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OPTIMIZING FLY ASH IS USED AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL

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Abstract-* Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. A supplementary cementitious material, when used in conjunction with portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both. As such, SCM's include both pozzolans and hydraulic materials. A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value, but that will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties. Pozzolans that are commonly used in concrete include fly ash, silica fume and a variety of natural pozzolans such as calcined clay and shale, and volcanic ash. SCM's that are hydraulic in behavior include ground granulated blast furnace slag and fly ashes with high calcium contents (such fly ashes display both pozzolanic and hydraulic behavior).

I. INTRODUCTION

Concrete, typically composed of gravel, sand, water, and Portland cement, is an extremely versatile building material that is used extensively worldwide. Reinforced concrete is very strong and can be cast in nearly any desired shape. Unfortunately, significant environmental problems result from the manufacture of Portland cement. Worldwide, the manufacture of Portland cement accounts for 6-7% of the total carbon dioxide (CO2) produced by humans, adding the greenhouse gas equivalent of 330 million cars driving 12,500 miles per year.

Fortunately, a waste product Fly Ash can be substituted for large portions of Portland cement, significantly improving concrete's environmental characteristics. Fly Ash, consisting mostly of silica, alumina, and iron, forms a compound similar to Portland cement when mixed with lime and water. Fly ash is a non- combusted by-product of coal-fired power plants and generally ends up in a landfill. However, when high volumes are used in concrete (displacing more than 25% of the cement), it creates a stronger, more durable product and reduces concrete's environmental impact considerably. Due to its strength and lower water content, cracking is reduced.

In the HVFAC mechanism, physical and chemical factors combine at all ages to densify and bind the paste. In the early age of concrete, the important factors of strength development are

(i) Physical effect - fine particles of fly ash act as micro aggregates and densify the mass

(ii) Chemical contribution of the formation of ettringite or related sulpho-aluminate production. In the later age hydration reaction dominate in the strength development process as additional binders are generated by reaction involving fly ash. Any concrete that uses more fly ash than 25% (weight of cement) would be considered high volume fly ash concrete. With high volume fly ash concrete, you will see less early age strength, but the long-term strength is about the same as with normal concrete

Identify the constructs of a Journal – Essentially a journal consists of five major sections. The number of pages may vary depending upon the topic of research work but generally comprises up to 5 to 7 pages. These are:

Abstract

Introduction

- LITERATURE REVIEW
- SCOPE OF PRESENT STUDY
- NEED OF THE STUDY
- OBJECTIVES OF THE STUDY
- EXPERIMENTAL PROGRAMME
- REFERENCES

II. LITERATURE REVIEW

Saraswathy, V. et al. (2003) in their paper " Influence of activated fly ash on corrosion–resistance and strength of concrete" investigated the influence of activated fly ash on the compressive strength of concrete. Various activation techniques, such as physical, thermal and chemical were adopted. Concrete specimens were prepared with 10, 20, 30 and 40% of activated fly ash replacement levels with cement. Compressive strength was determined at 7, 14, 28 and 90 days. They concluded that:

1) Activation of fly ash improved the strength of concrete. However, the compressive strength of fly ash concrete was less than that of ordinary portland cement (OPC) even after 90 days of curing.

2) Among the activation systems, chemically activated coal fly ash (CFA) improved the compressive strength to a certain extent, only with 10 and 20% replacements. Since the CFA surface layer is etched by a strong alkali to facilitate more cement particles to join together and also the addition of CaO which is further promoting the growth of CSH gel and Ca(OH)2 which is more advantageous to enhance the strength development. Siddique, R. (2003) in his paper "Effect of fine aggregate replacement with class F fly ash on the mechanical properties of concrete", studied the effect of partial replacement of fine aggregate (sand) with varying percentages of Class F fly ash on the compressive strength, splitting tensile strength, flexural strength and modulus of elasticity of concrete up to the age of 365 days. Fine aggregate (sand) was replaced with five levels of percentages (10, 20, 30, 40, and 50%) of Class F fly ash by weight.

