International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 10, Issue 11 (November 2014), PP.54-58

An Experimental Study on Structural Grade Concrete Using Multi Mineral Admixtures

Ch.Giri Phani[1], Ch.L.K.M.Gupta[2]
[1]PG Student, Pydah Engineering College, Srikakulam
[2]Assistant Professor, D.M.S.S.V.H College of Engineering, Machilipatnam

Abstract:- Supplementary cementitious material (SCM) such as fly ash, ground granulated blast furnace slag sand silica fume are extensively used in construction. A partial replacement of cement by mineral admixtures such as, fly ash, GGBFS, silica fume (SF) in concrete mixes would help to overcome these problems and lead to improvement in the durability of concrete. In this thesis of work, an attempt has been made to study the mechanical properties of structural grade concrete using ternary blend.

Keywords:- Structural grade concrete, ternary blend, cube compressive strength, split tensile strength

I. INTRODUCTION

Supplementary cementitious material (SCM's) such as fly ash, ground granulated blast furnace slag, silica fume, Metakaoline are extensively used in construction. A partial replacement of cement by mineral admixtures such as, fly ash, GGBFS, silica fume (SF) in concrete mixes would help to overcome these problems and lead to improvement in the durability of concrete. The primary advantage of concrete prepared from these materials and Portland cement is in the enhancement of fresh and hardened properties of the concrete and ecological benefits resulting from industrial by-products utilization ratios this would also lead additional benefits in terms of energy savings, promoting ecological balance and conservation of natural resources etc. however the degree to which particular property is improved or the rate at which a property is improved is dependent on the type and amount of supplementary cementitious material/s used. Among the various minerals additives used in concrete mortars, silica fume is highly favoured for its superior concrete durability properties. Concrete is composed of fine as well as coarse aggregates as fillers, and hydrated cement paste (HCP) as a binder resulting from reaction of cementitious materials with water. The structure of cement hydration products is greatly influenced by the rate of hydration reaction, type of hydration products formed, and their distribution in the HCP. The rate of hydration reaction and the resulting hydration products can be substantially modified by addition of mineral and chemical admixtures.

It has been well established that in cement-rich mixtures, the rate of hydration reaction is high enough to cause plastic shrinkage cracks as well as non-homogeneity in microstructure of concrete. The accelerated hydration results significantly from evolution of high level of heat due to hydration reaction in the mixture. Consequently, long and thin cementing C-S-II crystals are formed during the hydration process under such a condition. Such crystals occupy less space compared to that formed during normal hydration process, leading to a less dense concrete microstructure. As a result, concrete strength and durability properties are adversely affected. To avoid these, low-heat cement as well as mineral and chemical admixtures are added. Class C fly ash and silica fume can be added to concrete to control rate of hydration reaction and to improve its microstructure. The improvement in microstructure occurs due to grain as well as pore refinements, especially in the interface region between the aggregates and HCP.

II. LITERATURE REVIEW

Ozkan Sengul and Mehmet Ali Tasdemir (2009), have concluded that for the improvement of strength, the pozzolanas were more effective in the low water/binder ratio i.e. for high strength concrete.

M. Sharfuddin Ahmed, Obada Kayali et al. (2009) observed the use of ternary blend in chloride ion penetration by using rapid chloride permeability test. They concluded that the ternary blend comprising 25% fly ash and 10% silica fume showed a significant decrease in average charge compared to the corresponding binary blend.

Tahir Kemal Erdem2009), and used the **Onder Kırca (**ternaryblendofsilicafume and fly ash to obtain high strength concrete mix. They have shown that Ternary blends almost always made it possible to obtain higher strengths than PC + SF mixtures at all ages provided that the replacement level by FA/ F or FA/C or S was chosen properly. They also showed that the improvements in strengths by ternary blends were more significant at 7 and 28 days than at 3 days.

