Paper from Proceeding of the National Conference on Innovative Developments in Science, Technology & Management (NCIDSTM-2015) Organized by Ganga Technical Campus, Soldha, Bahadurgarh, Haryana (India) March 1st 2015 Published by International Journal of Engineering Sciences Paradigms and Researches (IJESPR) with ISSN (Online): 2319-6564, Impact Factor: 2.20 and Website: www.ijesonline.com

Use of High Volume Fly Ash to Enhance Performance of Concrete

Neha Solanki
Department of Civil Engineering ,
Ganga Technical Campus, Haryana, India

Abstract

Higher values of cement replacement with fly ash will require lower water contents to achieve the same compressive strength. The long term compressive strength of HVFAC normally exceeds that of conventional concrete. The ratios of the flexural and tensile strength to the compressive strength are comparable to conventional concrete. The foamed concrete mixtures with high ash contents might need a longer period of time to reach their ultimate strength. This strength could be higher than the ultimate strength that can be achieved using only cement. The long-term gain of strength observed was for well-cured samples and this gain of strength might not be as great with specimens that have not been so well-cured. Replacing high proportions of cement with fly ash does not significantly affect the long-term compressive strength of well cured foamed concrete.

The compressive strength of the mixtures decreased with the increase of rubber waste particles for all curing periods tested (7, 14 and 28 days). The strength of the mixtures increased with an increasing fly ash content. Compressive strength is slightly influenced by the particles size. The mixtures with a 20% rubber waste content present the maximum compressive strength of 4.84 MPa at 28 days. Some fly ashes shows significant decrease in heat generation as the concrete hardens and strengthens. It generally provides increased concrete strength for much longer periods than mixes with Portland cement only. Fly ash also improves the permeability of concrete by lowering the water-to-cement ratio. Fly ash will require lower water contents to achieve the same compressive strength.

For mass concrete placements such as mat or raft foundations, the use of even higher quantities of fly ash is recommended.

Keywords: *Fly Ash, Concrete.*

1.Introduction

In India, nearly 130 million-tonne of fly ash is generated per annum as a waste by-product and is largely responsible for environmental pollution. Fly ash emissions from a variety of coal combustion units show a wide range of composition. All elements below atomic number 92 are present in coal ash. A 500 MW thermal power plant releases 200 m t SO_2, 70 t NO_2 and 500 t fly ash approximately every day. Particulate matter (PM) considered as a source of air pollution constitutes fly ash. The residual particles being silica (40–73%) cause silicosis. Fly ash contain heavy metals (Ni, Cd, Sb, As, Cr, Pb, etc.) are toxic in nature. Presently, in India around 55 of the fly ash generated is being utilized, whereas, in developed countries it to the tune of 80 % or more. In this article attempts made to highlight the effective utilization of fly ash in order to save our environment as well as reduce the cost of construction. Studies also show that coal ash satisfies the criteria for landfill disposal, according to the Environmental Agency of Japan[2]. Fly ash can be treated as a by-product rather than waste[3].

The concrete designers use fly ash as a partial replacement for Portland cement up to 30 percent of the total cementitious composition. The use of high percentages (high volumes) of fly ash has been studied extensively over the last 15 years, and the benefits of this type of concrete have been appreciated. The use of high volume fly ash concrete has gained increasing acceptance by structural engineers and architects from an environmental standpoint, as well as the life cycle cost approach. When designing and specifying concrete for strength and durability, the proper selection of constituent materials depends on the exposure conditions, type of structure and intended use. For applications such as footings, columns, walls and beams, where surface exposure is minimal, high volume fly ash concrete mixes may be used effectively.

2. Carbonation in Concrete

It revealed from the review that in the design of concrete structures, carbonation is one of the important factors that determine the service life of a concrete structure. The high volume fly ash (HVFA) concrete has many excellent properties for structural concrete. The presence of fly ash enhances the carbonation process through change of CO_2 concentration and relative humidity. The reactivity of CO_2 with concrete depends mainly upon the type and the content of binder and the degree of hydration.

3.Fly ash and Waste Tires Properties

Fly ash improves the pump-ability of concrete by making it more cohesive and less prone to segregation. The spherical shape improves the pump-ability by decreasing the friction between the concrete and the pump line. Fly ash also improves the permeability of concrete by lowering the water-to-cement ratio, which reduces the volume of capillary pores remaining in the mass. The spherical shape of fly ash improves the consolidation of concrete, which also reduces permeability. During the hydration process, fly ash chemically reacts with the calcium hydroxide forming calcium silicate hydrate and calcium aluminates, which reduces the risk of leaching calcium hydroxide and concrete's permeability.