Control mix (without fly ash) was proportioned to have a 28-day cube compressive strength of 26.4 MPa. Based on the results, it was concluded that:

1) Compressive strength of fine aggregate (sand) replaced fly ash concrete specimens was higher than the plain concrete (control mix) specimens at all the ages. The strength differential between the fly ash concrete specimens and plain concrete specimens became more distinct after 28-days.

2) Compressive strength continued to increase with age for all fly ash replacement levels.

3) The maximum compressive strength occurs with 50% fly ash content at all ages. It was 40.0 MPa at 28-day, 51.4 MPa at 91-day, and 54.8 MPa at 365-day.

4) Splitting tensile strength, and flexural strength of fine aggregate (sand) replaced fly ash concrete specimens was higher than the plain concrete (control mix) specimens at all the ages. The strength differential between the fly ash concrete specimens and plain concrete specimens became more distinct after 28-days.

5) Both splitting and flexural strengths continued to increase with age for all fly ash percentages.

6) At all the ages, the maximum splitting tensile strength was observed with 50% fly ash content. It was 3.5 MPa at 28-day, 4.3 MPa at 91-day, and 4.4 MPa at 365-days.

7) Maximum flexural strength was found to occur with 50% fly ash content at all ages. It was 4.3 MPa at 28-day, 5.2 MPa at 91-day, and 5.4 MPa at 365-days.

8) Modulus of elasticity of fine aggregate (sand) replaced fly ash concrete specimens was higher than the plain concrete (control mix) specimens at all the ages. The differential between the fly ash concrete specimens and plain concrete specimens became more distinct after 28-days.

9) Modulus of elasticity of fine aggregate (sand) replaced fly ash concrete continued to increase with age for all fly ash percentages.

10) At all ages, the maximum value of modulus of elasticity occurs with 50% fly ash content. It is 24.5 GPa at 28-day, 28.0 GPa at 91-day, and 29.0 GPa at 365-day. Atis et al. (2004) in their paper " Strength and shrinkage properties of mortar containing a nonstandard high-calcium fly ash" assessed the drying shrinkage of mortar mixtures containing high calcium nonstandard fly ash up to the age of 5 months. Five mortar mixtures including control Portland cement and fly ash mortar mixtures were prepared. Fly ash replaced cement on mass basis at the replacement ratios of 10, 20, 30 and 40%. Water–cementitious materials ratio was 0.4. Mixtures were cured at 65% relative humidity and 20 ± 2O C. They reported that shrinkage of Portland cement mortar at 5 months was 0.1228%. Shrinkage of fly ash mortar decreased with the increase in fly ash content. Shrinkages of mortar containing 10, 20 and 30% fly ash were 25, 37 and 43%, lower than the shrinkage of Portland cement mortar at the end of 5 months. The reduction in shrinkage with the use of fly ash in mortar could be explained by the dilution effect of fly ash. The expansive property of fly ash most probably contributed to the reduction in drying shrinkage.

Demirboga et al. (2007) in their paper "Thermo-mechanical properties of concrete containing high-volume mineral admixtures" investigated the Thermal Conductivity (TC) of HVFA concrete at the age of 28 days. Cement was replaced with 0, 50, 60, and 70% of Class C fly ash. They concluded that TC of concrete decreased to 32, 33, and 39% for 50, 60 and 70% fly ash replacement, respectively.Siddique, R. (2003) in his paper " Effect of fine aggregate replacement with class F fly ash on the abrasion resistance of concrete" studied the abrasion resistance of concrete proportioned to have four levels of fine aggregate replacement (10, 20, 30 and 40%) with Class F fly ash. A Control mixture with ordinary Portland cement was designed to have 28 days compressive strength of 26 MPa. Concrete specimens were made for the purpose. The abrasion resistance of concrete mixtures was determined at the ages of 28, 91, and 365 days in accordance with Indian Standard Specifications. It was measured in term of depth of wear. The variation of depth of wear versus percentage of fine aggregate replacement with Class F fly ash, at 60 min of abrasion time concluded that with the increase in fly ash content, depth of wear decreased, which indicated that the abrasion resistance of concrete increased with the increase in fly ash content. This showed that for a particular percentage of fine aggregate replacement with fly ash, depth of wear decreased with increase in age, which means that abrasion resistance increased with age. This could be primarily attributed to the increase in compressive strength resulting from increased maturity of concrete with age.