Isaia GC, Gastaldini ALG et al. (2003), observed the physical and pozzolanic action of mineral additions on the mechanical strength of high-performance concrete. Particle packing is one reason. In the case of fly ash, the particle is often finer that the cement, this means that the small silica fume particles can perform better in particle packing since the intermediate particle space, slightly smaller than cement, is filled by the fly ash.The chemical binding of chlorides by fly ash due to its content of aluminum works together with the pore refinement due to silica fume to give excellent performance in a chloride environment, Due to low reaction rate, fly ash has often been used in HPC to reduce the heat of hydration and will also give good flow in fresh concrete. However, this gives a problem in fly ash concrete is the early age, what to do until the fly ash has hydrated sufficiently to have strength and to protect against aggressive. In a triple blend, the silica fume takes care of properties in the early age, while fly ash adds its contribution at later ages. Many reinforced concrete structures have suffered from premature chlorides induced corrosion damage and the specification of concrete to prevent this has proven to be difficult. Benefits, in terms of improved resistance to chloride ingress, through the use of additional materials in ternary blends, such as silica fume (SF) and fly ash (FA) are now well established.

M.R. Jones, R.K. Dhir et al (2003), have shown resistance to chloride ingress and carbonation by concrete containing ternary blended binders. **Lynsdale and Khan** studied chloride and oxygen permeability of Triple blends. Their main conclusion is the ternary blends enabled negligible chloride transport even at early ages, both fly ash and silica fume contributing. At low w/b with 10% silica fume, 15-20% fly ash gave the lowest chloride transport of the tests. Studies at the Virginia Transportation Research Council (**VTRC**) have also demonstrated that silica fume added in relatively small amounts to fly ash concrete significantly improves early resistance of the concrete to penetration by chloride ions and also **D.S. Lane and C. Ozyildirim(1994)** from VTRC.

III. EXPERIMENTAL INVESTIGATION

Mix design has been conducted for M 30 concrete making use of IS 10262:2009 code with normal constituents of concrete like locally available UltraTech OPC 53 grade cement. river sand and mechanically crushed 20 mm conventional granite. The experimental investigation consists of studying the mechanical properties of structural grade concrete with blending by two mineral admixtures such as fly ash, and silica fume for 7 days and 28 days respectively. In the study, cement is replaced with combination of fly ash and silica fume in percentages of 30%,45%,60% and 75% by keeping the percentage of silica fume as 15% and increasing the content of fly ash to desired level. Cubes and cylinders were prepared so as to study the cube compressive strength, split tensile strength of concrete respectively after 7 days, 28 days & 90 days of curing.

IV. RESULTS AND DISCUSSIONS

4.1 Variation of cube compressive strengths

The following tabular form gives the variation of compressive strengths after 7,28 & 90 days of curing which was blended with fly ash and silica fume mineral admixtures.

Table 4.1 Variation of 7, 28 & 90 days

S.No	Mix Designation	Percentage replacement of silica fume & fly ash	Compressive strength at 7 days (MPa)	Compressive strength at 28 days (MPa)	Compressive strength at 90days (MPa)
1.	R-0	0	18.88	34	37.33
2.	R-30	15+15	18.67	33.33	37.11
3.	R-45	15+30	17.77	38.44	42.88
4.	R-60	15+45	16.88	31.11	36.66
5.	R75	15+60	12.44	20.88	32.44

Fig: 1 Cube Compressive Strength (Mpa) with the replacement of fly ash and silica fume

V. DISCUSSION

1. The compressive strength of any mix increases with curing time. The percentage increase in compressive strength of control mix from 7 days to 28 days is71.69%. This percentage increment increases up to 45% replacement and, after 45% replacement this increment starts decreasing and minimum at 75% replacement.

