

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

Mechanical Strength of Concrete with Different Mineral Admixtures: A Review

Syed Abuthahir¹, Nirmalkumar²

P.G. Student, Department of Civil Engineering, Kongu Engineering College, Perundurai, Erode, India¹

Professor, Department of Civil Engineering, Kongu Engineering College, Perundurai, Erode, India²

ABSTRACT: The mineral admixtures are now commonly used to reduce the environmental effect of cements. From the past decades several researches have been carrying out on various experimental investigations to evaluate the suitable alternative for the cement in concrete production. Various mineral admixtures were found to be efficient when it is replaced in optimum quantity. These mineral admixtures significantly contribute in the strength and durability aspects. This paper reviews the work carried out on the use of various mineral admixtures as the partial replacement for cement in concrete in mechanical strength aspects. The literatures visualise that mineral admixtures are an effective replacement which causes great improvement in mechanical strength.

KEYWORDS: Mineral Admixtures, Strength, Fly ash, Rice husk ash, GGBFS, Metakaolin, Silica Fumes and Marble Powder.

I. INTRODUCTION

Concrete is a most important material in the construction sector. It is next to water as a most heavily consumed substance with about six million tons being produced every year (1). This is mainly due to vast availability of raw materials for the cement production, economical factors and the versatility of concrete in various constructions. However on environmental aspects consideration, both on during extraction of raw materials and also during production of cement, damages to the environment are caused. The amount of CO₂ produced during the production of cement contributes maximum amount for the manmade emissions. On account of this various alternative materials have been experimented to use as an alternative for cement.

II. MINERAL ADMIXTURES

The mineral admixtures are either natural or artificial materials which possess pozzolanic properties. Most of the mineral admixtures are waste products or by-products of industries. These materials contain silica, aluminium oxide and ferrous oxide more than 70%. These materials act either as filler, nucleating, and pozzolanic materials. The term pozzolana refers to the naturally formed volcanic ashes and calcined earths. But in recent times this term was extended to all siliceous and aluminous materials which are very fine and react with calcium hydroxide (CH) to form compounds that possess cementing property (CSH).

There are various mineral admixtures like, Fly ash, Rice husk ash, GGBFS, Metakaolin, Silica Fumes and Marble Powder.

III. FLY ASH

In India the main source for producing electricity was thermal power plants. Fly ash is a by-product obtained during the combustion of coal in electric and steam generating power plants. Estimated amount of 200 million tons of coal ash being generated from thermal power plant. Types of fly ash (ASTM classification). Type C: This is also called High Calcium fly ash, and possesses both cementitious and pozzolanic properties. 10 – 15% of the material has a particle size greater than 45 µm, and the fineness (Blaine) is 300 – 400 m²/kg. The particles are primarily solid spheres with a smooth texture. The average particle size is less than 20 µm. Type F: This is also called Low Calcium fly ash, and is a

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

normally pozzolanic material. 15 – 20% of the material is larger than 45 μm , and the fineness is 200 – 300 m^2/kg . Particles are solid spheres with a smooth texture, and the average particle size is 20 μm .

Bhanumathidas N and kalidas N (2) researched on usage fly ashes on concrete with different ground fineness and carried out test to evaluate the strength of the concrete partially replaced with fly ashes for cement. The test results suggest that the fineness of 52% increases strength by 13% and with increase in fineness by 64% the strength was increased by 77%. Namagg and Atadero (3) experimentally studied the effect of fly ash as a partial replacement of cement in concrete. The replacements were carried out from 0% to 50% for cement by fly ash. The test for compressive strength were carried out and the test results shows that the concrete with 25% to 35% replacement by fly ash are found to be optimum and increased its compressive strength.

Poon et al. (4) experimentally studied the effect of fly ash as a partial replacement for cement. The replacements were carried out between 15% and 25% and tests were carried out to evaluate the workability, mechanical and durable properties of the concrete. The test results concluded that there was an improvement in the workability and there were little increase in the compression in comparison with normal concrete and he concluded that the grinding of the fly ash seems to be less effective. Hwang et al. (5) carried out experimental studies to evaluate the compressive strength of the concrete containing fly ash as a partial replacement for cement and test results conclude that the addition of fly ash reduces the pores in the concrete and also found to be effective in compression strength

IV. RICE HUSK ASH

Rice husk ash is a high reactive pozzolan produced by the controlled calcination of rice husk. It is an fine material with a particle size less than 45 micron and contains about 90% of silica.

