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EXPERIMENTAL INVESTIGATION FOR STRENGTH OF CONCRETE BY USING FLY ASH

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Abstract - *The objective of this study was to understand the effect of physical and chemical properties of fly ash on strength development and hydration kinetics of mortars and cement pastes.*

Different fly ashes, collected, were used. All the fly ashes and cements were characterised using X-ray diffraction (XRD) and X-ray fluorescence (XRF). The mortar mixes were prepared by replacing 25% of cement with fly ash, using three different water to binder ratios viz. 0.4, 0.45, 0.5, which were cured under water at a temperature of 27°C. The compressive strength of mortars was measured at 1, 3, 7, 28 and 90 days.

The results from experiments show that the early strength of mortars with fly ash is lower than cement mortar but most of the mortars recover strength by 28 days. Finer fly ashes show higher or equal strength as compared to OPC after 28 days.

Key Words Development, X-ray, cement Hydration, Compressive Strength, Binder Ratio.

1. INTRODUCTION

Concrete is the most used construction material in the world. Cement is the main binding material in concrete. Over the past 3 decades, the production of cement has grown rapidly all over the world. cement production has major environmental issues that are of concern worldwide.

Supplementary cement materials (like fly ash) are used to partially replace clinker, which eventually reduces the harmful emissions. The coal used in India has a higher ash content of about 35-40%, which produces more quantity of fly ash during combustion of coal in electricity generation.

The energy consumption and CO2 emissions associated with the manufacturing of cement can be reduced when fly ash is used as a partial replacement of clinker. The utilization of fly ash as cement replacement material in concrete or as an additive has many benefits from economical, technical and environmental points of view.

1.1 ADVANTAGES OF FLY ASH

- It is highly economical
- Use of Fly Ash is environmentally friendly as the waste materials from industries are effectively being used to create quality building materials
- Fly Ash has very small particles which makes the concrete highly dense and reduces the permeability of concrete. It can add greater strength to the building .
- The concrete mixture generates a very low heat of hydration which prevents thermal cracking.
- Fly Ash concrete is resistant to acid and sulphate attacks
- The shrinkage of fly ash is very less.

1.2 Disadvantages of Fly Ash

- The quality of fly ash can affect the quality and strength of cement concrete
- Poor quality fly ash can increase the permeability of the concrete and cause damage to the building.

2. LITERATURE REVIEW

To predict the compressive strength of concrete six input parameters cement, water, silica fume,super plasticizer, fine aggregate and coarse aggregate were identified considering two hidden layers for the architecture of neural network. The results of the study indicated that ANNs have strong potential as a feasible tool for predicting the compressive strength of concrete.

Atici et al., (2009) applies multiple regression analysis and an artificial neural network in estimating the compressive strength of concrete that contains varying amounts of blast furnace slag and fly ash. The results reveal that the artificial neural network models performed better than multiple regression analysis models.

Serkan subas (2009) investigated that the estimation ability of the effects of utilizing different amount of the class C fly ash on the mechanical properties of cement using artificial neural network and regression methods. Experimental results were used in the estimation methods. The developed models and the experimental results were compared in the testing data set. As a result, compressive and flexural tensile strength values of mortars containing various amounts class C fly ash can be predicted in a quite short period of time with tiny error rates by using the multilayer feed-forward neural network models than regression techniques.

Seyed et.al (2011) studied the application of artificial neural networks to predict compressive strength of high strength concrete (HSC). A total of 368 different data of HSC mix-designs were collected from technical literature. The authors concluded that that the relative percentage error (RPE) for the training set was 7.02% Silica Fume reduces bleeding significantly, also blocks the pores in the fresh concrete so water within the concrete not allowed to come to the surface**(Bs 1881:part 116:1983;Neville and brooks,2010)** Silica Fume is added to concrete to improve its properties both the mechanical improvements resulting from addition of a very fine powder as well as from the reactions between the silica fume and free calcium hydroxide in the paste **(Detwiler and Mehta, 1989; Ahmad and Awaad, 2014)**Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride rich environment **(ASTM C511;Detwiler and Mehta, 1989; Awwad Ahmad 2017)**

3. MATERIAL USED

Cement

Ordinary Portland cements (OPC) of 53 grade, as defined in IS: 12269-2004, were used in this study. Standard mortars prepared using a 53 grade cement following the description given in the Indian standards achieve compressive strengths of 53 MPa at 28 days. Two cements of the same grade were obtained from cement plants located in Jawad, Madhya Pradesh and Jojobera, Jharkhand and labelled as C1 and C2 respectively (Table 3.1). The cements originated from different limestone sources and had different chemical compositions. The cement C1 is commercially available in the market. The cement C2 is not sold commercially as OPC and is normally blended with around 40% to 50% ground granulated blast furnace slag (GGBFS) through mechanical mixing before sale and therefore contains a higher quantity of gypsum than is usual in India Fly ashes were sourced from eight different thermal power plants; most of them from northern and central part of India as shown in Figure 3.1. The list of sources of the cements and fly ashes is listed in Table 3. 1. Fly ashes F6 and F7 were obtained by the mechanical processing of fly ash F5 in an air separator where the coarser particles in F5 were removed. The chemical composition of the cements and the fly ashes were measured using X-Ray Florescence and XRay Diffraction (Table 3.4). All the mortar mixes were prepared by replacing 25% of cement with fly ash either by weight or by volume of the cement.

