Assessment of Construction in Concrete by Mixing Activator Material- A Review

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Abstract— The utilization of fly ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account the improvements in the long – term durability of concrete combine with ecological benefits. Technological improvements in thermal power plant operation and fly ash collection system have resulted in improving the consistency of fly ash. In this paper the effect of fly ash on compressive strength is studied. Today, fly ash is used in high-way bridges and has been used on regular basis to produce high performance concrete. High performance concrete can be defined as a concrete in which certain characteristics are developed for particular application and environment. Examples of these characteristics are ease of placement, compaction without segregation, early age strength, long-term mechanical properties, permeability, density, heat of hydration long life severe environments. Many concrete mixes are now available to produce high performance concrete for pre-cast. Bridge girders. Most of these mixes have been designed based primarily strength criteria. Durable concrete is usually archived because of low permeability associated with high strength concrete and use of combination of cementitious materials such as fly ash. To carry this project concrete cube were casted. The concrete cubes are placed in water tank for the curing for 7 days, 14 days and 28 days. Concrete cubes were then tested with compression strength test. These tests were conducted to insure the quality of material, to reduce the cost and the important thing is to reduce the parties involved from having the problem at the next stages. These investigation shows that by using fly ash as replacing material with cement is suitable and can be used in construction industries. In these we are using NaoH (Sodium hydroxide) as activator in concrete. It increases strength of concrete. It reduces settling time of concrete.

Key words: M25 Cement, Fly Ash, Sodium Hydroxide, Activator Material, Compression Strength

I. INTRODUCTION

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generation thermal plant. Fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Moreover, utilization of waste materials in cement and concrete industry reduces the environmental problems of power plants and decreases electricity generation costs. Cement with fly ash reduces the permeability of concrete and dense calcium silicate hydrate (C–S–H). Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. In the present experimental investigation the fly ash has been used to study the effect on compressive and split strength on M25 and M40 grades of concrete.

Geopolymer concrete is an innovative and eco-friendly construction material and an alternative to Portland cement concrete. Use of geopolymer reduces the demand of Portland cement which is responsible for high CO_2 emission.

Composition of Geopolymer Concrete:

Following materials are required to produce this concrete:

- Fly ash – A by product of thermal power plant
- GGBS – A by product of steel plant
- Fine aggregates and coarse aggregates as required for normal concrete.
- Alkaline activator solution for GPCC as explained above. Catalytic liquid system is used as alkaline activator solution. It is a combination of solutions of alkali silicates and hydroxides, besides distilled water. The role of alkaline activator solution is to activate the geopolymeric source materials containing Si and Al such as fly ash and GGBS.

A. *Mechanical Properties of Geopolymer Concrete*

Compressive strength of geopolymer concrete have been found up to 70 MPa (N/mm2). The concrete gains its compressive strength rapidly and faster than ordinary Portland cement concrete. The concrete strength after 24 hours have been found to be more than 25 MPa. Compressive strength after 28 days it has been found to be 60 to 70 MPa.

B. *Other Properties of Geopolymer Concrete*

- The drying shrinkage of is much less compared to cement concrete. This makes it well suited for thick and heavily restrained concrete structural members.
- It has low heat of hydration in comparison with cement concrete.
- The fire resistance is considerably better than OPC based concrete.
- This concrete jas chloride permeability rating of ‘low’ to ‘very low’ as per ASTM 1202C. It offers better protection to reinforcement steel from corrosion as compared to traditional cement concrete.
- This concrete are found to possess very high acid resistance when tested under exposure to 2% and 10% sulphuric acids.

C. Material in use

1) Fly ash

Fly ash is defined in cement and concrete terminology as the finely divided residue resulting from the combustion of ground or powdered coal, which is transported from the firebox through the boiler by flue gases". Fly ash is a by-product of coal-fired electric generating plants. Fly ash can be used in Portland cement concrete to enhance the performance of the concrete. Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases.

2) Coarse aggregate

Coarse aggregate are a broad category particulate inert materials used in construction. Hard stones are crushed to the required size and are used as coarse aggregate. The material that is retained on as IS sieve of size 4.75 is called coarse aggregate. Aggregate of essentially the same nominal maximum size and grading will produce concrete of satisfactory workability. These aggregates are bound together by the cement and fine aggregate in the presence of water to form concrete.

