

MELIORATE STRENGTH OF CONCRETE BY USING FLY ASH

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Abstract -Fly ash, the fine particulate waste material produced by pulverized coal-based thermal power station, is an environmental pollutant, it has a potential to be a resource material. Ever since its use in the construction of concrete dams in the 1940s by U. S. Bureau of Reclamation, fly ash started being accepted as a building material, which can be used to replace part of the cement in concrete. With increasing research, use and experience, fly ash is now accepted by many as a constituent, which must be used in making concrete having sufficient strength, load-carrying capacity and durability. Use of fly ash need to check quality of fly ash, detail data of properties, extensive experimental work results etc. The laboratory tests for the different parameters in behaviors of the concrete elements in normal and aggressive condition were carried out in research work.

Key Words: fly ash, concrete strength, permeability test, slake durability test, Pressure type test.

1. INTRODUCTION

Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. It is removed by the dust collection system as a fine particulate residue from the combustion gases before they are discharged into the atmosphere. Fly ash particles are typically spherical, ranging in diameter from less than 1 micron to 150 micron, the majority being less than 45 micron. The range of particle sizes in any given fly ash is largely determined by the type of dust collection equipment used. The fly ash from boilers at some older plants, where mechanical collectors alone are employed, is coarser than from plants using electrostatic precipitators.

The chemical composition of fly ash is determined by the types and relative amounts of incombustible matter in the coal used. More than 85% of most fly ashes comprise chemical compounds and glasses formed from the elements of silicon, aluminium, iron, calcium and magnesium. Generally, fly ash from the combustion of sub-bituminous coals contains more calcium and less iron than fly ash from bituminous coal.

2. METHODOLOGY

The fly ash is chosen for its low lime content as well as its availability in abundance. On the basis of the literature reviewing, different lime proportions (0, 5, 10, and 15) % of fly ash (by weight) were selected. Similarly, percentages of gypsum were (0, 0.2, 0.4, 0.6, 0.8) % of fly ash (by weight). The additives selected are commercially available which are lime, gypsum and surfactant. The addition of lime enhances the pozzolanic reactivity of fly ash containing

insufficient free lime required for pozzolanic reaction with its reactive silica. Gypsum is chosen for avoiding the interference of impurities because impurities may retard the initial hydration process. Depending on the sample dimension, required quantities of fly ash (500 gm), lime, gypsum and water quantity (80-90 %) of the weight of fly ash sample and are thoroughly mixed by hand. Then it was kept inside a plastic mould for 24 hour for moisture homogenization. The samples were cast to NX size core i.e. 54 mm diameter and 108 mm length for compressive strength tests. The samples were taken out of mould after 72 hours and kept in moist proof containers that were in turn placed inside humidity control chambers where the temperature was maintained at about 30°C ±1%.

Table -1: proportions of the additives taken in preparation of sample

ITEM	AMOUNT TO BE TAKEN
Fly ash (A)	500 gm.
Surfactant or Gypsum (B)	B ₀ = 0 %, B ₁ = 0.2 %, B ₂ =0.4%,
Lime (C)	B ₃ =0.6%, B ₄ =0.8%

The following matrix shows the different combinations of the samples prepared. The ingredients were fly ash (A), lime (C) and Gypsum (B).

Table -2: preparation of sample by using matrix

AB ₀ C ₀	AB ₁ C ₀	AB ₂ C ₀	AB ₃ C ₀	AB ₄ C ₀
AB ₀ C ₁	AB ₁ C ₁	AB ₂ C ₁	AB ₃ C ₁	AB ₄ C ₁
AB ₀ C ₂	AB ₁ C ₂	AB ₂ C ₂	AB ₃ C ₂	AB ₄ C ₂
AB ₀ C ₃	AB ₁ C ₃	AB ₂ C ₃	AB ₃ C ₃	AB ₄ C ₃

3. STRENGTH TESTS

3.1 UNIAXIAL COMPRESSION TEST: Purpose: To determine the uniaxial compressive strength of rock ($q_u = F_u = F_c$).

Procedure: In this test, cylindrical rock specimens are tested in compression without lateral confinement. The test procedure is similar to the unconfined compression test for soils and concrete. The test specimen should be a rock cylinder of length-to-width ratio (H/D) in the range of 2 to

2.5 with flat, smooth, and parallel ends cut perpendicular to the cylinder axis. Originally, specimen diameters of NX size were used ($D = 2c \text{ in.} = 44\text{mm}$), yet now the standard size is NQ core ($D = 1f \text{ in.} = 47.6 \text{ mm}$).