2. The percentage increase in compressive strength of control mix from 28 days to 90 days is 8.36%.This percentage increase in compressive strength from 28 days to 90 days, continuously increases from control mix to 75% replacement and equals to 36.59%.
3. The compressive strength for 7 days curing period, continuously decreases from control mix to, mix for replacement of 75%, whereas for 28 days curing period, it increases from control mix to, mix for 45% replacement, the increment is 6.53% from R-0 mix (control mix) to R-30 mix (total variation is 30%) and 8.14% from R-30 mix to R-45 mix(total variation is 45%), after this compressive strength suddenly decreases, this decrement is 24.69% from R-45 mix to R-60 mix(total variation 60%) and 36.85% from R-60 mix to R-75 mix(total variation 75%). For 90 days curing period variation is same as 28 days curing period. The increment from R-0 mix to R-30 mix is 7.56% and from R-30 mix to R-45 mix is 7.70%. The decrement from R-45 mix to R-60 mix is 19.944% and from R-60 mix to R-75 mix is 35.6%.

4.2 Variation of split-tensile strengths

The following tabular form gives the variation of split tensile strength at 28 days of curing which was blended with fly ash and silica fume mineral admixtures.

Table 2: Variation in split tensile strengths at 28 days

S.No	Mix Designation	Percentage replacement of silica fume & fly ash	28days tensile strength (MPa)
1.	R-0	0	3.52
2.	R-30	15+15	3.61
3.	R-45	15+30	3.71
4.	R-60	15+45	3.23
5.	R75	15+60	2.61

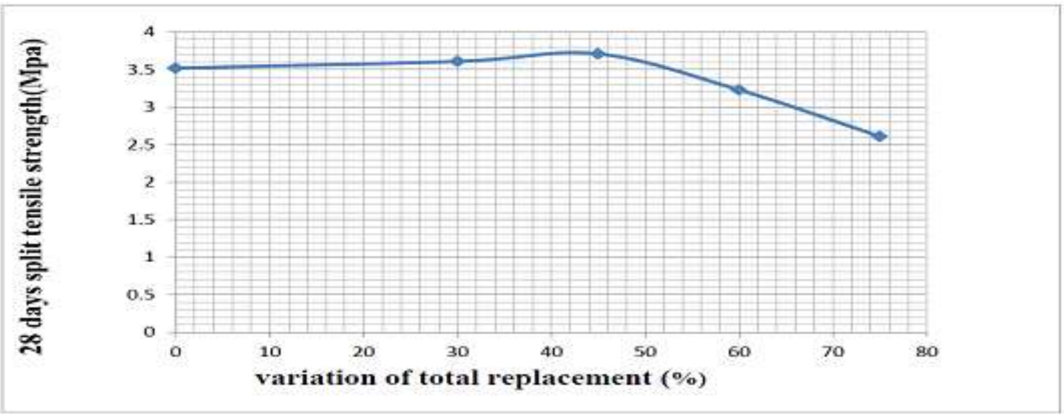

Fig.2 Variation in split tensile strengths at 28 days

The variation in 28 days split tensile strength is very similar to the 28 days compressive strength, it increases from R-0 mix to R-45 mix and then deceases from R-45 mix to R-75 mix. The increment from R-0 mix to R-30 mix is 2.55% and from R-30 mix to R-45 mix is 2.77%. The decrement from R-45 mix to R-60 mix is 12.93% and from R-60 mix to R-75 mix is 19.

