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STUDY OF UTILIZATION OF FLY-ASH GENERATED FROM BARAPUKERIA POWER PLANT AS ADMIXTURE IN MANUFACTURING OF CEMENT

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ABSTRACT

In this paper, an attempt is made to find out sustainable use of fly ash generated from Barapukoria Power Plant. This is used as an admixture with Shah Special Cement in 5%, 10% and 15% proportion. Laboratory test for different parameters such as compressive strength, workability, flexural strength, splitting tensile strength of such mixtures are carried out to find out optimum content. The results show almost no sacrifice for the strength of cement due to mixture of fly ash with a proportion of 10%.

Keywords: flyash, admixture, compressive strength, flexural strength

1. INTRODUCTION

In thermal power plant, coal is burnt at temperatures ranging around 1400-1500^{0}C with about 20% excess air in the furnace. The utilization of flyash is 70% in Australia, 40% in UK, 40% in cement manufacturing in France [1]. Actually flyash is extensively used in concrete as an admixture in order to reduce cost of cement. Upto 25% to 30% industrial flyash was successfully blended with ordinary Portland cement without sacrificing strength and durability characteristics [2]. Moreover, manufacture of Portland cement is a significant contributor of greenhouse gases [3]. With a view to reduction of green house gases, in this study flyash was colleted from Barapukoria Power Plant, for checking its feasibility to manufacturing of cement in Bangladesh. Coal from Barapokoria has been also colleted and made it to ash by burning at 1200-1500^{0}C. Table 1 shows the chemical characteristics of flyash.

It is clear from the table 1 that percentage of reactive silica is 69.21, which is higher than

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that of flyash of Kalurghat Power Plant [2].

Table 1. Characteristics of flyash of Barapukaria Power Plant

Constituents	% weight
SiO_2	23.72
Al_2O_3	5.30
Fe_2O_3	2.8
CaO	65.80
MgO	1.26
K_2O	1.60
Surface area	755 m^2/g

Source: [3]

2. METHODOLOGY

A concrete mix with a characteristics mean strength of 20Mpa was designed with an aggregate cementations ratio of 5.76 and water-cement ratio of 0.539. The total content of cementations material was maintained at 337 kg/m^2. The flyash/total cementitions ratios used for replacement were 0.05, 0.10 and 0.015 apart from the plain concrete without any flyash. The fineness of the flyash used was 16,000 cm^2/g on Blaine's apparatus as it was found that this fineness gave maximum strength.

For each of the flyash addition, concrete cubes were cast as per design mix as per the specifications given ASTM. For determining, the flexural strength, beam specimens of 100mm x 100mm x 500mm was cast for all the flyash. For determining, splitting tensile strength cylindrical specimens of 100mm diameter and 300mm long were cast for different flyash contents.

Prior to acid digestion approximately 10 gm of dry fly ash was roundly selected from composite samples. They were digested with 20 ml nitric acid and 10 ml perchloric acid. The digested material was filtered through a No 42 filter paper and diluted to 100ml with distilled water. A liquost were taken for heavy metal determination.

3. RESULTS AND DISCUSSION

The water content of a paste has a marked effect upon the time of set as well as upon other properties. The paste at normal consistency is fairly stiff and is used only for determination of time of set and soundness. The effect of increase of flyash content on water content is shown in Table 2.

A soft plastic paste of Portland cement and water gradually becomes less plastic and finally becomes less stiff and hard. When the paste becomes sufficiently stiff it is said to have set. The definition of the term stiffness of the paste, which is considered, set is somewhat arbitrary. Two terms, "initial" and "final" are used to distinguish between the beginning and ending of setting. The term hardening means a gain of strength of a cement paste follows the final setting. For practical reasons, it is essential that cement should set neither too rapidly nor too slowly. If a cement paste sets very rapidly there might be insufficient time to transport and place concrete before it becomes too stiff. This setting process is always accompanied by temperature changes in the paste, initial set corresponds to a rapid rise in temperature and final set to the peak temperature. Table 3 presented the effect on initial and final setting time by mixing of flyash with cement.