In this figure we can see the Uniaxial Compression Test (a) Definitions of stress conditions and strains, (b) Derived stress-strain curve with peak stress corresponding to the uniaxial compressive strength ($q_u = F_u$).

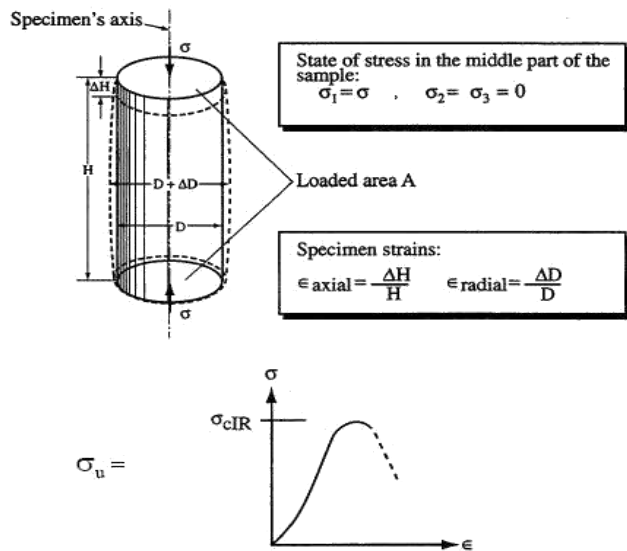


Figure No 3.1 - Uniaxial Compression Test

3.2 BRAZILLIAN TEST: Purpose: To evaluate the (indirect) tensile shear of intact rock core, FT.

Procedures: Core specimens with length-to-diameter ratios (L/D) of between 2 to 2.5 are placed in a compression loading machine with the load platens situated diametrically across the specimen. The maximum load (P) to fracture the specimen is recorded and used to calculate the split tensile strength.

3.3 SLAKE DURABILITY TEST: Purpose: To determine the durability of shale or other weak or soft rocks subjected to cycles of wetting and drying.

Procedure: In this test dried fragments of rock of known weight are placed in a drum fabricated with 2.0 mm square mesh wire cloth. Figure 3.5 shows a schematic of the test apparatus. The drum is rotated in a horizontal position along its longitudinal axis while partially submerged in distilled water to promote wetting of the sample.

The specimens and the drum are dried at the end of the rotation cycle (10 minutes at 20 rpm) and weighed. After two cycles of rotating and drying the weight loss and the shape and size of the remaining rock fragments are recorded and the Slake Durability Index (SDI) is calculated. Both the SDI and the description of the shape and size of the remaining particles are used to determine the durability of soft rocks.

3.4 PERMEABILITY TEST: Purpose: to determine the permeability of fly ash using "Miniature high pressure permeameter".

Equipment comprises one each of the following:

- b. Mould 50 mm diameter x 100 mm high
- c. Collar for mould
- d. Top plate
- e. Base plate with a recess for porous stone
- f. Porous stone
- g. Glass stand pipe (indicator pipette) 6 mm x 300 mm long
- h. Reservoir tank fitted with flow control regulator, valves & two pressure gauges 0- 7 kg/cm² , 0 - 10.5 kg/cm²

The miniature high pressure permeameter is used for studying the permeability characteristics of rock specimens, chemically solidified soils, & industrial products under high pressures. Normally every material can be studied for its permeability characteristics. The small internal dimensions make it possible to perform tests on specimens which have been trimmed from large undisturbed block samples or undisturbed samples obtained by thin wall tube or piston sampling methods or on samples which have been trimmed from larger laboratory compacted specimens.

