Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 11, November -2015

Characteristics study of high volume fly ash concrete

N. G. Patoliya et. al.[1],Dr. Anurag Misra[2] et. al.

[1]*Narmada, Water Resources, Water Supply and Kalpsar Department, Government of Gujarat,*

[2]*Applied Mechanics Department, MNIT, Jaipur*

Abstract— *This experimental study is aimed at investigating the characteristics of fly ash concrete by varying the water cement ratio and percentages of fly ash, replacing the cement by weight. The data obtained in this work would be of use in determining the appropriate mixture proportions for high volume fly ash concrete. Total twelve mixes were prepared in this project with three w/c ratios (0.55,0.475 and 0.4) and fly percentage was varied as 0%,30%,40% and 50% of cement. Compressive strength and water absorption test was carried out. It was found that with lower water cement ratio and an increase in the amount of fly ash , water absorption of concrete is lowered and it also leads to an increase in the strength of the concrete, the making a durable concrete. It was also found that for the mix under consideration and the given fly ash, 0.475 w/c ratio and 40% fly ash is the optimum dose from water permeability and strength point of view (given all the other conditions remain the same)*

Keywords- *High volume Fly ash concrete; Compressive strength; Water absorption; Durability;*

I. INTRODUCTION

The deterioration of reinforced concrete structures usually involves the transport of aggressive substances from the surrounding environment followed by physical and chemical actions in its internal structure. The transport of aggressive gases and/or liquids into concrete depends on its permeation characteristics. As the permeation of concrete decreases, its durability performance, in terms of physico-chemical degradation, increases. Therefore, permeation of concrete is one of the most critical parameters in the determination of concrete durability in aggressive environments.

The permeation related properties, which mainly govern the ingress of the aggressive substances into the concrete, are permeability, absorption. Permeability is a measure of the ease with which the substances are transported due to a pressure differential, while absorption/porosity (saturation method) are measures of the absorption characteristics of concrete. Permeation, which is dictated by the microstructure of concrete, controls the ingress of moisture, ionic, and gaseous species into concrete. Chemical degradation, e.g., corrosion of steel reinforcement, sulphate attack, carbonation, and alkali-aggregate reaction as a result of reaction between an external agent and the ingredients of concrete, and some physical effects such as frost attack can be greatly reduced by reducing the permeation of concrete.

Conventional concretes often fail to prevent the ingress of moisture and aggressive ions adequately. The use of blended cements or supplementary cementing materials has been reported to decrease the permeability, thereby increasing the resistance of concrete to deterioration by aggressive chemicals such as chlorides Therefore, the blending of Portland cement with pozzolanic materials has become an increasingly accepted practice in the construction of structures exposed to harsh environments such as offshore structures, highway bridges, tunnels, sewage pipes, and structures for wastes containing toxic chemicals and radioactive

II. EFFECT OF FLY ASH ON THE PROPERTIES OF FRESH CONCRETE

Fresh concrete is a concentrated suspension of particulate materials of widely differing densities, particle sizes, and chemical compositions in a solution of lime and other components. The system is not static. As soon as the cement and water mix, reactions commence that ultimately produce the binder that consolidates the concrete mass. New particles are formed, and the original particles dissolve or are coated with cementitious products. Heat is released during the chemical reactions, and the temperature rises. In all of these events, fly ash plays some role. Low-calcium fly ash will act largely as a fine aggregate of spherical form; high-calcium fly ash, on the other hand, may participate in the early cementing reactions, in addition to being part of the particulate suspension.

2.1. Influence of fly ash on the setting time of Portland cement concrete

The chemical and physical influences that fly ash might have on the setting of concrete been attempted to separate. In concrete not containing fly ash, the setting time should be a function of two parameters (a) The cement factor (b) Water/cement. As the cement factor increases, the setting time decreases, as the water/cement ratio increases, the setting time increases.

Fly ash generally slows the setting of concrete. This may be due to the proportions of the fly ash, its fineness, and its chemical composition; however cement fineness, water content of the paste, and ambient temperature are considered as having a much greater effect. [**Lane and Best, 1982**]. In another study with Fly ash – cement mixtures set more slowly than corresponding cements but that the setting times are within the specified limits. [**Davis et al. 1937**].