The specimens with waste tire rubber showed higher flexural strength values than the control mix, probably due to the effect of rubber fibers. Water absorption decreased slightly with the increase in the size of the rubber particles. The increase in rubber waste content increased the water-to- binder ratio. The increase in fly ash content decreases the water requirement of the mixture. Also, the fineness of rubber waste particles influences the water requirements for the preparation of the mixtures.

4.Strength Properties of Fly ash and Waste Tires

Higher values of cement replacement with fly ash will require lower water contents to achieve the same compressive strength. The long term compressive strength of HVFAC normally exceeds that of conventional concrete. Longer term (56 day) compressive strength requirements are often specified. The ratios of the flexural and tensile strength to the compressive strength are comparable to conventional concrete.

The compressive strength of the mixtures decreased with the increase of rubber waste particles for all curing periods tested (14, 28 and 56 days). The strength of the mixtures increased with an increasing fly ash content. Compressive strength is slightly influenced by the particles size. The mixtures with a 20% rubber waste content present the maximum compressive strength, 4.84 MPa at 28 days

5. Material and Method

To produce high volume fly ash concrete, the fly ash (after burning coal), waste rubber tyre chips, sodium meta silicate, sodium silicate solution (Na_2SiO_3), water and super plasticizer are selected as study material. The aggregate impact value (AIV) and aggregate crushing value (ACV) for the aggregate were tested according to BS 812-112:1990 and BS 812-110:1990 standards respectively.

The low calcium (ASTM Class-F) fly ash is used as a binder, instead of Portland or other hydraulic cement paste, to produce concrete. The fly ash paste binds the loose coarse aggregates, fine aggregates and other un-reacted materials together to form high volume fly ash concrete, with the pressure of admixtures. The high volume fly ash concrete is manufactured by using the usual concrete technology.

HVFAC normally requires low water for cementitious material ratio (0.30) to achieve compatible strength early as compare to portland cement mixtures . With the same amount of water, fly ash increases workability as compared to normal concrete and also overcome the bleeding problem. However, when placing HVFAC in hot weather precautions should be taken to avoid plastic shrinkage cracking.

Case study was done for M15 mix design.

Case study I -Replacement of 55% fly ash with cement

The mix design ratio of cement, fine aggregate and coarse aggregate (1.4: 2.1: 4.2) was taken for sample with water cement ratio of 0.5. After preparing the mixture a cube was molded and kept for 7 days in mold. The mold was removed carefully, cube was tested for compressive strength by Universal testing machine. The strength obtained was 8 N/mm^2 which is below desired strength. The reason may be high moisture content in atmosphere due to rainy season.

Case study II- Replacing cement with 55% fly ash and coarse aggregate with waste tyre (7%)

The same procedure is followed to form the cube as in case I. The cube was kept for dry curing in oven for 3 days. After 3 days cube was tested for compressive strength. The strength obtained was 10.4 N/mm^2.

Case study III - Replacing cement with 60% fly ash

Mixture was prepared as above and kept in the mold to set for 28 days. The cube was then demolded carefully and tested for compressive strength by Universal testing machine. The compressive strength obtained was 16.44 N/mm^2.

Case study IV - Replacing cement with 65% fly ash

The same process was followed and tested the compressive strength after 28 days. The strength obtained was 12.28 N/mm^2. The results are shown in table-1 and fig-1.

Table 1 The compressive strength of different combination of cement and fly ash

Specimen (C%,F%)	Cement (kg)	Fly ash (kg)	Coarse aggregate	Fine aggregate	Tire content (%)	Admixture	Ratio (Admixture: Water)	Compressive strength (N/mm^2)
C45 F55	0.63	0.77	4.2	2.1	7	Meta silicate	1:5	8
C45 F55	0.63	0.77	3.36 (Waste tyre)	2.1	7	Meta silicate	1:5	10
C40 F60	0.56	0.84	4.2	2.1	0	Meta silicate	1:5	16.44
C35 F65	0.49	0.91	4.2	2.1	0	Meta silicate	1:5	12.28
C48 F52	0.672	0.728	4.2	2.1	0	Meta silicate	1:5 (1.5 % CaCl2 of meta	17.32

							silicate)	
C45 F55	0.63	0.77	4.2	2.1	0	Meta silicate	1:5 (1.5 % CaCl2 of meta silicate	17.34
C50 F50	0.70	0.70	4.2	2.1	0	Meta silicate	1:5 (1.5 % CaCl2 of meta silicate	12.28
C42F58	0.588	0.812	4.2	2.1	0	Meta silicate	1:5 (1.5 % $CaCL_2$ of meta silicate)	14.66