Ahmadi et al. (6) experimentally investigated the effect of rice husk ash on self-compacting concrete. The replacement for cement by rice husk ash was 10% and 20% with two different water binder ratios 0.35 and 0.40. Test were carried out to evaluate the compressive strength and test results shows that the strength were increased upto 40% than normal concrete. Safiuddin et al. (7) carried out an experimental study with partial replacement of rice husk ash in concrete. The mixes were prepared with 0.35 water cement ratio. The tests were carried out to study the compressive strength at 28 days the test results shows that the compressive strength was between 45 and 98 Mpa. The optimum was found at 30% replacement of rice husk ash. Chopra et al. (8) experimentally investigated the effect of rice husk ash on concrete. The replacement for cement by rice husk ash was 0%, 10%, 15% and 20% with water binder ratio of 0.41. The tests were carried out to study the compressive strength at 28 days the test results shows that the compressive strength was between 36.7 and 40.2 Mpa. The optimum was found at 15% replacement of rice husk ash. Sua-iam and Makul (9) experimentally investigated the effect of rice husk ash on concrete. The replacement for cement by rice husk ash was 0%, 20%, 40%, 60%, 80% and 100% with water binder ratios of 0.22, 0.31, 0.46, 0.75, 1.17, 1.80 and 2.18. The tests were carried out to study the compressive strength at 28 days the test results shows that the compressive strength was between 2 and 65 Mpa. The optimum was found at 10% replacement of rice husk ash with a water binder ratio of 0.31.

V. GROUND GRANULAR BLAST FURNACE SLAG

Blast furnace is a by-product obtained during the extraction of iron from the iron ore. This blast furnace slag is used as a cementitious material since 1892. The reactivity of the slag depends on the rate of cooling to increase the order of reactivity slow cooling has to be carried out. On comparison with the other mineral admixtures slag possess the high specific gravity in range of 2.83 to 3. Oner and Akyuz (10) experimentally investigated the optimum level of GGBFS. The mixes were prepared with replacement of GGBFS from 0% to 100% of cement. The tests were carried out to evaluate the compressive strength. The test result shows that the replacement of GGBFS by 55% found to be optimum for the required compressive strength. Sivasundaram and Malhotra (11) carried out experimental investigation on the cement concrete with high volumes of GGBFS. The replacements of GGBFS are 50% to 75%. Three different series of concrete specimens were prepared. The 14 days of flexural strength of concrete with GGBFS were about 8 Mpa which is more efficient than controlled concrete. Khatib and Hiddbert (12) experimentally studied the concrete with GGBFS. The mixes were prepared with replacement of 0%, 40%, 60% and 80%. The tests were carried out to evaluate the flexure strength of concrete and it is evident that the concrete with 60% GGBFS are found to be efficient in flexural

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

strength. Megatjohari et al. (13) experimentally studied the effect of partial replacement of GGBFS for concrete and the concrete specimens were casted for different mixes of upto 60% replacement of GGBFS. The test were carried out to evaluate the static elastic modulus of concrete. The test results shows that the effective optimum level of 60% for static elastic modulus of concrete.

VI. METAKAOLIN

Metakaolin is an artificial pozzolan. Heat treatment between 600-800°C of Kaolinitic clay gives metakaolin by dehydroxylation of the crystalline structure of kaolinite. Metakaolin reacts with the calcium hydroxide (lime) byproducts produced during cement hydration. It is very fine and highly reactive, gives fresh concrete a creamy, non sticky texture that makes finishing easier.

H. Paiva et al (14) experimental studies were carried out on the fresh and hardened state properties of the concrete with metakaolin as partial replacement (10, 20, and 30 wt%)for cement. To assess the system rheological parameter(yield stress and viscosity) , the fresh concrete was tested on a compact rheometer. Workability and mechanical test were carried out. The results shows that ,The slump value lowers with increases in metakaolin content so in order to keep the workability constant water or superplasticizer content must be increased. It is observed that rheological parameters are sensitive to changes in slump. There is an increase in the viscosity or yield stress as decrease of slump, since the concrete became more rigid or less fluid. The mechanical strength increased even with metakaolin replacing the cement up to 30%. Salim Barbhuiya Et al (15) carried out experimental investigation to evaluate the microstructure , hydration and Nano mechanical properties of concrete containing metakaolin (0%, 5%, 10% and 15%) as replacement for mass of cement. The mixes were prepared for two different water binder ratios such as 0.5 and 0.6. Various tests like sorptivity, X-ray diffraction, compressive strength and carbonation resistance were carried out. The results shows that, The sorptivity decreases with increases in metakaolin content at lower water-binder ratio. Metakaolin converts portlandite into C-S-H by pozzolanic actions. Up to 10% replacement of cement by metakaolin increases the compressive strength of the concrete. There is an increase in the carbonation depth for the 15% replacement mix. J.M. Khatib (16) Experimental investigation was carried out to study the performance of the concrete containing the metakaolin at low water-binder ratio of 0.3. Six different mixes were prepared with 0 % , 5%, 7.5%, 12.5%, 15% and 20% of metakaolin replaced for mass of cement. The workability, compressive strength , dynamic modulus of elasticity, ultrasonic pulse velocity and length change were tested. Test results concludes that, the workability was low for all mixes, thus metakaolin reduces the workability. The optimum replacement level to give maximum compressive strength was 15%. 12.5 % and 15% replacement gives maximum dynamic modulus of elasticity value. Increase in MK content up to 20% as partial replacement for cement, leads to a decrease in shrinkage of concrete and an increase in expansion after 56 days of curing.