2.2. Effect of fly ash on workability, water requirement and bleeding of fresh concrete

The small size and the essentially spherical form low-calcium fly ash particles influence the rheological properties of cement pastes, causing a reduction of in the water required or an increase in workability compared with that of an equivalent paste without fly ash. Fly ash differs from other pozzolans, which usually increase the water requirement mixtures. The improve workability allows a reduction in the amount of water used in concrete. [**Davis ET al.1937**]

The major factor influencing the effects of ash on the workability of concrete is the proportion of coarse material (>45µm) in the ash. For example, substitution of 50% by mass of the cement with fine particulate fly ash can reduce water requirement by 25%. A similar substitution using ash with 50% of the material >45µm has no effect on the water requirement. [**Owens, 1979**]

It was found in a study that the water requirement was reduced by 7.2% in a mixture in which 30% fly ash replaced 20% cement. [**Pasko and Larson, 1962**]. In another similar study with percentage of fly ash replacement for the same workability with 21, 28, and 34MPa nominal-strength concrete mixtures, it was concluded that as the amount of fly ash increased in the mixtures, the water requirement decreased. [**Naik and Ramme, 1990**]

Experimental studies have shown that with HVFA concrete mixtures, depending on the quality of fly ash and the amount of cement replaced, up to 20% reduction in water requirements can be achieved. [**Owen, 1979; Jiang and Malhotra, 2000**]

2.3 Effect of fly ash on temperature rise of fresh concrete.

The hydration or setting of Portland cement paste is accompanied by an evolution of heat that causes a temperature rise in concrete. Replacement of cement by fly ash results in a reduction in the temperature rise in fresh concrete. This is of particular importance in mass concrete, where cooling following a large temperature rise can lead to cracking. The first major use of fly ash in concrete was in the construction of a gravity dam, where it was employed principally to control temperature rise [**Philleo, 1967**]

It has been estimated that the contribution of fly ash to early-age heat generation is 15-30% of that of the equivalent mass of Portland cement. [**ACI Committee 211.1-81, 1984**]

III. EFFECT OF FLY ASH ON THE PROPERTIES OF HARD CONCRETE

The main factors determining strength in concrete are the amount of cement used and water/cement. In practice, these are established as a compromise between the need of workability in the freshly mixed state, strength and durability in the hardened state and cost. The degree and manner in which fly ash affects workability are major factors in its influence on strength development. A fly ash that permits a reduction in total water requirement in concrete will generally present no problem in the selection of mixture proportions, permitting any desired rate of strength development. Many variables influence the strength development of fly ash concrete, the most important being the (a) The properties of fly ash (b) Chemical composition (c) Particle size (d) Reactivity (e) Temperature and other curing conditions.

IV. EFFECT OF FLY ASH ON THE DURABILITY OF CONCRETE

The water and chloride permeability of concrete containing a class F fly ash was determined at water-to-cementitious materials ratios of 0.33, 0.38, and 0.45.Fly ash content range between 10% and 50% of the total weight of cement used. They reported that the water permeability at 91 d was reduced by as much as 50% in some concrete mixtures. [**Arnaghani et al., 1991**]

The 28d permeability values for fly ash concretes show higher than no-fly-ash concrete. However, fly ash concretes exhibit lower permeability than plan Portland cement concrete when durations of curing is increased to 91 d. [**Al-Amoudi et al. ,1989**]

It has been reported that the ionic concentration in the pore solution of a fly ash cement paste also decreases as the fly ash content increases. [**Berry et al., 1994**]

In an experiment the influence of inclusion of fly ash, slag, and silica fume, on the chloride ion intrusion into concretes was studied. The results indicated that good resistance to the penetration of chloride ions can be achieved at relatively early ages by addition of slag or silica fume as a supplemental cementitious material with a low water-to-cementitious materials ratio. [**Ozylidirim and Halstead, 1988**]

The effect of replacement ratio of fly ash, initial curing period in water, and air content on the carbonation phenomenon in concrete was investigated. It was reported that the carbonation of concrete with fly ash was affected by initial curing conditions and increased with an increase in the replacement ratio of fly ash. It was also found that the depth of carbonation of concrete was in proportion to the square root of exposure duration in the accelerated carbonation test. [**Ohga and Nagataki, 1989**]