Chalee et al. (2007) in their paper " Effect of W/C ratio on covering depth of fly ash concrete in marine environment" studied the effect of W/C ratio on covering depth required against the corrosion of embedded steel of fly ash concrete in marine environment up to 4-year exposure. Fly ash was used to partially replace Portland cement type I at 0, 15, 25, 35, and 50% by weight of cementitious material. Water-to-cementitious material ratios (w/c) of fly ash concretes were varied at 0.45, 0.55, and 0.65. Tests were conducted for corrosion of embedded steel bar after being exposed to tidal zone for 2, 3, and 4 years. Based on the tests, they concluded that:

1) Covering depth required for the initial corrosion of embedded steel bar in concrete could be reduced with fly ash.

2) Decrease in W/C ratio resulted in reducing the covering depth required for initial corrosion, and generally affected the cement concrete rather than the fly ash concrete.

3) Fly ash concretes with 35 and 50% replacements and W/C ratio of 0.65, provided the result of corrosion resistance at 4-year exposure as good as cement concrete with W/C ratio of 0.45.

4) Concrete with compressive strength of 30 MPa could reduce the covering depth from 50 to 30 mm by using fly ash to replace Portland cement of 50%. From the above observations, it can be seen that there is an immense need to carry out systematic and comprehensive research on the utilization of fly ash and other industrial wastes, like gypsum, to develop a binder of sufficient strength by exploiting their inherent pozzolanic /cementing characteristics at normal temperature and evaluate the strength and durability characteristics of concrete, based on such a binder, to determine the potential use, in Civil

Engineering constructions.

III. SCOPE OF PRESENT STUDY

The scope of present study aims at providing the M40 concrete with that optimum quantity of fly ash content which could be used in structure or road construction with acceptable strength values so, that the cost of construction can be reduced to a great extent and also by achieving this the harmful impact of fly ash on environment could be reduced.

IV. NEED OF THE STUDY

Consequent upon increased generation of electricity through thermal route involving combustion of pulverized coal/ignite, concurrent generation of fly ash in bulk quantities is a matter of serious concern not only because of issues associated with its disposal and utilization but also because of its threat to public health and ecology. At present, large quantity of fly ash is being dumped in slurry form in large areas close to the power plants without being put to gainful use in India. Only a very small percentage (<35%) of fly ash generated in India is being used for gainful applications whereas the corresponding figures of other countries may vary from 60 to 100%

Although fly ash offers environmental advantages, it also improves the performance and quality of concrete. Fly ash affects the plastic properties of concrete by improving workability, reducing water demand, reducing segregation and bleeding, and lowering heat of hydration. Fly ash increases strength, reduces permeability, reduces corrosion of reinforcing steel, increases sulphate resistance, and reduces alkali-aggregate reaction. Fly ash reaches its maximum strength more slowly than concrete made with only portland cement. The techniques for working with this type of concrete are standard for the industry and will not impact the budget of a job. So as a Civil Engineer we should effectively try to use fly ash in construction, as it helps in saving environment with reduced construction cost along with many other advantages, but now question rises to what extent or percentage fly ash could be used in concrete for construction works, and to answer this present study have been made

4.1 .ADVANTAGES OF FLY ASH IN CONCRETE

The advantages of the fly ah in concrete are listed below:

1) Fly Ash is a pozzolana: A pozzolana is a siliceous or luminosities material that, in finely divided form and in the presence of moisture, chemically reacts with the calcium hydroxide released by the hydration of Portland Cement to form additional calcium silicate hydrate and other cementitious compounds. The hydration reactions are similar to the reactions occurring during the hydration of Portland Cement. Thus, concrete containing Fly Ash pozzolana becomes denser, stronger and generally more durable long term as compared to straight Portland Cement concrete mixtures.

