PROPERTIES OF MULTI COMPONENT COMPOSITE CEMENT CONCRETE

Dr. D. V. Prasada Rao[1], N.Lakshmi Narayana[2]
[1]Professor
Department of Civil Engineering
Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India
[2]PG Student
Department of Civil Engineering
Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India

ABSTRACT:

The aim of the experimental investigation is to understand the behavior of concrete produced from multi component composite cements. In this study, cement is replaced with various pozzolanic materials up to 65% and the mechanical properties have been evaluated. The pozzolanic materials used in this investigation are fly ash, rice husk ash, silica fume and metakaolin in varying parentages up to 35%. The fly ash and rice husk ash percentages are kept constant throughout the experimental investigation as 15% and 7.5% respectively. Compressive strength, split tensile strength, flexural strength and modulus of elasticity tests were conducted on M25 grade concrete standard specimens. The results were then compared with the controlled concrete. Based on the experimental investigation, it can be observed that the various strength properties of concrete are completely depends on the metakaolin replacement levels. As the metakaolin content increases upto 12.5% the strength of concrete increases. The results showed that the combination of 15% fly ash, 7.5% Rice husk ash, silica fume 0% and 12.5% Metakaolin 12.5% results in improved strength properties of concrete compared to the controlled concrete.

Key Words: Fly ash, Rice Husk Ash, Silica fume, Metakaolin, Compressive strength, Spilt tensile strength, Flexural strength and Modulus of elasticity.

1.0 INTRODUCTION

In the last few decades, industrial by-products such as fly ash, silica fume, metakaolin, and ground granulated blast-furnace slag have been increasingly used as mineral additives in the preparation of concrete. The production of cement is an energy intensive process, resulting in emission of green house gases which adversely impact on the environment. At the same the cost of production of cement is increasing at alarming rate and natural resources used for manufacturing are cement are depleting. The use of industry by-products having cementitious properties as a replacement of cement in the preparation of concrete has become the thrust area for construction material experts and researchers. The use of these pozzolans can achieve not only economical and ecological benefits but technical benefits as well. It is generally agreed that with proper selection of admixture, mixture proportioning, and curing technique, mineral additives can greatly improve the strength and durability characteristics of concrete.

2.0 OBJECTIVE

The main objective of the experimental investigation is to find the proportions of the multi component composite cement concrete. In this study, cement is replaced with pozzolanic materials upto 65% and the mechanical properties of the concrete have been evaluated. The pozzolanic materials used in this investigation are fly ash, rice husk ash, silica fume and Metakaoline in varying parentages up to 35%. The fly ash and rice husk ash percentages are kept constant for all mixes as 15% and 7.5% respectively. Compressive strength, split tensile strength, flexural strength and modulus of elasticity of concrete are to be obtained and the results have to be compared with the controlled concrete.

3.0 EXPERIMENTAL PROGRAME

3.10 Materials

3.11 Cement

The cement used for present study was 53 grade Ordinary Portland cement confirming to IS: 8112-1989.

3.12 Fine aggregate

Locally available river sand confirming to IS specifications was used as the fine aggregate for the concrete preparation. The properties of fine aggregate are shown in Table 1.

Table 1: Properties of Fine Aggregate

S.No	Property	Values
1	Specific Gravity	2.56
2	Fineness Modulus	0.95
3	Grading of Sand	Zone – II

3.13 Coarse aggregate

Coarse aggregate of nominal size 20 mm and 12.5 mm, obtained from the local quarry confirming to IS specifications was used. The properties of coarse aggregate are shown in Table.2. The coarse aggregate used for the preparation of concrete is a mixture of 60% of 20 mm and 40% of 12.5 mm size aggregates.

Table 2: Properties of Coarse Aggregate

S.NO	PROPERTY	VALUES
1	Specific Gravity	2.61
2	Water Absorption	0.4%

3.14 Fly ash

Fly ash used in this present experimental study is obtained from ASTRRA chemicals, Chennai. The properties of fly ash are indicated in the Table 3 and Table 4.

Table 3: Physical Properties of Fly Ash

Colour	White grey
Specific gravity	2.28
Bulk Density	0.994 gm/cc

Table 4: Chemical Properties of Fly Ash

SiO_2	59.00%
Al_2O	21.00%

Fe_2O_3	3.70%
CaO	6.90%
MgO	1.40%
SO_3	1.00%
K_2O	0.90%
LOI	4.62%

3.15 Rice Husk Ash

Rice husk ash used in this present experimental study is obtained from ASTRRA chemicals, Chennai. Properties of rice husk ash are shown in the Table 5 and Table 6.