Fig.3 Cube specimen under compression

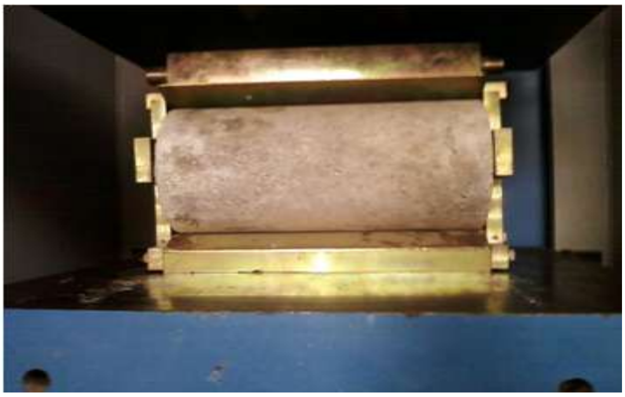

Fig.4 Cylinder Specimen under testing

Fig.5 Cube specimen after failure

Fig.6 Cylinder specimen after failure

VI. CONCLUSIONS

1. Compressive strength for 7 days for control mix was found as 33.70 MPa. generally it should be the about 43 MPa (70% of target mean strength). It may be due to the effect of temperature of curing water as the temperature of curing water was less than normal temperature required. Compressive strength was consciously decreases from R-0 to R-75. Decrease from R-0 to R-45 is very less but it was more for R-45 to R-75. it may be due to the increased content of fly ash. as reaction of silica fume and fly ash starts after some days.
2. Compressive strength at 28 days curing period was found maximum for 45% total replacement (15% silica fume and 30% fly ash). It may be due to the decrease in porosity and due to the change of calcium hydroxide in to CSH gel by silica fume and fly ash. On further addition of fly ash, compressive strength starts decreasing. This decrement is due to the decrease in quantity of CSH gel due to the decrease in quantity of cement in mixture.
3. Variation of 90 days compressive strength is very similar to the 28 days compressive strength. It is also found maximum at 45% total replacement.
4. Increase in 7,28 & 90 days compressive strength and 28 days split tensile strength up to 45% is due to decrease in permeability by the finer particles of silica fume and due to the conversion of $Ca(OH)_2$ in to C-S-H gel by the fly ash, which(C-S-H gel) is responsible for the strength of concrete.
5. Decrease in 7,28& 90 days compressive strength and 28 days split tensile strength after total replacement of 45%, is due to increase in fly ash content. Because due to the addition of fly ash after 45% total replacement, percentage of cement is very less due to which formation of C-S-H gel decreases, same time formation of $Ca(OH)_2$ is also decreases. Due to decrease in $Ca(OH)_2$ and increase in fly ash quantity most of the fly ash remains useless and strength decreases.
6. By using fly ash and silica fume, we can make a concrete with higher strength as per Indian standards which cannot be possible by using ordinary portland cement alone.
7. Also by replacing cement with silica fume and fly ash mix we can reduce the use of cement and by this emission of CO_2, which forms during the formation of cement.
8. Use of fly ash in making concrete, results in ecological benefits as now a days Fly ash is a major solid industrial waste. It occupies a considerable amount of land and pollutes air and water sources. The disposal of fly ash is an environmental problem, as fly ash discharged on land may quickly spread far.

REFERENCES

[1] Pierre-Claude Aitcin, “Developement in the application of high performance **concrete**”, Construction and Building Material, Vol. 9. No. 1, 1995, 13-17

[2] Andrzej Ajdukiewicz and Wojciech Radomski, “Trends in the Polish research on high-performance concrete”, Cement and Concrete Composite, Vol. 24, 2002, 243-251

[3] Pierre-Claude Aitcin, “The durability characteristics of high performance concrete”, Cement & Concrete Composite, Vol. 25, 2003, 409-420

[4] Moayad N Al-Khalaf and Hana A Yousif, “Use of Rice husk ash in concrete”, The International Journal of Cement Composites and Lightweight Concrete, Vol. 6, November 4 1984.

[5] Muhammad Soaib Ismail and A. M. Waliuddin, “Effect of rice husk ash on **high** strength concrete”, Construction and Building Material, Vol. 10. No. 7, 1996, 521-526

[6] Gemma Rodriguez de Sensale, “Strength development of concrete with rice- husk ash”, Cement & Concrete Composite, Vol. 28, 2006,158-160
[7] A Oner & S Akyuz, “An experimental study on optimum usage of GGBS for the compressive strength of concrete”, Cement & Concrete Composite, Vol. 29, 2007, 505-514.
[8] Caijun Shi and Jueshi Qian, “High performance cementing materials from industrial slags”, Resourses Conservation & Recyclin, Vol. 29, 2000, 195-207
[9] K Ganesh Babu and V. Sree Rama Kumar, “Efficiency of GGBS in Concrete”, Cement and Concrete Research, Vol. 30, 2000, 1031-1036.