ISSN: 10003428 https://journalofcomputerengineering.com/

Sustainable Construction: Utilizing Industrial Byproducts to Reduce Carbon Footprint in Concrete Production.

Dr. Paulo J.M. Monteiro
University of California, Berkeley, USA.

ABSTRACT

Cement is one of the most extensive materials used in the construction industry. It was estimated that the production of 1 ton of cement produces 1 ton of carbon dioxide which results in increase in the emission of green-house gases. With the advancements in research, the utilization of mineral admixtures like fly ash, ground granulated blast furnace slag, silica fume, metakaolin, sugar cane bagasse ash, rice husk ash are reduces the use of cement and also the effective utilization of waste byproducts in which the disposal is a major problem in the regard of environmental pollution. According to considering all the above issues a research work was done to study the effect of binary blending of mineral admixtures on the fresh & hardened properties M35 grade concrete were studied and reported. Also an analytical equation was proposed between compressive and flexural strength of concrete on par with IS:456-2000 and a good agreement was found between them.

Keywords: *Cement, admixture, flexural strength, concrete.*

INTRODUCTION

The sustainable advancements in the field of construction industry should meet the requirements of the current day needs without troubling the future generations. In the regard of environmental pollution, the production of cement causes major environmental pollution by liberating the green houses during the production time of cement. In order to reduce the emission of green house gases, many investigations were done by using the mineral admixture replacement in the concrete. Fly ash and GGBS at low volumes in the concrete can be effective as supplementary cementitious materials of all the pozzolanic materials, silica fume was found to be effective in mechanical properties of concrete [1]. Optimum replacement level silica fume of 7 days and 28 days compressive and flexural strengths are in the range of 10-15% [2]. Replacement of mineral admixtures increased the compressive and flexural strengths in all ages of curing. The optimal replacement of blending of mineral admixture was found to be 10% [3] .The effective replacement of micro silica with ground granulated blast furnace slag was found to be 10% and 30% respectively[4].

In the present study, a contrastive work is done to find the effective replacement of mineral admixtures by binary blending of 4 mineral admixtures, viz., ground granulated blast furnace slag and Metakaoline, ground granulated blast furnace slag and silica fume combinations were studied and presented. For this approach, the fresh properties of concrete like setting times of cement in both initial and final timings cement, normal consistency and also the hardened properties like compressive strength & flexural strength of M35 grade concrete were studied and reported.

EXPERIMENTAL INVESTIGATION

In the present investigation study, mix design was done for M35 grade concrete which satisfies the requirements of

IS:10262;2009. The cement used in this present study is which is available in the local market confirming to codal requirements. River sand used in this current study was confirmed to IS:383:1980 and zone – II and the various properties of the used materials are as follows:

Cement
Ordinary Portland Cement confirming to IS standards of IS:12269-1987 was used in the casting of specimens and the tests were conducted as per IS:4031-1988.

Fine aggregate
In the current investigation, locally available clean and dry river sand of Godavari was used as fine aggregate and it was confirmed as zone-II.

Coarse aggregate
The crushed 20 mm maximum size of the aggregate was collected from the nearby quarry area of Rajahmundry which is free clay, weeds and other forms of organic materials. The physical properties confirming to IS:2386-1963 were used.

Water
Potable Drinking water confirming to codal requirements of IS:456-2000 was used in the current study.

Superplasticizer
To achieve desired workability, HI-FORZA 245 is used as chemical admixture in the present study.

Mineral Admixture
GGBS
Ground Granulated Blast Furnace Slag was procured from the Steel industry, Vizag Steel Plant and the color is in grey and the specific gravity was found to be 2.85.

Metakaolin
Minerals which are rich in kaolinite which is used in the manufacture of porcelain. The particle size of metakaolin is smaller than the cement particles. The color is in pink and the specific gravity was found to be 2.60.

Silica Fume
Silica fume is a by-product from the reduction of high quantity quartz with coal in electric arc in the production of silicon. The color is white and the specific gravity was found to be 2.30.