Table 5: Physical Properties of Rice Husk Ash

Colour	Off White
Specific gravity	2.25
Bulk Density	0.39 gm/cc

Table 6: Chemical Properties of Rice Husk Ash

Silica	SiO_2	88.90%
Alumina	Al_2O	2.50%
Ferric Oxide	Fe_2O_3	2.19%
Calcium Oxide	CaO	0.22%
Total Alkalies	$(Na_2O+K_20$	0.69%
Loss on Ignition		4.01%

3.16 Silica fume

Silica fume is a by-product resulting from the reduction of high quantity quartz with coal in electric arc in the manufacture of silicon or ferrosilicon alloy. And it is obtained from ASTRRA chemicals, Chennai. The properties of silica fume are indicated in the Table 7 and Table 8.

Table 7: Physical properties of Silica Fume

S.No.	Properties	Results
1	Physical State	Micronised Powder
2	Odour	Odourless
3	Appearance	White Colour Powder
4	Colour	White
5	Pack Density	0.76 Gm/Cc
6	Ph Of 5% Solution	6.90
7	Specific Gravity	2.63
8	Moisture	.058%
9	Oil Absorption	55 ml / 100 gms

Table 8: Chemical properties of Silica Fume

S.No.	Property	Results
1	Silica (SiO_2)	99.886%
2	Alumina (Al_2O2)	0.043%
3	Ferric Oxide (Fe_2O_3)	0.040%
4	Titanium Oxide (TiO_2)	0.001%
5	Calcium Oxide (CaO)	0.001%
6	Magnesium Oxide (MgO)	0.000%
7	Pottasium Oxide (K_2O)	0.001%
8	Sodium Oxide (Na_2O)	0.003%
9	Loss On Ignition	0.015%

3.17 Metakaolin

Another pozzolanic material used in this investigation is metakaolin. Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Stone that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume. Metakaolin used in this present experimental study is obtained from ASTRRA chemicals, Chennai. Properties of metakaolin are given in the Table 9 and Table 10.

Table 9: Physical Properties of Metakaolin

Properties	**Value**
Density (gm/cm^3)	2.17
Bulk density (gm/cm^3)	1.26
Particle shape	Spherical
Colour	Half-white
Specific gravity	2.1

Table 10: Chemical Properties of Metakaolin

Constituent	**Values**
Silica	53%
Alumina	43%
Iron Oxide	0.5%
Calcium Oxide	0.1%
Sulphate	0.1%
Sodium Oxide	0.05%

Potassium Oxide	0.4%

3.18 Superplasticizer

Superplasticizer used in this investigation is MYK Save Mix SP200 based on Sulphonated Naphthalene Polymers having a specific gravity of 1.25 and is supplied as a brown liquid instantly dispersible in water. MYK Save Mix SP200 has been specially formulated to give water reductions up to 25% without loss of workability and to produce high quality concrete of reduced permeability.

3.19 Water

Water fit for drinking is generally considered for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. The local drinking water free from the impurities has been used in this experimental programme for mixing and curing.

3.20 CONCRETE MIX DESIGN

M25 grade of concrete was designed as per the Indian Standard code of practice. The percentage replacement of various pozzolanic materials in concrete mixes is as shown in the Table 11.

Table 11: Percentage Replacement Levels of Cement by Various Pozzolanic Materials

	Cement %	Fly Ash %	Rice Husk Ash %	Silica fume %	Metakaolin %
Mix-1	100	0	0	0	0
Mix-2	65	15	7.5	7.5	5
Mix-3	65	15	7.5	5	7.5
Mix-4	65	15	7.5	0	12.5
Mix-5	65	15	7.5	12.5	0

3.30 TEST SPECIMENS

The Cubes of size 150 × 150 × 150 mm, cylinders with dimension of 150 mm diameter and 300 mm height and prisms with dimension of 100 × 100 × 500 mm are prepared for each type of mix to obtain the compressive strength, split tensile strength, flexural strength and modulus of elasticity of concrete.

4.0 RESULTS AND DISCUSSIONS

4.10 Compressive strength:

The variation of compressive strength of concrete containing various percentages of pozzolanic materials at the age of 3, 7, and 28 days is shown in Fig. 1. The compressive strength of controlled concrete is at the age 28 days are 32.3 MPa. It can be observed that the compressive strength of concrete prepared with the combination of 65% of OPC, 15% of fly ash, 7.5% of rich husk ash and 12.5% of metakaolin is 34.2MPa.

