ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.6

Partial Replacement of Cement with Fly Ash: Review Paper

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Abstract:
In this process mortar containing flyash as a partial replacement of sand by weight as well as by volume were carried out to quantify its utilization. Both the types of pond and bottom flyash in various ratios were used in preparing cement mortar and their strengths in compression and tension were tested. Out of the various proportions the mortar mix 1:2.5:2.5 (cement: coarse sand: pond flyash) designed by method of volume is found satisfactory as for as the strength is concerned. The maximum utilization of flyash almost 75% and cost saving about 58% were ascertained with the plain mortar of ratio 1:5 (cement : sand). The utilization of flyash in mortar designed by weight provides 50% to 60% financial saving while 9% to 16% by method of volume. However, the flyash mortar mix 1:1:5 (cement:flyash:sand) by weight consumes about 20% less quantity of cement and overall consumption of flyash is also less.

Keywords: dry ash, method of volume, maximum utilization of flyash.

I. INTRODUCTION

Presently about 105 million tons flyash is generated every year in India as a by-product of coal consumed in the thermal power plants. The thermal power plant is only the source to produce 65% of the total electricity produced in our country. Investigation on utilization of flyash in cement mortar is carried out by many authors (1,2) reported in the literature. Several million tons of coal for generating the electricity is being consumed in India out of which 40% of coal is accounted for generating of flyash as a bye product. By the year 2010 more than 180 million tons of flyash would be generated every year (1).

The type of flyash collected at the bottom of boiler furnace having lesser fineness & high carbon content is called bottom fly ash (3).

The finest flyash is called dry fly ash, collected from different electrostatic precipitators (ESP) in dry form. While the ash mixed with water, forming slurry and drained out in ponds is referred as pond fly ash (3).

The mineralogical studies of fly ash reveals that silica is present in crystalline forms of quarts (sio3) and partly is associated with alumina as mullite (2AL2O32Sio2), the rest being mostly in the glassy phase. The huge amount of fly ash imposing challenges for its disposal and management.

At present flyash is disposed in slurry form in large ponds managed by Thermal power corporation plant units. A small percentage that is 3% to 5% of flyash is being used in India while in other countries the percentage of utilization is 30% to 80%, whatever be the type of flyash, it causes types of pollution (4) and air born diseases such as silicoses, fibrosis of lungs, bronchitis etc.

Due to the presence of toxic metals in flyash, it causes water pollution through percolation. Its disposition on agricultural land affects the horticulture and also made the soil infertile.

Figure.1[3]

It also affects adversely the civil and mechanical structures. It also causes silting and other problems for human and aquatic life, therefore, it cannot be disposed in sea or river (4). Flyash is being consumed (tones/day) by several organizations in production of cement, bricks, cellular blocks, asbestos sheets, filling low lying areas and construction of roads as shown in Table 1. The impacts of flyash usage in road works including embankments are wind erosion, surface water erosion and leaching of toxic heavy metals into water bodies including underground aquifers. The sub base/base layers of road pavements constructed using flash need to be covered with black top to prevent percolation of rain water to avoid ground water intrusion and to keep sub grade dry as per standard road construction practices. It is to be ensured that leaching of heavy metals is minimized. Flyash may sometimes accidentally comes in contact with running water and ground water and the flyash water mixture is basic in nature.

II. EXPERIMENTAL INVESTIGATIONS

The methodology adopted for experimental study has fully been described by selecting four different ratios of mortar consisting flyash in different proportions such as 1:0.5:4:5, 1:1:4, 1:2:3, 1:2.5:2.5 (cement : coarse/fine sand: pond/bottom ash) were considered for experimentation. Keeping water cement ratio a constant of 0.8 adopting both the methods of mix design (by weight and volume), replacing sand by flyash

partially. Cubes and briquettes were prepared for compressive and tensile strength tests of mortar. Their strengths were compared with the standard mortar mix 1:5 (cement: sand) for 7, 28 and 96 days. Likewise, a comparative study of compressive strength of the same mix by the same method of design. The ratio of mortar mix 1:1:5 (cement: flyash : sand) adopting both the methods of mix design (by weight and volume), replacing cement by flyash partially, cubes were also prepared for compressive strength tests of mortar. Their strengths were compared with the strengths of cubes prepared replacing sand by flyash . Likewise, a comparative study of compressive strength of the same mix by the same method . On rigorous analysis, it has been observed that method of volume is suited best than the method of weight. Similarly, the inclusion of pond flyash in mortar gives better results than bottom flyash. All the above results (tabular and graphical) presented here with are obtained on the tests carried out on mortar prepared by partial replacement of sand by pond flyash and adopting method of volume for design of the mix. The comparative graphs for strength of different ratio are shown for curing period of 7, 28 and 96 days and compared with the standard plain mortar of ratio 1:5. The tabular form of data showing the compressive strength of different ratio of mortar mix in contrast with the strength of standard mix 1:5. On experimental analysis, it has also been observed that the mortar of the ratio 1:1:5 (cement : flyash : sand) when the replacement of cement is made by flyash, it gives lesser strength in comparison to the replacement of sand by flyash. Furthermore, the consumption of flyash is also reduced appreciably. With the aim of higher consumption of flyash and strength, former is preferred.

Table .1 . Flyash Utilization Status (5)

Product	Quantity in tonnes/day
cement	2781.00
bricks	16.00
Cellular Blocks	250.00
Asbestos Sheets	130.00
Filling low lying and construction of roads	260.00
Total	3437.00

FLY ASH

Fly ash is a fine powder byproduct from industrial plants using pulverized coal or lignite as fuel .It is the most widely used pozzolona siliceous or alumina siliceous in nature in a finely divided form .They are spherical shaped “balls’’ finer than cement particles A. Sources of fly ash Fly ash is powder recovered from the gases of coal fired electricity production Inexpensive replacement of Portland Cement Improves strength, segregation and ease of pumping the concrete.