TEST RESULTS & DISCUSSION
The fresh properties like initial and final setting time as well as normal consistency of binary blended M35 grade concrete are as follows:

Table 1:-*Fresh properties of binary blended M35 grade concrete*

S.No	Mix Description	% replacement of mineral admixture	Setting time in Mins	
			Initial	Final
1.	M1CM	0	35	325
2.	M2(GGBS+MK)	(7.5+7.5)	45	210
3.	M3(GGBS+SF)	(7.5+7.5)	38	192

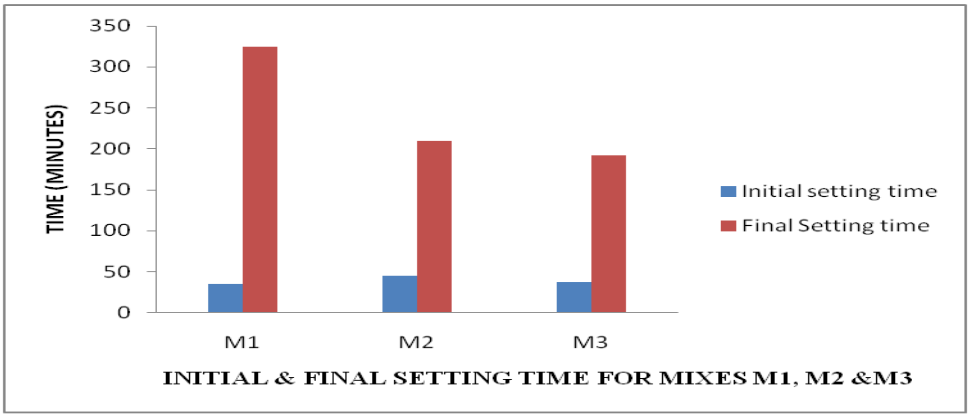

Fig.1:-*Fresh properties of binary blended M35 grade concrete*

The initial and final setting time for binary blended M35 grade concrete with combination of (7.5%+7.5%) (GGBS+MK)-Mix1 and (7.5%+7.5%)(GGBS+SF) Mix2 was presented in table 1 and it was found to be the initial and final setting time for Mix1 was little higher than the Mix2. This is due to the kaolinite mineral in the Metakaoline.

Table 2:-*Hardened properties of binary blen*

S.No	Mix Description	% replacement of mineral admixture	Compressive strength after 28 days of curing (MPa)	C st cu
1.	M1 M35 CM	0	43.55	
2.	M2 (GGBS+MK)	(7.5+7.5)	46.22	
3.	M3 (GGBS+SF)	(7.5+7.5)	48.00	

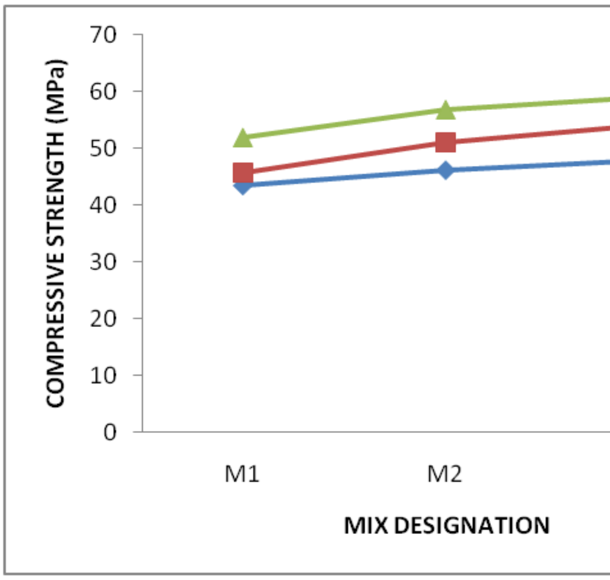

Fig.2:-*Compressive strength of M35 grade concrete afte curing*

From the above figure 2, it can be concluded that with the addition of (GGBS+SF) –Mix2 the compressive strengths were found to be higher than the (GGBS+MK)-Mix1 and the compressive strength was found to be increased in the percentages of 6.13%,11.66% and 9.3% for mix 1 when compared with control mix and 10.2%,18.66 and 13.6% for mix 2 when compared with the control mix for 28, 60 and 90 days of curing.

