International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.5., Issue.4, 2017
July-August

RESEARCH ARTICLE

ISSN: 2321-7758

AN COMPARATIVE STUDY OF OPC AND PSC WITH PARTIAL REPLACEMENT OF DIFFERENT POZZULONIC, MATERIALS

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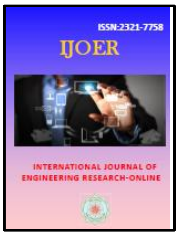

ABSTRACT

In the present investigation an attempt is made to compare various compressive strengths of cement mortar cubes. Mathematical models were elaborated to predict the strength of mortar cubes with 10% partial replacement of cement by various types of mineral admixtures with and without super plasticizers. The strength of cubes with different types of cement (OPC, PSC) after 3,7,28 and 90 days with 28 days curing and also durability tests after 60 days, have been analysed to evaluate the effect of addition content, the time of curing and the type of cement on the changes in compressive strength. The test results of selected properties of binders and hardened mortar cubes with admixtures are also included. The analysis showed that mortar cubes with admixtures is characterized by advantageous applicable qualities.

The investigation revealed that use of waste materials like fly ash, micro silica, rice husk ash and ground granulated blast furnace slag, which are otherwise hazardous to the environment may be used as a partial replacement of cement, leading to economy and in addition by utilizing the industrial wastes in a useful manner the environmental pollution is also reduced to a great extent.

Key Words: OPC, PSC, Fly ash, Micro silica and rice husk.

1. INTRODUCTION

The greatest challenge before the construction industry is to serve the two pressing needs of human society namely the protection of the environment and meeting the infrastructure requirement of our growing population and consequentially needs of industrialization and urbanization in the past. The concrete industry has met these needs very well. However for a variety of reasons, the situation has been changed now.

The cement and concrete industries due to their large size are unquestionably feasible scope for economic and safe disposal of millions of tonnes of industrial by products such as fly ash, microsilica, slag, rice husk ash. Due to their properties, byproducts can be used in certain amount such as cement replacement material than in the practice today. In fact, these mixes replaced by 15% of by-products have shown high strength and durability at relatively early ages. This development has removed one of the strong objections to the use of high volume of by products in mortar cubes.

1.1. ADMIXTURES

This publication provides information on the types and functions of admixtures that have been, or are being, standardized in Europe for implementation in national standards in CEN member countries. It also provides guidance on the circumstances when it may be necessary to specify an admixture to a concrete producer.

Admixtures are now widely accepted as materials that contribute to the production of durable and cost- effective concrete structures. The contributions include improving the handling properties of fresh concrete making placing and compaction easier, reducing the permeability of hardened concrete, and providing freeze/thaw resistance.

1.2. MINERAL ADMIXTURES

Mineral admixtures (fly ash, silica fume [SF], and slag) are usually added to concrete in larger amounts to enhance the workability of fresh concrete; to improve resistance of concrete to thermal cracking, alkali-aggregate expansion, and sulfate attack; and to enable a reduction in cement content.

1.3. MINERAL ADMIXTURES

Chemical admixtures are added to concrete in very small amounts mainly for the entrainment of air, reduction of water or cement content, plasticization of fresh concrete mixtures, or control of setting time. Seven types of chemical admixtures are specified in ASTM C 494, and AASHTO M 194 [06], depending on their purpose or purposes in PCC.

2. LITERATURE REVIEW

Cement is an extremely pulverized material having adhesive and cohesive properties, which provide a binding media for the discrete ingredients. Cement is obtained by burning, in definite proportion, a mixture of naturally occurring argillaceous (containing alumina) and calcareous (containing calcium carbonate or lime) materials to a partial fusion at high temperate about 1450°C. The solid matrix obtained on burning, called clinker, is cooled and ground to the required fineness to produce a material known as cement. The common calcareous materials are limestone, chalk, oyster shells and marl. The argillaceous materials are clay, shale, slate and selected blast furnace slag.