In a series of tests on the effects of lignite fly ash on the resistance of concrete to freezing and thawing the results showed that the use of high percentages of fly ash in concrete (35-50%) reduced its resistance to freezing and thawing even thought it contained ~6% air and was moist cured for 80 d. It was also found that concrete containing 20% fly ash had a satisfactory performance, provided its air content and strength were comparable to those of control concrete. [**Nasser and Lai, 1992**]

The effects of the source and amount of fly ash on abrasion resistance was examined by using Class C fly ash from three sources were used. Concrete mixes were prepared with varying fly ash percentage by 40, 50 and 60% with constant w/c ratio of 0.30. Concrete abrasion resistance was not greatly influenced by inclusion of Class C fly ash up to 40% of total cementitious materials. However, a slight decrease in abrasion resistance of HVFA concrete (especially at fly ash content above 50%) was noted as compared to the reference mixture without fly ash. [**Naik et al., 2002**]

For high strength grades (>40 MPa) the abrasion resistance of HVFA concrete with 70% replacement of cement is higher than that of counterpart control OPC concrete and concrete made with 50% fly ash. Superplasticizer and curing conditions have no significant influence on the general trend of the abrasion of concrete studied. [**Atis, 2002**]

The results of sulphate-resistance studies on 30 concrete mixtures made with Portland cement, Portland-fly ash cement, or fly ash concluded that fly ashes greatly improved sulphate resistance. [**Dikeou, 1970**]

V. EXPERIMENTAL PROGRAMME

In this work, a laboratory investigation was carried out to evaluate the strength and the water absorption of concrete containing high volumes of fly ash. Here aggregate–cement ratio was kept constant and water-cementitious material ratio was varied as 0.4, 0.475 and 0.55; at the same time for each water cement ratio percentage of fly ash replacing cement (by weight) was varied by 0%, 30%, 40% and 50%. The control mix was prepared using 0.55 water cement ratio and 0% fly ash to achieve a target strength of 20Mpa (M20) at the end of 28 days .Compressive strength and water absorption test was performed on the test specimens. The properties of other mixes were compared with that of the control mix. ISAT test was also intended to be performed but due to time constraint it was not possible to do the test.

VI. RESULTS

6.1. Result of Water absorption test

Water absorption test was performed taking three cubes from each mixes. The result of the test is shown in

Figure 6.1 below

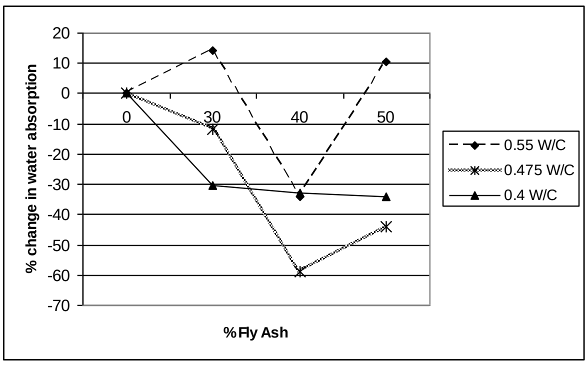

Figure 6.1. Percentage variation in water absorption with change in %fly ash

6.2. Results of Compressive strength test

6.2.1. 7 days Compressive strength test result

The 7 days compressive strength test was performed taking three cubes from each mixes, after curing them in water for 7 days. The result of the test is shown in Figure 6.2 below

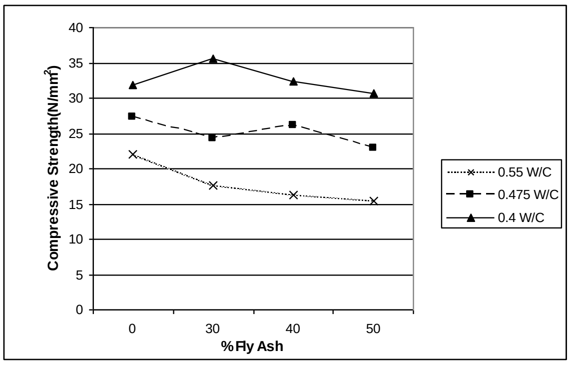

Figure 6.2. Compressive strength(7 days)with change in %fly ash replacement

6.2.2. 28 days Compressive strength test result

Like the 7 days compressive strength test three cubes from each mixes cured in water for 28 days and their compressive strength test was performed It seen from test result of the 28 days compressive strength value at w/c ratio 0.475 and fly ash replacement 40% is not following the trend of change of value like the other series so it has not been considered in plotting the curves. The result of the test is shown in Figure 6.3 below