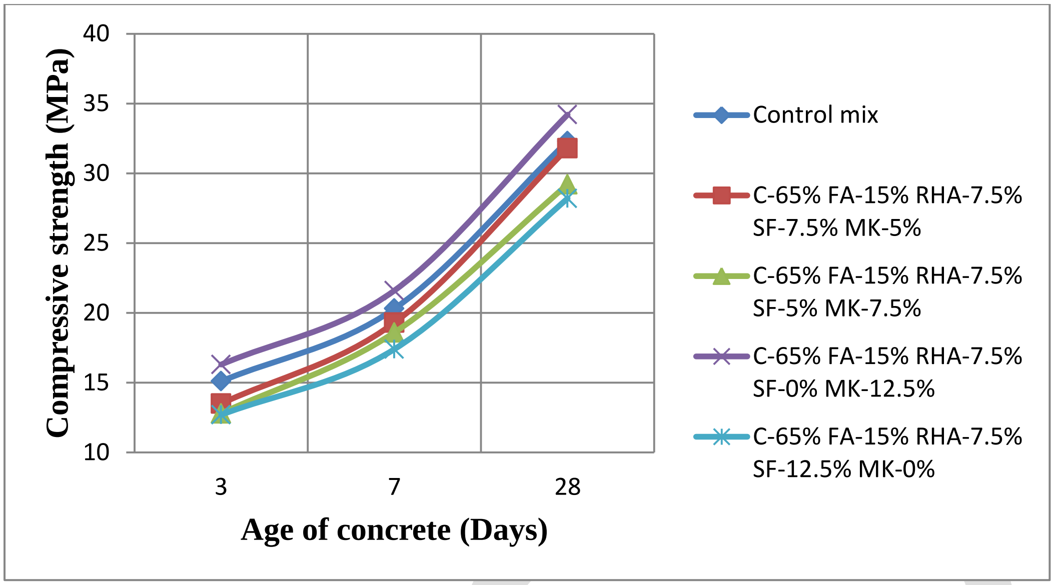

Fig 1: Variation of Cube Compressive Strength of Various Types of Concrete Mixes.

4.20 Split Tensile Strength

Fig. 2 shows variation of the split tensile strength of various concrete mixes containing different percentages of pozzolanic materials. The split tensile strength of controlled concrete is 3.44 MPa. It can be observed that the split tensile strength of concrete prepared with the combination of 65% of OPC, 15% of fly ash, 7.5% of rich husk ash and 12.5% of metakaolin is 3.86 MPa.

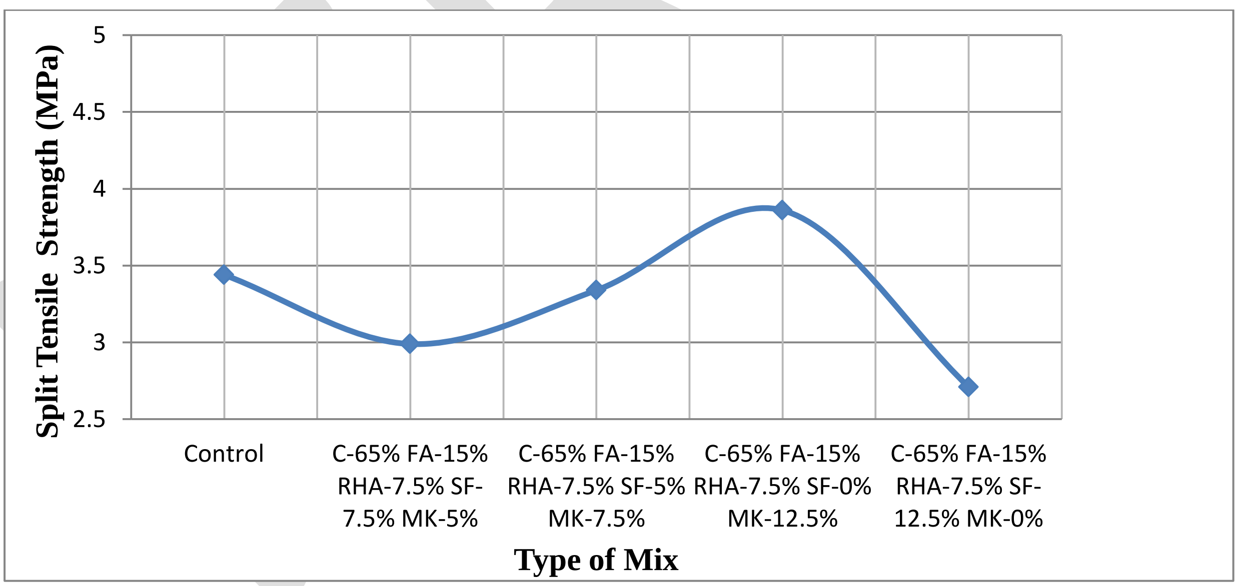

Fig 2: Variation of Split Tensile Strength of Various Types of Concrete Mixes.