2.1. HYDRATION OF CEMENT

Anhydrous cement compounds when mixed with water, react with each other to form hydrated compounds of very how solubility. The hydration of cement can be visualized in two ways i.e., "Though solution" mechanism and "solid state" mechanism. In early stages of hydration the former mechanism predominates while the later mechanism may dominate during the later stages of hydration.

2.2. PHYSICAL PROPERTIES OF PORTLAND CEMENT

The fineness of cement is a measure of the size of particles of cement and is expressed in terms of "Specific surface" of cement. The finer the cement, the higher is the rate of hydration, as more surface area is available for chemical reaction. This results in the early development of strength. If the cement is ground beyond a certain limit its cementatious properties may be adversely affected due to rehydration by atmospheric pressure.

2.3. SETTING TIME

Cement when mixed with water forms paste which gradually becomes less plastic, and finally a hard is obtained. In this process, a stage is reached when the cement paste is hard to withstand a definite amount of pressure. The time to attain this stage is known as setting time. The attained to lose the plasticity of paste is known as initial time and the stage when the paste becomes a hard mass is final setting time. The setting process is dependent on the temperature change. A phenomenon of abnormal premature hardening within a few minutes of mixing of water is termed as false set.

2.4. COMPRESSIVE STRENGTH

The compressive strength of the hardened cement is the most important of all the properties. Strength tests are not made on cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement. Strength of cement is found indirectly on cement sand mortar. The standard sand is used for finding the strength of cement. Cement mortar cubes (1:3) having an area of 50 cm1 are prepared and tested in compression testing machine.

2.5. FLYASH

It is one of the by-products which will be coming burning coal to generate electric power. Two-thirds of the 55 million tonnes of fly ash produced in the U.S. in 1999 were sent to waste piles, with only 9 million tonnes used to make concrete. The carbon content of fly ash is a major concern. Class 'C' fly ash, most of which is produced in the west from lignite coal, contains little carbon. However, Class F fly ash, produced primarily from anthracite and bituminous coal, contains significant amounts of carbon. Class C and Class F material also differ from each other and from source to source with regard to strength, rate of strength gain, color and weather ability.

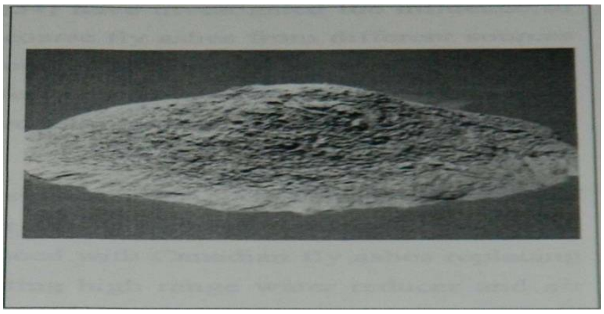

Fig.1. Flyash sample picture

Huang and Feldman, 1985 [1] found that mortar without silica fume has lower strength than cement paste with the same water-cement ratio, while mortar with 30% of cement replaced with silica fume has a higher strength than cement- silica fume paste with the same water-cementitious ratio. **Mehtra, P. K. and Folliard, K. J.,** 1995 [2] Presented a review of recent research focusing on the durability of concrete and mortar containing rice husk ash (RHA). The purpose of the investigation was to determine the effects of RHA in cement products exposed to hostile environments. Included are the results of laboratory research on hydrochloric acid attack, sulphate attack, alkali-silica reaction, and frost action on mortar or concrete mixtures containing RHA.

Min-Hong Zhang and V. **Mohan Malhotra,** 1996 **[3]**determined results on the physical and chemical properties of rice husk ash (RHA), and deals with the properties of fresh and hardened concrete. The test results indicate that the RHA is highly pozzolanic and can be used as a supplementary cementing material to produce high- performance concrete. The flexural and the splitting tensile strengths, modulus of elasticity, and drying shrinkage of the control concrete and the concrete incorporating RHA or silica fume were comparable.