VII. SILICA FUMES

Silica fume is a mineral admixture composed of very fine solid glassy spheres of silicon di oxide (SiO₂). Each particles are less than 1 micron in diameter, generally 50 to 100 times finer than average cement or fly ash particles. Silica fume, is a by- product of the industrial manufacture of ferro silicon and metallic silicon in high-temperature electric arc furnaces.

J.M.R. Dotto Et al An experimental studies on workability, compressive strength and durability properties to evaluate the effect of the concrete with Silica fume as partial replacement of cement (0%, 6% and 12%) and with different water-binder ratio 0.50, 0.65 and 0.80 were used. The test results shows that, there is no considerable loss in slump value with increases in silica fume content. Both 6% and 12% replacement of silica fume in concrete enhances a gain in compressive strengths compared with the plain concrete. The concrete electrical resistivity increases with the increasing amount of Silica fume. C.S. Poon et al (17) An comparative study on the mechanical and durability properties of the high performance metakaolin and silica fume concretes were conducted. The compressive strength and chloride penetrability of the control and concretes incorporated with metakaolin(5, 10, 20%) and silica fume(5% and 10%) at water to binder ratios of 0.3 and 0.5 were tested. Test results concludes that , Among all the mixes, the use of metakaolin at the replacement level of 10% performed the best in compressive test at all the test ages (3, 7, 27, 90

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

days). It is observed that all the mixes gained strength more than the control concrete. Metakaolin contributes to the strength of concrete at early ages mainly by the fast pozzolanic reaction. El-HadjKadri et al An comparative study on the properties of mortar containing metakaolin (MK) and silica fume as partial replacement for cement. Metakaolin of two different specific surface area of 19.0 (MK1) and 17.0 m² / g (MK2) were used. Four different mixes (controlled, MK1, MK2, SF) were designed for the investigation. The 10% of OPC was partially replaced with constant W/C ratio of 0.36. Tests were carried out to determine the slump, heat of hydration and compressive strength. Test results concludes that, To maintain constant workability, usage of super plasticizer is required. The requirement of super plasticizer for MK with lower surface area and silica fume was more than that of MK with higher surface area. The dormant period is less than 4 hours for MK and silica fume mortars, whereas it is more than 8 h for OPC mortars. Blended mortar with MK can reach higher heating with respect to 100% OPC.

VIII. MARBLE POWDER

Marble is considered as one of the most important decorative building materials. Marble powder is the by product of the marble which severally affects the environment and causes many health hazards. Marble industry produces large amounts of waste as environmental threat. Waste marble powder can be used as an admixture material or aggregate in the concrete production. Waste is generated from sawing, shaping, and polishing processes.

Ramya Raju et al Study on the concrete with marble powder was carried out. The compressive & tensile strength is checked by varying the percentage (0,4,8,12 and 16%) of partial replacement of cement with marble powder with respect to different water cement ratio and different for grades of concrete. (M25 with 0.40, .43 and 0.45 W/C ratio, M30 with 0.40 W/C ratio and M40 with 0.30 W/C ratio.). The results shows that, As the grade of concrete increases percentage of optimum replacement decreases. In case of M25 grade concrete, there was a gain of strength up to 12% replacement for lower water /cement ratio. The use of super plasticizer was suggested for higher grade of concrete. A. Talahan experimental study on the influence of marble powder used as partial substitute for portland cement on the high performance concrete. Both mechanical and durability properties were tested for the mix with 0 and 15% substitution of marble powder. The specimens were subjected to water curing and aggressive curing. The following conclusion were drawn from the test results, There was an considerable increase in the compressive strength of the concrete with 15% of marble powder. For the specimens subjected to different curing, the compressive strength of the reference concrete deviated up to 29%, but in case of concrete with marble powder, the deviation was only about 3%. The durability properties were also found to be improved in case of concrete with marble powder.