3) Fine aggregate

Fine aggregate should consist of natural sand or crushed stone sand. It should be hard, durable and clean and be free from organic matter etc. fine aggregate should not contain any appreciable amount of clay balls and harmful impurities such as alkalis, salts, coal, decayed vegetation etc. The silt contents should not exceed 4%.

4) Sodium hydroxide solution

The most common alkaline activator used in geo polymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. The type and concentration of alkali solution affect the dissolution of fly ash. Leaching of Al^{3+} and Si^{4+} ions are generally high with sodium hydroxide solution compared to potassium hydroxide solution. Therefore, alkali concentration is a significant factor in controlling the leaching of alumina and silica from fly ash particles, subsequent geo polymerization and mechanical properties of hardened geopolymer.

Fig. 1: Material's in use

II. Literature review

Alkali-activated cements gain their strength, and other properties, via chemical reaction between a source of alkali (soluble base activator) and aluminate-rich materials. The aluminate-containing material - the pozzolan/latent hydraulic binder component of the cement - can be coal fly ash, municipal solid waste incinerator ash (MSWIA), metakaolin, blastfurnace slag, steel slag or other slags, or other alumina-rich materials. The alkali used as the activator tends to be an alkali silicate solution such as sodium silicate (waterglass) but can also be sodium hydroxide solution, or a combination of the two, or other source of alkali (such as lime).Geopolymeric cements are particular examples of ´alkali-activated pozzolanic cements´ or ´alkali-activated latent hydraulic cements´. All alkali-activated cements tend to have lower embodied energy/carbon footprints than Portland cements (up to 80-90% but this is pozzolan dependent).

The activators used for AAC are mainly sodium or potassium hydroxide and silicate and in some mixes sodium carbonate. "Fly ash concrete: a technical analysis for compressive strength". flyash is used as replacement as 5-25%. The optimum percentage is 10-20% provides higher strength [1]. Geopolymer concrete have been compared with ordinary Portland cement (OPC) concrete considering the same paste volume in the previous papers of Habert et al. [2]. The Effect of class F-flyash as partial replacement with cement and fine aggregate in mortar". Fly ash is used as 10%, 20%, 25% &30% by weight. 10 % replacement will give the maximum strength [3]. High volume fly ash concrete: a green concrete". In this particular work fly ash was used from 25% to 60% by total weight and the optimum percentage was found to be 15%- 20% [16].

Other papers on environmental impact of AAC compares concrete with similar strength but that do not always have the same amount of aggregates, which induce a bias in the results. This lead for instance Yang et al. [4] to compare concrete with OPC, concrete with blended cement and concrete with alkali activated cement and to conclude that the concrete with blended cement is the worst. However, it comes mainly from the fact that more cement was used while keeping the same water/cement ratio. The Effect of fly ash on properties on concrete". In this work the percentage of concrete used was 10%, 20% and 30% by total weight and found that 10% - 20% gives the maximum strength after 30 days [5]. An Investigation on behaviour of high performance reinforced concrete columns with metakaolin and fly ash as admixture was done, Metakaolin: 5%, 7.5%, 10% and fly ash: 10% constant is used as replacement. 7.5 % is the optimum percentage where maximum strength is achieved [6]. In cement based concrete technology, it is known that the ingredients for a bad concrete are exactly the same as those required for a good concrete and that it is the relative proportions that matter [10]. Furthermore, since Féret or Bolomey, it has been established that the compressive strength depends mainly on the water to cement ratio (w/c) and not so much on the specific amount of cement used in one cubic meter [11].

Another type of alumino-silicate precursor is waste from other industrial sectors. Among them, fly ash (FA) resulting from coal power plants and granulated blast furnace slags (GBFS) resulting from crude iron production in a blast furnace are the most widely used. This option allows for a significant, both environmental and economic cost reduction in the AAC manufacturing process by saving burning costs of clay-based precursors. However, this interesting alternative is raising an accounting problem in the LCA method. Actually, according to ISO standards used in LCA [12]. In a research conducted by Palomo, Grutzeck, and Blanco, the effects of curing temperature, curing time, the solution / fly ash ratio, and alkali activation of fly ash with high concentration of activator, on the mechanical properties of Geopolymer were studied. Palomo et al. concluded that the amorphous polymer produced in the alkaline activation of metakaolin was a zeolitic precursor. From their research, they concluded that the effect of the activator-fly ash ratio was insignificant and the increase of curing temperature accelerated fly ash activation [14].