4.30 Flexural strength

Fig. 3 shows the variation of flexural strength of various concrete mixes containing various pozzolanic materials. The flexural strength of controlled concrete is 4.62 MPa. It can be observed that the flexural strength of concrete prepared with the combination of 65% of OPC, 15% of fly ash, 7.5% of rich husk ash and 12.5% of metakaolin is 5.43 MPa.

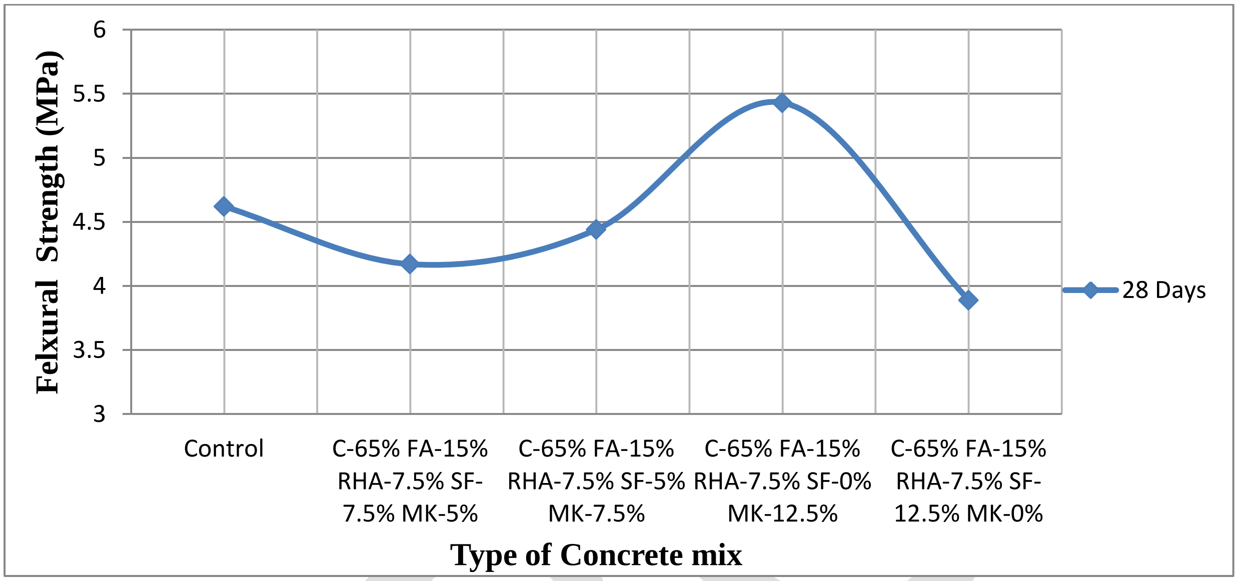

Fig 3: Variation of Flexural strength of Various Types of Concrete Mixes.

4.40 Modulus of elasticity

Fig. 4 shows the variation of modulus of elasticity of various concrete mixes containing various pozzolanic materials. The modulus of elasticity of controlled concrete is 25.2 GPa. It can be observed that the modulus of elasticity of concrete prepared with the combination of 65% of OPC, 15% of fly ash, 7.5% of rich husk ash and 12.5% of metakaolin is 25.9 GPa.