Figure.2[4]

III. MATERIALS USED

A. Cement: Ordinary Portland cement is used in the project work, as it is readily available in local market. The cement used in the project has specific gravity was 3.15.

B. Coarse Aggregate: Crushed angular coarse aggregate were used. The specific gravity was 2.60. The coarse aggregate used in the project work are 20 mm down grade.

C. Fine Aggregate: River white sand was used as fine aggregate. The specific gravity was 2.40. The fine aggregate used in the project work is 4.75 mm down grade

D. Silica fume: Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It is usually a grey coloured powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementations properties.

E. Fly ash: Fly ash is powder recovered from the gases of coal fired electricity production Inexpensive.

IV. SCOPE OF WORK

The scope of the study is restricted to the following aspects. 1.The workability , compressive strength, split tensile strength of silica fume and fly ash concrete of different ratio, different mix proportions with constant water cement ratio’s have been investigated. 2. High-performance concrete of grades M-25 the replacement levels of cement by silica fume and fly ash are selected as 0%, 6%, 8%, 10%, 12% & 14% for standard sizes cubes for testing. Silica fume can improve resistance to chloride penetration.

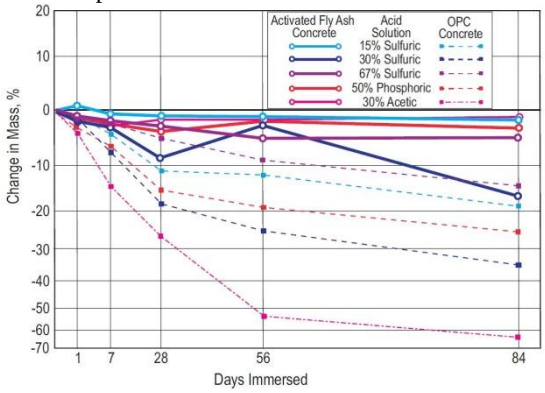

Figure.3.[5]

•Several studies have combined fly ash and Silica Fume in various proportions. In general, concrete made with Portland cement containing both Silica Fume and fly ash has a higher compressive strength than concrete made with Portland cement containing either Silica Fume or fly ash on their own.

USES OF FLY ASH

Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. When used in portland cement improve properties of the hardened concrete. SCM's include both pozzolans and hydraulic materials.

EFFECT OF FLY ASH ON IMPORTANT PROPERTIES OF CONCRETE

The addition of fly ash to cement has been found to enhance cement properties:

1) Normal consistency increases with increase in the grade of cement and fly ash content.

3) Workability increases in fly ash concrete

4) As the fly ash contents increases in all grades of OPC there is reduction in the strength of concrete.

5) In all grades OPC, fly ash concrete is more durable as compared to OPC concrete and fly ash up to 40% replacement increase with grade of cement.

6) Shrinkage of fly ash concrete is similar to the pure cement concrete in all grades of OPC.

TEST METHODS

A. Workability: The workability tests were performed using standard sizes of Slump Moulds 1) Slump Test

B. Compressive Strength: The Steel mould of size 150 x 150 x 150 mm is well tighten and oiled thoroughly. then tested in 7, 28 days.

C. Split Tensile Strength: The cylindrical specimen for routine testing and comparison of results, unless otherwise specified the specimens shall be cylinder 150 mm in diameter and 300 mm long.

V. RESULTS AND DISCUSSIONS

A. Workability The workability of M-25 grades of concrete with various proportions of silica fume and fly ash was estimated in terms of Slump test 1) Slump Test: The Slump test was conducted as per IS: 1199-1999. The results of Slump test M-25 grades of concrete outcomes that there is a slump loss for every increase in silica fume and fly ash when compared with conventional concrete.

B. Compressive Strength Test: The Compressive Strength test was conducted as IS: 516-1979.. The results of Compressive Strength tests conducted on different grades of concrete without and with.

C. Split Tensile Test: The Split Tensile Strength test was conducted as per IS 5816-1999. The results of Split Tensile Strength tests conducted on different grades of concrete are tabulated below Variation of Split Tensile Strength of fly ash and silica fume concrete in N/mm2.

VI. CONCLUSION

Out of the various proportions under study the mortar mix containing 1:2.5:2.5 (cement : coarse sand : pond flyash) by method of volume is observed to satisfy the strength criteria very well whereas the same ratio when considered by the method of weight is found to be most economical. With the view of maximum utilization of flyash almost about 75% and cost saving about 58% are ascertained with 1:2:3 mortar (cement : coarse sand : pond ash) when compared with plain mortar 1:5 (cement : coarse sand). Similarly the mortar containing 1:1:5 (cement : flyash : sand) replacing cement by flyash saves 20% cement. However, the strength of 1:2:3 mortar and 1:1:5 mortar is not as good as the strength of mortar of 1:2.5:2.5 ratio. In statistical analysis of experimental results reveals that water absorption of flyash mix mortar of ratio 1:2:3 and 1:2.5:2.5 is twice to that of plain cement mix mortar of ratio 1:5. For workability the flyash, mixed mortar required 5% to 10% more water than that of plain cement mix mortar of ratio 1;5. Utilization of flyash in mortar designed by the method of weight gives 50% to 60% financial savings while the saving is 9% to 16% in case of the method of volume. When the cement is replaced by flyash in mix of 1:1:5 (cement : flyash : sand) mortar, 20% saving of cement is achieved by the method of weight but the strength and consumption of flyash reduced significantly.

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