IX. CONCLUSION

It is clearly understood that utilization of waste by-products as a partial cement replacement material were found to be efficient. Utilization of these materials not only concerned about the reuse of the waste material but also reduces the demand for cement thereby reducing the volume of cement production which consecutively reduces the amount of CO₂ emission. Overall the usage of these mineral admixtures were found to be eco-friendly and economical. From results of several experiment carried out by various researchers were found to be effectively significant compared with normal concrete.

REFERENCES

- [1] Sabir B.B, wild S, and Bai.J, (2001) "Metakaolin and calcined clays as pozzolans for concrete: a review", Journal of cement and concrete composites, Vol. 23, No. 6, PP. 441-454.
- [2] Bhanumathidas N and Kalidas, N, (2002) "Fly Ash for Sustainable Development", Journal of Materials in Civil Engineering, June 2, PP. 783-788.
- [3] Hwang, K., Noguchi, T., and Tomosawa, F. (2004) "Prediction model of compressive strength development of fly ash concrete", Journal of Cement and Concrete research, Vol-34, PP. 2269-2276.
- [4] Namagg, C. and Atadero, R. A. (2009) "Optimisation of fly ash in Concrete: High Lime Fly Ash as a Replacement for Cement and Filler Material", World of Coal Ash Conference, Lexington, USA, PP. 1-6.
- [5] Poon, C S, Lam, L. and Wong, Y. L. (1999) "Effect of Fly Ash and Silica Fume on Interfacial Porosity of Concrete", Journal of Materials in Civil Engineering, PP. 197-205.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

- [6] Ahmadi M.A, Alidoust O, Sadrinejad I, Nayeri M, (2007) "Development of mechanical properties of self-compacting concrete contain rice husk ash", International journal Civil Structure Construction and Architecture, Eng., PP. 258–261.
- [7] Safiuddin M, West J.S, Soudki K.A, (2010) "Hardened properties of self-consolidating high performance concrete including rice husk ash", Cem. Concr. Compos, Vol. 32, PP. 708–717.
- [8] Chopra D, Siddique R, Kunal, (2015) "Strength, permeability and microstructure of self-compacting concrete containing rice husk ash", Journal Biosystem Engineering, Vol. 130, PP. 72–80.
- [9] Sua-Iam G, Makul N, (2013) "Utilization of limestone powder to improve the properties of self-compacting concrete incorporating high volumes of untreated rice husk ash as fine aggregate", journal of Construction Building and Materials, Vol. 38, PP. 455–464.
- [10] Oner A, Akyuz S, (2007) "An experimental study on optimum usage of GGBS for the compressive strength of concrete", Journal of Cement Concrete Composites, Vol. 29, PP. 505–514.
- [11] Sivasundaram V, Malhotra V.M, (1992) "Properties of concrete incorporating low quantity of cement and high volumes of ground granulated slag", Journal of ACI, Vol.89, PP. 554–563.
- [12] J.M. Khatib, J.J. Hibbert, Selected engineering properties of concrete incorporating slag and metakaolin, Journal of Construction Building and Materials, Vol. 19, No. 6, PP. 460–472.
- [13] Megat Johari M.A, Brooks J.J, Kabir S, Rivard P, (2011) " Influence of supplementary cementitious materials on engineering properties of high strength concrete", Journal Construction Building and Materials, Vol. 25, PP. 2639–2648.
- [14] Paiva H, Velosa A, Cachim P, Ferreira V.M, (2012) "Effect of Metakaolin dispersion on the fresh and hardened state properties of concrete", Journal of Cement and Concrete Research, Vol.42, PP. 607-612.
- [15] Salim Barbhuiya, Pengloy Chow, and Shazim Memon, (2015) "Microstructure, hydration and nanomechanical properties of concrete containing Metakaolin", Journal of Construction and Building Materials, Vol.95, PP. 696-702.
- [16] Khatib J.M, (2008) "Metakaolin concrete at low water to binder ratio", Journal of Construction and Building Materials, Vol.22, PP.1691-1700.
- [17] Poon CS, Kou SC, and Lam L, (2006) "Compressive strength, chloride diffusivity and pore structures of high performance metakaolin and silica fume concrete", Journal of Construction Building Material, Vol. 20, PP. 858-865.