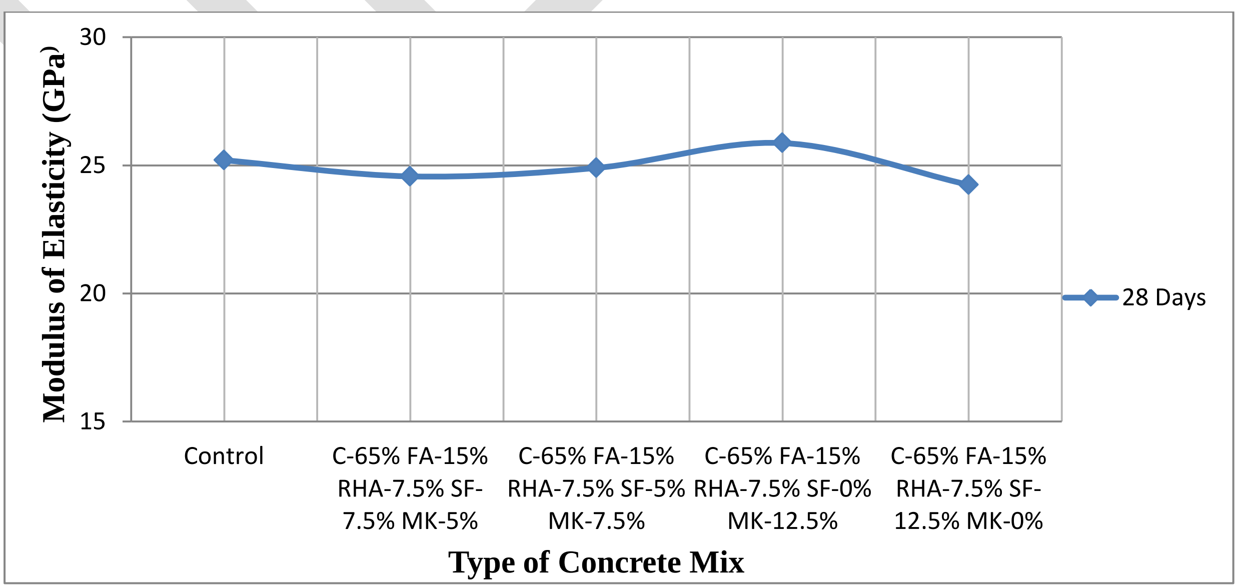

Fig 4: Variation of Modulus of Elasticity of Various Types of Concrete Mixes.

5.0 CONCLUSIONS

The main aim of the study is to obtain the suitability material as replacement of OPC in concrete. The variation of compression strength, split tensile strength, flexural strength and modulus of elasticity of various concrete mixes is obtained. The silica fume, metakaolin and rice husk ash are expensive compared to cement leading to increase in the cost of production of multi-component cement concrete. But, the reduction in the demand of cement of protects our environment from pollution.

The following conclusions are drawn from the study

1. The result shows the blending of material hasn't compromised on strength of concrete.
2. The partial replacement of OPC in concrete by industry by-products facilitates environmental friendly disposal of the waste which is generated in huge quantities by various industries.

REFERENCES:

1. Concrete Technology by Shetty.M.S, first edition, S.Chand publications,1982.
2. IS 456-2000. Plain and Reinforced concrete code for practice. Bureau of Indian Standards, New Delhi (India).
3. IS 383-1970. Specification for coarse and fine aggregate from natural sources for concrete. Bureau of Indian Standards, New Delhi (India).
4. IS 516:1959, Methods of tests for strength of concrete.Bureau of Indian Standards, New Delhi (India).
5. IS 10262:2009. Concrete Mix proportioning- Guidelines. Bureau of Indian Standards, New Delhi (India).
6. IS 12269:1987. Specifications of 53 grade OPC cement. Bureau of Indian Standards, New Delhi (India).
7. Jayeshkumarpitroda, L.B.zala, F.S. umrigar "Experimental investigation on partial replacement of cement with fly ash in design mix concrete" IJAET, Vol. 3, issues 4, Oct – Dec 2012, pg no. 126–129
8. Chung-ho Hunag, Shu-ken lin, chao-shun chang, How-ji Chen "Mix proportions and mechanical properties of concrete containing very highvolume of fly ash "Construction and Building Materials Vol. 46, May 2013, pg no. 71 -78
9. N.K.Amudhavalli, Jeena Mathew "Effect ofsilica fumes on strength and durability parameters of concrete" Vol. 3, issues 1, August 2013, pg no. 28-35
10. Pacheco Trogal F, Armanshasavandhi, Said Jalai "Using metakaolin to improve the compressive strength and durability of concrete" INVACO2, Nov 2011, pg no. 23-25
11. Murali G, SrutheeP "Experimental study of concrete with metakaolin as partial replacement material of cement" IJIRSET Vol. 4, Issue 2 May 2012, pg no. 344-348
12. S.Arivalagan "Sustainable studies on Concrete with GGBS as partial replacement material in cement" JJCE, Vol. 8, Issue 3, march 2014
13. K.V.Pratap, M.Bhasker, P.S.S.R.Teja " Triple blendeding of cement concrete with fly ash and ground granulated blast furnace slag" IJEAR, Vol. 4, Issue spl-2, Jan-June 2014
14. Mukeshkumar, S.K.Singh, N.P.Singh, N.B.singh "Hydration of multicomponent composite cement" Construction and Building Materials, Vol. 36, November 2012, Pages 681–686