Bentur et.al 2003 [4] reported that the strength of silica fume concrete is greater than that of silica fume paste which they attributed to the change in the role of the aggregate in concrete.

2.6. QUALITY ASSURANCE

As per IS: 456-2000 [22] the quality controls and assurance would involve quality audit of both the input as well as the output. Inputs are in the form of materials in concrete; workmanship in all stages of batching, mixing, transportation, placing, compaction and curing, and related equipment and plant resulting in the output in the form of concrete in place. The quality controls measures are both technical and organizational. ACI 363 R [02] recommends following phases of quality assurance for field applications of high strength concrete but this measure will be for normal strength concrete also.

3. SCOPE AND OBJECTIVES

The present investigation is aimed at using of waste material like fly ash, Microsilica, slag, rice husk ash, which is otherwise hazardous to environment. This may be used as partial replacement of cement. This leads to economy, utilization of industrial waste in useful manner and environmental reduction of pollution to great extent.Initial and final setting times, compressive strength of cement mortars 1:3 (made from Portland Slag Cement and Ordinary Portland Cement) and soundness of cement were the factors considered which are likely to be influenced by the partial replacement of cement by admixtures.

I. To study the effect of replacement of cement y various admixtures like flyash, ground granulated blast furnace slag, microsilica, rice husk ash when they are mixed with super plasticizer and without superplasticizer on initial and final setting times of cements both the Portland slag cement and the ordinary Portland cement.
II. To examine the effects of these substances with 10 percent replacement of cement mortar cubes on short term and long term strength development.
III. To find the strengths of cement mortar cubes after conducting various durability tests like acid, alkaline and sulphte test.

4. EXPERIMENTAL INVESTIGATION

The physico-chemical properties of cement, sand and water used in the investigation were analyzed based on and also the standard experimental procedure laid down in the standard codes, like IS, ASTM and BS codes. These standard experimental procedures were adopted for the determination of normal consistency, initial and final setting times, and soundness of cement and compressive strength of cement mortar cubes. In establishing these requirements, careful consideration of properties of locally available materials has to be accounted for.

4.1. Portland Cement

Even though only Ordinary Portland Cement is graded according to strength, the other cements too have to gain a particular strength. 33, 43 and 53 grade in OPC indicates the compressive strength of cement after 28 days when tested as per IS: 4031-1988[25], eg, 33 Grade means that 28 days of compressive strength is not less than 33 N/mm2 (MPa) . Similarly for 43 grade and 53 grade the 28 days compressive strength should not be less than 43 and 53 MPa respectively. 43 and 53 grade are also being introduced in PPC and PSC shortly by the Bureau of Indian Standards (BIS). The compressive strength of cement when tested as per IS code shall be minimum 43 MPa. Cement used in the present investigation is Zuari 43 Grade.

4.2. Fly Ash

All Indian fly ashes tested at CANMET correspond to the category of ASTM class C fly ashes: Typically all fly ashes had very low lime (CaO < 1.5%), low alkali (Na20 < 1.34%) and Sulphur (S02 < 0.01 %) contents. The physical properties of most of the fly ashes are found to be excellent. Most of them are better than Canadian Sundance fly ash. The workability of the fresh concrete made with cement and fly ash are found to be the best.

4.3. Ground Granulated Blast Furnace Slag-GGBS

In the production of cast iron, also called pig iron, if the slag is cooled slowly in air, the chemical components of slag are usually present in the form of crystalline melelite (C3 AS-C2 MS2 solid solution), which does not react with at ordinary temperature. The granulated slag when finely ground and combined with Portland cement has been found to have excellent cementitious properties. GGBS has an inherent ability to reduce heat evolved during exothermic reaction of cement and water. It has been observed that GGBS has the largest potential to replace cement due it's in built cementitious property. Hence a high volume replacement of cement by GGBS is an attractive option; usually for every tones of pig iron produced about 1.0 to 1.5 tonnes of slag is discarded as a waste material.