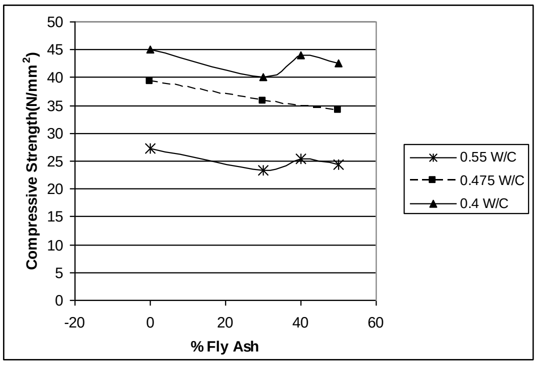

Figure 6.3. Compressive strength(28 days)with change in %fly ash replacement

VII. CONCLUSIONS

From the results obtained from water absorption and compressive strength test the following conclusions can be drawn –

a) Percentage of water absorption of concrete mix falls with decrease in water cement ratio. An increase in the amount of fly ash in the mix also decreases its water absorption.
b) Up to 50% fly ash replacement indicated approximately same compressive strength as that of control mix, but the water absorption was substantially lower.
c) The increase in compressive strength with lower water content is visible in 28 days compressive strength curves (Fig.6.3) also. Here though the fly ash concrete indicated lower strength at early ages. However, compressive strength of fly ash concrete is almost equal or little less than that of the control mix but it can be expected that by 90 days after casting it will be higher than the compressive strength of the control mix.
d) From all the results obtained it can be concluded that 0.475 water cement ratio and 40% fly ash is the optimum dose for the concrete mix under observation, given other conditions remain the same.

REFERENCES

[1] Owen, P.L. "Fly Ash and Its Usage in Concrete." Journal of Concrete Society,vol. 13(7), pp. 21-26, 1979.

[2] Al-Amoudi. S. B., Rasheeduzzafar, A. and Maslehuddin, M. "Permeability and corrosion resisting characteristics of fly ash concrete in Arabian Gulf Countries." Proc., 3rd CANMET/ACI Int. Conf. on Use of Fly Ash, Silica Fume. Slag, and Natural Pozzolans in Concrete: ACI SP-114, Am Concrete Inst., Detroit, Mich., vol. 1, pp. 295-314, 1989.

[3] Armaghani, J. M., Romano, D. C., and Larsen. T. J. "Strength and durability of concrete in Florida." Proc., 2nd CANMETIACI Int. Conf. on Durability of Concrete: Supplementary Papers, Am. Concrete Inst., Detroit, Mich., pp. 723-748, 1991.

[4] Atis, C.D. "High Volume Fly Ash Abrasion Resistant Concrete." Journal of materials in civil engineering, May-June,2002.

[5] Berry, E. E., Hemmings, R. T., Zhang, M. H., Cornelius, B. J., and Golden, D. M. ''Hydration in high-volume fly ash concrete binder.'' ACI Material. Journal.vol. 91, pp. 382–389, 1994.

[6] Jiang, L.H., and Malhotra, V.M. "Reduction in Water Demand of Non Air-Entrained Concrete Incorporating Large Volume of Fly Ash." Cement and Concrete Research, vol. 30, pp. 1785-1789, 2000.

[7] Naik, T. R.and Ramme, B. W.1990. "High Early Strength Concrete containing Large Quantities of Fly Ash. Serviceability and Durability of Construction Materials." Proceedings of the First Materials Engineering Congress, held Aug 13-15, 1990

[8] Nasser, K. W. and Lai, P. S. H. "Resistance of Fly Ash Concrete to Freezing and Thawing. Fly Ash, Silica Fume, Slag, and Natural Pozzolans in Concrete." Proceedings of the Fourth International Conference, Istanbul, Turkey, May 1992; Ed. by V. M. Malhotra; American Concrete Institute, Detroit, MI, Vol. 1, ACI SP-132, pp. 205-226, 1993.