3.5 Pressure type test:

Develop pressure in the water reservoir. Connect the bottom of the permeameter assembly to the water reservoir. Apply required pressure by operating the regulator (10.5 kg/cm² pressure gauge indicates the water reservoir pressure & 7.0 kg/cm² pressure gauge indicates the test pressure.) when constant flow is established, measure the discharge for a given time.

$$K = (QL / hAt) \text{ cm/ sec}$$

Where, Q = discharge in ml.

$$A = \text{area of specimen in cm}^2$$

$$h = \text{head causing the flow}$$

$$L = \text{length of specimen}$$

4. DISCUSSION OF TEST RESULTS

4.1 Alkali Aggregate Reaction: The expansion of mortar prisms due to alkali aggregate reaction with 100% natural sand (A), optimum replacement level of 70% manufactured sand (H) and 100% manufactured sand (K) are enumerated in chart 1

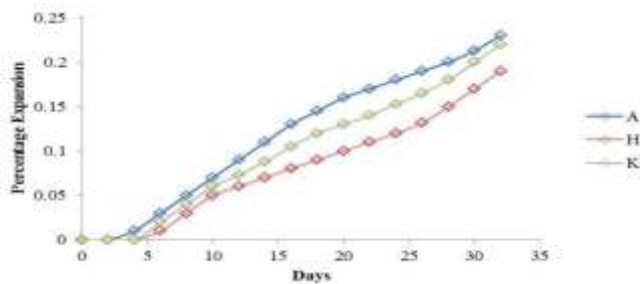


Chart 1-Expansion of mortar bar due to alkali aggregate reaction with MS

From chart, it may be noticed that the percentage expansion got reduced while using the manufactured sand and it was the minimum for an optimum replacement level of 70% of manufactured sand. This is due to the rough and angular particles of manufactured sand creating better interlocking between the particles and hydrated cement paste, thus creates an impermeable surface. The impermeable surface prevent the penetration of moisture inside the specimens, thus reduces the de polymerization of silica, which is the reason for less expansion.

4.2 Drying Shrinkage

Drying shrinkage of the mortar with 100% natural sand, optimum replacement level of 70% manufactured sand and 100% manufactured sand was measured at different periods of 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 and 110 days. The results are conveyed in chart 2.

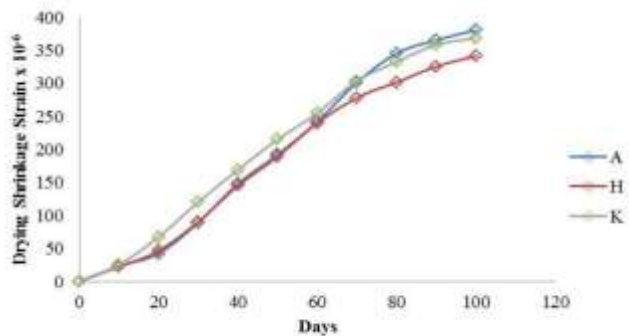


Chart 2. Drying shrinkage of mortar bar with MS

From this chart the drying shrinkage is reduced while using manufactured sand due to the larger particles, less strain, less clay content and less absorption capacity values. When compared to 100% manufactured sand, the optimum replacement level of 70% manufactured sand has very less shrinkage due to the less absorption capacity.

4.3 Abrasion: The percentage wear of M 20, M 30 and M 40 grade concrete with 100% natural sand, optimum replacement level of 70% manufactured sand and 100% manufactured sand are given in Table, it is found that the percentage of wear is reduced while using the manufactured sand due to its better interlocking between the particles.

Percentage of wear is less for the optimum replacement level of 70% manufactured sand due to the small amount of fines present in it. It may also be noted that the higher grade concrete has more abrasion resistance than the lower grades of concrete due to better packing.

Table 3 Percentage wear of M 20, M 30 and M 40 grade concrete with MS

Mix	Designations	% Wear
M 20	A	1.03
	H	0.95
	K	1.01
M 30	A	0.99
	H	0.84
	K	0.94
M 40	A	0
	H	0
	K	0

Percentage of wear is less for the optimum replacement level of 70% manufactured sand due to the small amount of fines present in it. It may also be noted that the higher grade concrete has more abrasion resistance than the lower grades of concrete due to better packing.

4.4 Water Permeability: The permeability coefficient of M 20, M 30 and M 40 grades of concrete with 100% natural sand, optimum replacement level of 70% manufactured sand and 100% manufactured sand are revealed in chart 3 and it expresses the fact that the coefficient of permeability is decreased while using the manufactured sand. This is due to the rough and angular particles of manufactured sand, which create better interlocking between the particles and cement paste, thus prevent the penetration of water inside the specimens. It was found that the coefficient of permeability is less for 70% manufactured sand. This is due to the presence of a small amount of micro fines in it. It was also noted that the permeability of water is reduced for higher grade concrete. This exhibits that there is less water penetration, due to the better interlocking between the particles.