4.4. Micro silica

The use of microsilica was limited to cement replacement due to its very high Pozzolanic reactivity. But, now-a-days microsilica has become an additional cementations component because of its increased performance both in fresh and hardened states. The experimental and field work results are also favorable.Currently, there are over a dozen standards of codes of practice of various nations around the world that allow the use of micro silica in cement and concrete.

5. RESULTS & DISCUSSIONS

The results of the present investigation are presented both in tabular and graphical forms. In order to facilitate the analysis, interpretation of the results is carried out at each phase of the experimental work. This interpretation of the results obtained is based on the current knowledge available in the literature as well as on the nature of result obtained. The significance of the result is assessed with reference to the standards specified by the relevant I S codes.

- The averages of both the initial and final setting times of three cement samples prepared with PSC/OPC and compared with those of the cement specimen prepared with different admixtures. If the difference is less than 30 minutes, the change is considered to be negligible or insignificant and if it is more than 30 minutes, the change is considered to be significant.
- The average compressive strength of at least three cubes prepared with PSC/OPC under consideration is compared with that of three similar cubes prepared with different admixtures. If the difference in the strength is less than 10%, it is considered to be insignificant and if it is greater than 10%, it is considered to be significant.
- The average soundness test results of three samples prepared with PSC/OPC under consideration are compared with those with different admixtures. The unsoundness of the specific sample, made with admixtures, is significant if the result of Le- Chatelier's test is more than 10 mm.
- Test results of initial and final setting times, soundness and percentage change in compressive strengths and durability tests regarding compressive strength t>f different types of cement mortar cubes with replacement of mineral.

- Though all the samples made with different types of cements (i.e. PSC and OPC) by replacement of chemical and mineral admixtures either accelerate or retard significantly the setting process. The limits for significance criteria in setting times of all these samples under consideration are within the range of standards specified in IS 8112:1989[30], The IS code specifies initial setting time should not be less than 30 minutes and final setting time should not be more than 600 minutes.
- Soundness test results of the samples made with different types of cements are presented in the Tables 5.1 to 5.2. The IS 269:1976[21] code specifies the limit for soundness as per the Le- Chatelier's test result should not be more than 10 mm for Ordinary Portland Cements. The Le- Chatelier's test results of soundness of different types of cements vary proportionately with the concentration of the cement.
- If But this increase in variation is very meager and less than the significant value, i.e., 10 mm and hence, there is no appreciable change in the volume of the samples.

5. CONCLUSIONS

Based on the results obtained in the present investigation in Chapter 5, the following conclusions can be drawn.

- PSC with 10% replacement of mineral admixtures like fly ash, ground granulated blast furnace slag, with superplasticizer retards the setting times significantly where as in the case of rice husk ash with and without superplasticizer accelerates both the initial and final setting times significantly.
- PSC with 10% replacement of all admixtures with and without SP the percentage change in compressive strength is meagre and further it is observed that the decrease in compressive strength is significant in the case of RHA with SP at lateral ages.
- Significant loss in compressive strength is observed in PSC and PSC with replacement of mineral admixtures with and without superplasticizer when the samples are tested in acid, alkali and sulphate solutions.
- OPC with 10% replacement of mineral admixtures like fly ash, ground granulated blast furnace slag and micro silica with super plasticizer retards final setting time significantly, where as in the case of rice husk ash with and without super plasticizer accelerates both the initial and final setting times significantly.
- OPC with 10% replacement of fly ash, ground granulated blast furnace slag and microsilica with and without super plasticizer the percentage change in compressive strength is decreased significantly and further, it is observed that this decrease in strength slightly increases at lateral days.
- OPC with 10% replacement of mineral admixtures like fly ash, ground granulated blast furnace slag, microsilica and rice husk ash with and without superplasticizer, the loss in compressive strength in Acid Test, alkali and sulphate test is significant.
- From the test analysis it can be inferred that the PSC in all the cases performing well than that of the OPC. Hence it is preferable to use PSC.

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