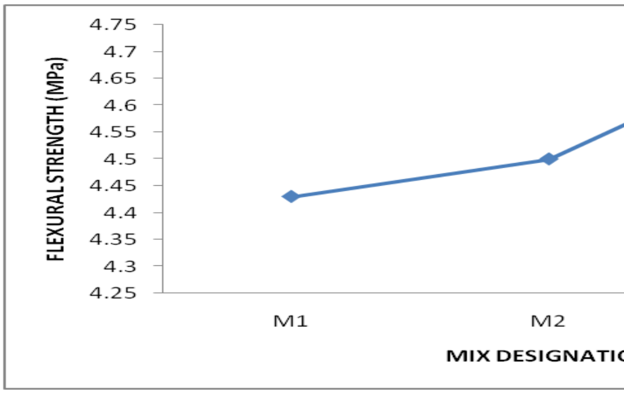

Fig.3:-*Flexural strength of M35 grade concrete after*

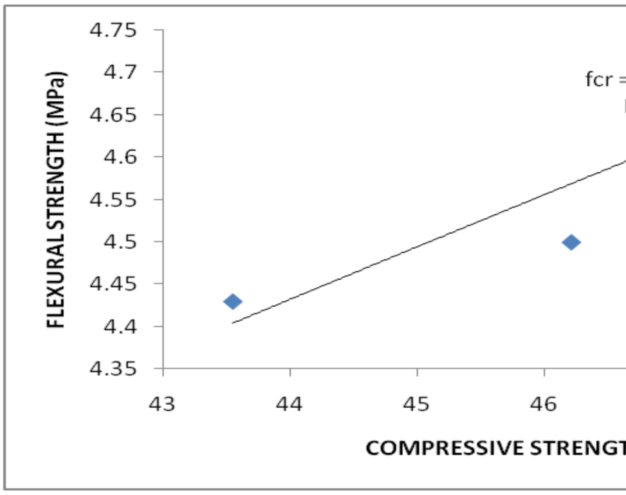

Fig.4:-*Relationship between Compressive strength & Fl*
concrete after 28 days of curi

From Figure 3, it is evident that the incorporation of silica fume in the M35 grade concrete in addition to GGBS is proven to be a best replacement material rather than the Metakaoline mineral admixture.

From Figure 4, it was proposed a relationship between compression strength and flexural strength of geo polymer concrete

$f_{cr}=0.429(f_{ck})^{0.617}$; $R^2 = 0.839$ --------(1) f_{ck} = Characterstic Compression Strength of Concrete

f_{cr} = Flexural Strength of the Concrete The above equations were validated with Indian Standard Code IS:456-2000 $f_{cr}=0.7\sqrt{f_{ck}}$ and found a good agreement between the experimental and theoretical results.

CONCLUSIONS

From the experimental study, it is concluded that the replacement of cement with the combination of ground granulated blast furnace slag and metakaoline increases the initial and final setting time when compared the combination of ground granulated blast furnace slag and silica fume and conventional cement materials. The compressive strengths were found to be increased when the mineral admixtures were added in binary blend and in that too the combination of ground granulated blast furnace slag and silica fume gave the best results in the regard of compressive strength when compared the combination of ground granulated blast furnace slag and metakaoline. The results are in good agreement with the Indian Standard Code IS:456-2000 as far as experimental and theoretical values are compared.

REFERENCES

1. Deepa A Sinha. *Comparative mechanical properties of different ternary blended concrete.* 2012.1(10).ISSN - 2250-1991.
2. D.Audinarayana, P.sarika, Dr.Seshadri Sekhar.T, Dr.Srinivasa Rao, Dr P Sravana G. Apparao. *Studies on Compressive Strength Of Ternary Blended Concretes At Different Water Binder Ratios.* American Journal of Engineering Research (AJER).e-ISSN

: 2320-0847 p-ISSN : 2320-0936.02(09):37-45p.
3. Ali Nazari*, Shadi Riahi, Shirin Riahi, Seyedeh Fatemeh Shamekhi and A. Khademno. *Influence of Al2O3 nanoparticles on the compressive strength and workability of blended concrete.* Journal of American Science 2010;6(5).
4. M. R. Arefi , M. R. Javeri , E. Mollaahmadi. *To study the effect of adding Al_2O_3 nanoparticles on the mechanical properties and microstructure of cement mortar*. Life Science Journal, 2011;8(4)
5. IS: 1727-1967 *Methods of test for Pozzolanic materials*
6. IS: 9103-1999 *Code of practice for specification for Admixture for concrete.*
7. IS: 10262-2009 *code of practice for mix design*.
8. IS 383-1970 *Indian standard specification and testing for fine and coarse aggregate*.
9. M.S. Shetty *Concrete Technology.*