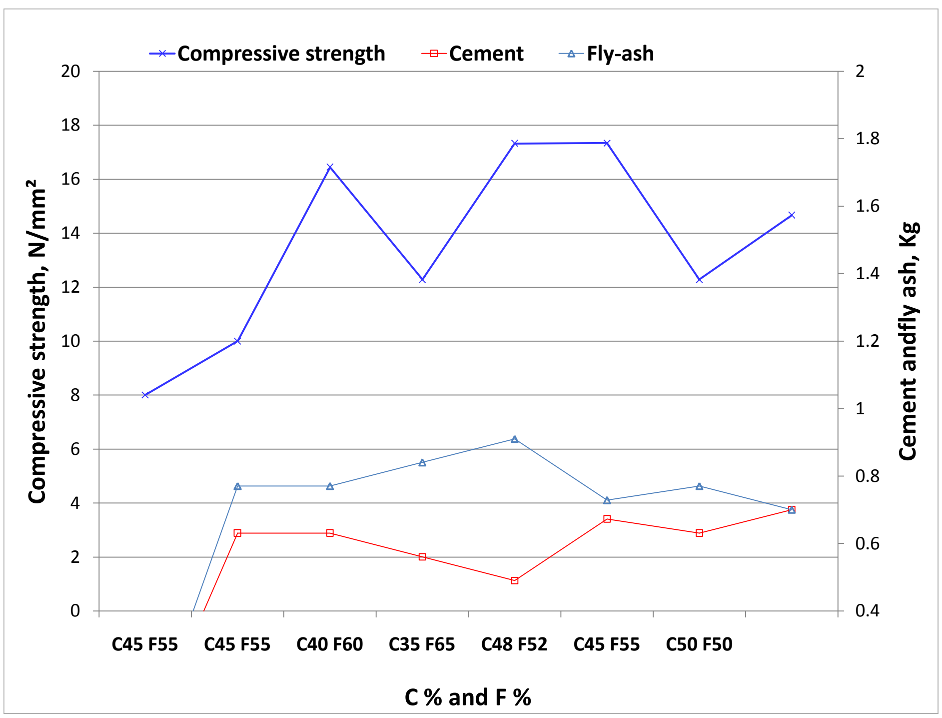

Fig 1 The compressive strength of different combination of cements and fly ash

6.Result and Discussion

The samples prepared with different combination of cement and fly ash, shows the compressive strength very close to the OPC concrete strength with better durability. The maximum compressive strength found for the 50-55% replacement of cement by fly ash, whereas for the 55-60%

replacement the strength was low comparatively. In one sample waste tire was also introduced having cubical shape around 5mm, which increases the compressive strength.

Reference

[1]. S. Chen, H. Su, J. Chang, W. Lee, K. Huang, L. Hsieh, Y. Huang, W. Lin, C. Lin, Emissions of polycyclic aromatic hydrocarbons (PAHs) from the pyrolysis of scrap tyres. Atmosf Environ 41 (2007)1209-1220.

[2]. N. Oikonomou, S. Mavridou, The use of waste tyre rubber in civil engineering works. In Sustainability of construction materials Ed. J., Khatib, ISBN 978-1-84569-349-7, WoodHead

[3]. Publishing Limited, Abington Hall, Cambridge, UK (2009)

[4]. European Commission. Council directive 1999/31/EC of 26 April 1999 on the landfill of waste. Official Journal of the European Communities, L182 (1999)1–19.

[5]. M. Bignozzi, F. Sandrolini, Tyre rubber waste recycling in self-compacting concrete, Cem Concr Res 36 (2006) 735–739.

[6]. G. Li, G. Garrick, J. Eggers, C. Abadie, M. Stubblefield, S. Pang, Waste tire fiber modified concrete. Composites: Part B 35 (2004) 305-312.

[7]. Rafat Siddique* Department of civil engineering, Thapar Institute of engineering and technology ; Deemed University, Patiala Punjab 147 004, India.

[8]. A. A. Ramezanianpour , (Amirkabir University of Technology , Tehran , Iran & V.M.Malhotra , Advanced Concrete Technology Program, Resource Utilization Laboratory, Mineral Science Laboratories, CANMET, Natural Resources Canada, Ottawa , Canada.

[9]. Cengiz Duran Atis, Department of Civil Engineering, Cukurova University, 01330, Balcali, Adana, Turkey.