2) Fly Ash improves concrete workability and lowers water demand: Fly Ash particles are mostly spherical tiny glass beads. Ground materials such as Portland Cement are solid angular particles. Fly Ash particles provide a greater workability of the powder portion of the concrete mixture which results in greater workability of the concrete and a lowering of water requirement for the same concrete consistency. Pump ability is greatly enhanced.

3) Fly Ash generally exhibit less bleeding and segregation: than plain concretes. This makes the use of Fly Ash particularity valuable in concrete mixtures made with aggregates deficient in fines.

4) Sulfate and Alkali Aggregate Resistance: Class F and a few Class C Fly Ashes impart significant sulfate resistance and alkali aggregate reaction resistance to the concrete mixture.

5) Fly Ash has a lower heat of hydration: Portland Cement produces considerable heat upon hydration. In mass concrete placements the excess internal heat may contribute to cracking. The use of Fly Ash may greatly reduce this heat build up and reduce external cracking.

6) Fly Ash generally reduces the permeability and adsorption of concrete: By reducing the permeability of chloride ion egress, corrosion of embedded steel is greatly decreased. Also, chemical resistance is improved by the reduction of permeability and adsorption.

7) Fly Ash is economical: The cost of Fly Ash is generally less than Portland Cement depending on transportation. Significant quantities may be substituted for Portland Cement in concrete mixtures and yet increase the long-term strength and durability. Thus, the use of Fly Ash may impart considerable benefits to the concrete mixture over a plain concrete for less cost.

V. OBJECTIVES OF THE STUDY

The main objective of the present study is to compare the strength characteristics of M40 concrete by using sample of different percentages of fly ash by mass of cementitious material, and also comparison is made between there cost. To achieve this objective following step are to be followed:

1) Design of M40 concrete mix to obtain the ratio of different components of concrete.

2) By using the above calculated ratio samples for compressive and flexural strength test for 28%, 50%, 70% replacement of cement by fly ash is to be made.

3) Compressive strength of 3,7 and 28 days is to be calculated by casting cubes for M40 mix at 28%, 50% and 70% fly ash replacement by cement.

4) Flexural strength of 28 and 56 days is to be calculated by casting beam shaped samples of M40 mix at 28%, 50% and 70% fly ash replacement by cement.

5) Comparison of the compressive and the flexural strength obtained at different percentages of fly ash is to be made.

6) Cost comparison of 28%, 50% and 70% fly ash concrete is to be made.

IV. EXPERIMENTAL PROGRAMME

The following test programme was planned to investigate the results:

1. To obtain the physical properties of the concrete constituents i.e. Pozzolanic Portland cement (PC), fine aggregates, coarse aggregate and fly ash.
2. Development of various mix combinations for concrete.
3. Casting and curing.

4. Testing of specimens for Compressive Strength and flexural strength.

6.1. MATERIALS
The properties of materials used in concrete are determined in laboratory as per relevant code of practice. Different materials used in the present study were cement, coarse aggregates, fine aggregates, fly ash, water and admixture. Result of the test conducted to determine physical properties of materials are reported and discussed in the section. The materials used were having the following characteristics:

6.1.1. Cement
Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravels and crushed stone to make concrete. The cement and water forms a paste that binds the other materials together as the concrete hardens. The ordinary cement contains the two basic ingredients namely argillaceous and calcareous. In argillaceous materials clay predominates and in calcareous materials calcium carbonate predominates. The basic composition is provided in table 1.1. In the present work Ambuja PPC was used for casting cubes and beam samples for all concrete mixes. The cement was of uniform colour i.e grey with a ligh greenish shade and was free from any hard lumps. All tests on cement were conducted, as per procedure laid down in code IS: 1489 (Part-I): 1991[36]. Summary of the results of various tests conducted on cement is provided in table 1.2

Tab 1.1 Composition Limits of POrtaland Cement Ingradient

Ingradients	Percentof Ingradientst
Lime	60-67
Silica	17-25
Alumina	3-8
Iron Oxide	0.5-6
Magnesia	0.1-4
Alkalies	0.4-1.3
Sulphur	1-3

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