Sand

River sand, sieved through the standard sieves as defined in Indian Standard (IS650 2007) to achieve a standardised grain size distribution, was used in this study. The specific gravity of the sand was found to be 2.62. All mortar mixes were prepared using this standardised sand. Several trials were done on mortars using different sand-to-cement ratios to obtain good consistency and compaction of the mix at all water to cement ratios and the sand-to-cement ratio was chosen to be 2.4. This sand-to-cement ratio was chosen since it was difficult to compact mortars with water-to-cement ratio of 0.4 and higher sand-to-cement ratio without using water reducers. Chemical admixtures were avoided to minimise the number of variables in the mixes.

Mixes

The experiments in this study were carried out on pastes and mortars. Three water-to-cement ratios of 0.40, 0.45 and 0.50 were used. A uniform replacement ratio of 25% was used in the blended pastes and mortars. One series of tests was carried out on cement paste and cement mortar blends prepared by replacing 25% of the weight of the OPC with the same weight of fly ash (weight replacement). The second series of tests was performed by replacing 25% of the volume of the OPC with the same volume of one fly ash at a time (volume replacement). In order to understand the effect of volumetric dilution of the cement by a less reactive material, pastes and mortars were also prepared by similarly replacing 25% of the cement by crushed quartz. The results on these pastes and mortars will be presented along with the other results. The compressive strength was measured on cement mortars at 1,3,7,14,28 and 90 day ages. All the cubes were cured under water at temperature of 27°C ± 2°C

4. Experimental Discussion

WORKABILITY

The workability of cement concrete is tested as per using standard sizes of Slump Moulds as per IS: 1199 - 1999.

COMPRESSIVE STRENGTH

For find out compressive strength of cement concrete we casted steel cube mould of size of 150mm*150mm*150mm. After 24 hour casting of cube removing the mould and allowed for curing in a curing tank for a period of 28 days. After 7days & 28 days of curing of cube we tested the cube on Universal Testing Machine. The test procedure is used as per IS: 516-1979.

SPLIT TENSILE STRENGTH

For find out split tensile strength of cement concrete we casted steel mould of cylinder with 150mm diameter and 300mm long. After 24 hour removing the mould and allowed for curing in a curing tank for a period of 28 days. After 7days and 28 days of curing of specimen we tested on Universal Testing Machine. The test procedure is used as per IS: 5816 – 1999.

FLEXURAL STRENGTH

For find out the flexural strength of cement concrete we casted steel mould of size 500mm*100mm*100mm. After 24 hour removing the mould and allowed for curing in a curing tank for a period of 28 days. After 7days 28 days of curing of specimen we tested in 200 tonnes electro-hydraulic closed loop machine. The test procedure is used as per IS: 516-1979

5. APPLICATION

Major applications of high-performance concrete in the field of Civil Engineering constructions have been in the areas of long-span bridges, high-rise buildings or structures, highway pavements, etc. Some of the application areas are discussed in brief below:

Bridges

The use of high performance concrete would result in smaller loss in pre-stress and consequently larger permissible stress and smaller cross-section being achieved, i.e. it would enable the standard pre-stressed concrete girders to span longer distances or to carry heavier loads. In addition, enhanced durability allow extended service life of the structure. In case of precast girders due to reduced weight the transportation and handling will be economical. Concrete structures are preferable for railway bridges to eliminate noise and vibration problems and minimize the maintenance cost (Dr. R. B. Khadiranaikar).

High Rise Structures

The reasons for using the high strength concrete in high-rise buildings are to reduce the dead load, the deflection, the vibration and the maintenance cost. 5.3 Highway

Pavements

High Performance concrete is being increasingly used for highway pavements due to the potential economic benefits that can be derived from the early strength gain of high performance concrete, its reduced permeability, increased wear or abrasion resistance to steel studded tires and improved freeze-thaw durability. A durable concrete known as fast track concrete designed to give high strength at a very early age without using special materials or techniques has been developed. Fast Track Concrete Paving (FTCP) technology can be used for complete pavement reconstruction, partial replacement by an inlay of at least one lane, strengthening of existing bituminous or concrete pavements by a concrete overlay, rapid maintenance and re-construction processes. The benefits of applying FTCP technology in such applications are : (a) a reduced construction period, (b) early opening of the pavement to traffic, and (c) reducing the use of expensive concrete paving plant

6. CONCLUSIONS

This project work is primarily focused on the properties of materials used, mix proportion of High Performance Concrete, making of concrete specimen, curing and testing of harden concrete.

On performing the various tests the physical properties of the specimens are studied and the following conclusions are arrived.

On comparing the result high performance concrete having 7.5% Silica Fume gives a maximum compressive strength value.

Maximum splitting tensile strength value is achieved when cement is replaced with 7.5% of Silica Fume.

Hence it is concluded 7.5% of Silica Fume gives the maximum compressive and tensile strength to the concrete we can say that concrete mix is high strength concrete. Performance properties of the concrete need to be studied

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