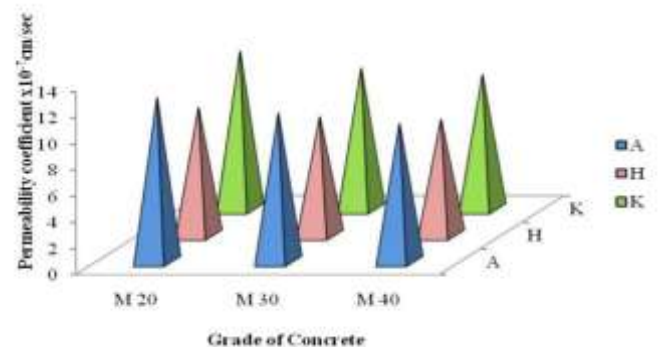


Chart 3 .Permeability coefficient of M 20, M 30 and M 40 grades concrete with MS

5. CONCLUSIONS

Based upon data recorded, it can be concluded that specimen containing fly ash with appropriate proportion of certain additives can be proportioned to meet the strength and workability requirement for structural grade concretes.

After conducting all the experiment related to strength development of fly ash based composite materials the following are the factors that affect Strength Gain of Lime-Gypsum-Fly ash composite material:

Fly ash type (classification, particle size distribution, etc.) Fly ash chemistry (pH, cat ion exchange capacity, etc.)

Types of stabilization agent/agents Packing tool / method Sample size (mold size) Curing time.

5.1 FUTURE SCOPE:

From the above analysis of samples & based on the results recorded, it can be suggested that the strength of the fly ash composite materials can be further increased by adding the necessary additives in a higher percentage amount & providing them enough curing period for better compaction. For which those composites can meet the requirements for construction purposes.

6. REFERENCES

1. R. J. McLaren and A. M. Digioia, The typical engineering properties of fly ash, Proc. Conf. on Geotechnical Practice for Waste Disposal, ASCE, New York, pp. 683-697 (1987).
2. N. S. Pandian, Rajasekhar, C and Sridharan, A, Studies of the specific gravity of some Indian fly ashes, Journal of testing and Evaluation, ASTM, 26(3), pp 177-186 (1998)
3. K. C. Sahu, S. Tripathy and C. Samuel, Geochemistry of Indian coal and fly ash. Environmental considerations, Proc. Int. Conf. on Environmental Impact of Coal Utilization from Raw Materials to Waste Resources (K. C. Sahu, ed.), Indian Institute of Technology, Bombay, pp. 23-38 (1991).
4. K. C. Sahu, Coal and fly ash problem, Proc. Int. Conf. on Environmental Impact of Coal Utilization from Raw Materials to Waste Resources (K. C. Sahu, ed.), Indian Institute of Technology, Bombay, pp. 11-22 (1991).
5. J. P. Prashanth, Evaluation of the properties of fly ash for its use in geotechnical applications, Ph. D. Thesis, Indian Institute of Science, Bangalore (1998).
6. D. N. Singh, Influence of chemical constituents on fly ash characteristics, Proc. Indian Geotechnical Conf. Madras, Vol. 1, pp. 227-230 (1996).
7. V. S. R. Murthy, Fly ash construction of roads and embankments, Ash ponds and ash disposal systems (V. S. Raju et al., eds), Narosa Publishing House, New Delhi, pp. 222-237 (1996).
8. P. C. Sharma, J. Swarup, O. P. Thakur, D. N. Trikha, A. V. S. R. Murthy, P. K. Dhawan and Deep Chandra, Fly ash: A potential filling material in civil engineering works, Ash ponds and ash disposal systems (V. S. Raju et al., eds), Narosa Publishing House, New Delhi, pp. 244-256 (1996).
9. N. S. Pandian and S. Balasubramanian, Permeability and consolidation behavior of fly ashes, J. Testing Evaluation, ASTM, 27, 337-342 (1999).
10. S. R. Singh and A. P. Panda, Utilization of fly ash in geotechnical construction, Proc. Indian Geotechnical Conf., Madras, Vol. 1, pp. 547-550 (1996).