A combination of sodium hydroxide solution and sodium silicate solution was used as the alkaline activator. Analytical grade sodium hydroxide in pellets form with 98% purity and sodium silicate with Na_2O= 12%, SiO_2 = 30%, and water= 58% by mass was used in this research. Sodium hydroxide solution was used as alkaline activator because it is widely available and is less expensive than potassium hydroxide solution. Higher concentration of sodium hydroxide solution results in a higher compressive strength of geopolymer mortor. The activator-to-fly ash ratio, by mass of 0.40 produced the highest compressive strength. Curing temperature plays an important role in the geopolymerization process. As the ratio of water-to-geopolymer solids by mass increases, the compressive strength of geopolymer mortar decreases. The setting time of geopolymer mortar due to different curing temperature has been determined. The initial setting time and final setting time ranged from 129 minutes to 270 minutes [15]. The higher the curing temperature, less setting time is required. Kritsada et al. researched the influence of fly ash and slag replacement on the carbonation rate of the concrete. An experimental investigation on the influences of pozzolanic replacement and curing period on carbonation resistance of concrete was carried out. A tentative model for estimating the carbonation depth of concrete under natural exposure was proposed based on the results from accelerated tests [17].

III. Mixture Design & Analysis

A. Mixture Design

Following will be the Data Required for Concrete Mix Design;

- Concrete Mixture Design Stipulation

Characteristic compressive strength required in the field at 28 days grade designation- M 25
Nominal maximum size of aggregate-20 mm
Shape of CA-Angular
Degree of workability required at site- 50-75 mm (slump)
Degree of quality control available at site- As per IS:456
Type of exposure the structure will be subjected to (as defined in IS: 456) –Mild
Type of cement: PSC conforming IS:455
Method of concrete placing: pump able concrete

- Test data of material (to be determined in the laboratory)

Specific gravity of cement- 3.15
Specific gravity of FA-2.64
Specific gravity of CA-2.84
Aggregate are assumed to be in saturated surface dry condition.
Fine aggregates confirm to Zone II of IS – 383

Steps involved in Concrete Mix Design of M25 Grade Concrete;
Step 1 - Determination of Target Strength
Step 2 - Selection of water / cement ratio
Step 3 - Selection of Water Content
Step 4 – Selection of Cement Contents
Step 5 - Estimation of Coarse Aggregate proportion
Step 6 - Estimation of the mix ingredients
Step 7: Correction due to absorbing / moist aggregate
Step 8 - Concrete trial mixes

The concrete cube made up of various combinations activator materials is tested using universal testing machine for determining compressive strength of concrete block.

Fig. 2: Compressive testing setup using universal testing machine

IV. Conclusions

This paper is an attempt is made to mix by products into concrete material in order to make concrete mixture more eco-friendly. Most of the by products like fly ash have been dumped openly which creates soil pollution as well as various health hazards. This combination of M25 cement with fly ash and activator material i.e. Sodium hydroxide was prepared. As per IS 456 standards the mixture is settled in the form of cubes and tested for compressive strength.
Compressive strength reduces when investigation replaced fly ash. As fly ash percentage increases compressive strength decreases. Use of fly ash in concrete can save the coal & thermal industry disposal cost and produce a ‘Greener’ concrete for construction. Concrete with 5% and 10% replacement of cement with Fly Ash show good compressive strength for 28 days than normal concrete 0.45 w/c ratio. But in case of 25% and 30% replacement of cement with Fly Ash ultimate compressive strength of concrete decrease. 10% Fly Ash is cost effective than 5% Fly Ash replaces as by cement in concrete. The cost analysis indicates that percentage cement reduction decreases cost of concrete but same time compressive strength of the concrete decreases.

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