Table 2. Comparison Table for water content (%) for Shah Special Cement, Shah Special Cement with 5%, 10% and 15% fly ash respectively

Type	Shah special cement	Shah special cement with 5% Fly ash	Shah special cement with 10% Fly ash	Shah special cement with 15% Fly ash
Water content (%)	28.6	29	28	27
Water content (ml)	185.9	188.5	182	175.5

Table 3. Comparison Table for Setting Time of Shah Special Cement, Shah Special Cement with 5%, 10% and 15% Fly ash respectively

Type	**Shah special cement**	**Shah special cement with 5% Fly ash**	**Shah special cement with 10% Fly ash**	**Shah special cement with 15% Fly ash**
Initial setting time (minutes)	135	90	120	75
Final setting time (minutes)	195	150	180	135

3.1 Workability

From figure 1, it can be observed that for the flyash concretes; there is an improvement in workability up to 10% of replacement beyond which it is reduced for replacements up to 20%. Similar result was reported by Kumar et al [5].

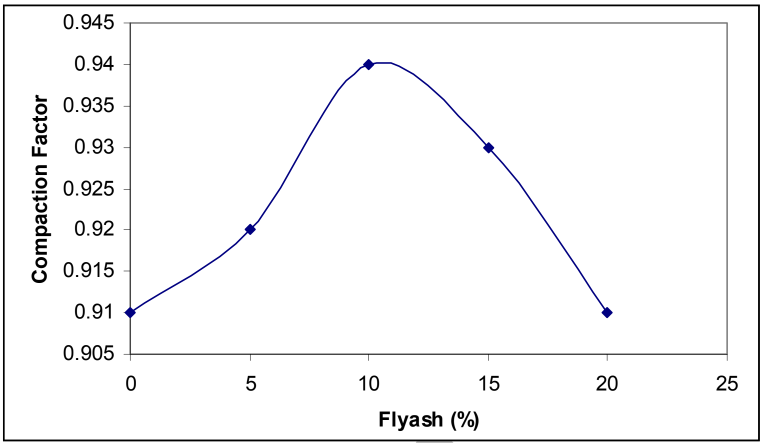

Figure 1. Variation of compaction factor with percentage of flyash

3.2 Compressive strength

The compressive strength of high flyash concrete for a given cement ratio, decreases as the flyash content increases. Rao [6] reported that addition of 30% rich hush ash with flyash (30% to 60%) showed in improvements in 7-days strengths from 31% to 53%. Table 4 shows that effect of flyash on compressive strength. The above analysis clearly indicates that the presence of silica in flyash of Barapokoria Power Plant has a complex impact on compressive strength. Otherwise percentage of reduction of strength (compressive) would be more.

Table 4. Comparison table for compressive strength of shah special cement, shah special cement with 5% , 10% and 15% fly ash respectively

Types of cement Age (Days)	Stress (PSI) of Shah special cement	Stress (PSI) of Shah special cement with 5% Fly ash	Stress (PSI) of Shah special cement with 10% Fly ash	Stress (PSI) of Shah special cement with 15% Fly ash
3	2332.08	2187.08	2189.01	2165.33
7	3169.06	2929.84	3196.28	3081.25
28	4046.46	3547.18	3991.4	3651.1

3.3 Tensile strength

The mechanical strength of hardened cement is the property of this material, which is perhaps the most important one for its structural use. Tests for strengths are not made on a neat cement paste because of difficulties in moulding and testing with consequent large variations in results. The strength of cement is usually determined from tests on mortars. Several tests are performed to determine the tensile, compressive and shear strength of cement of a certain proportion. Cement mortar of concrete gives a compressive strength of about 10 times its tensile strength [7, 8]. Table 4 shows the tensile strength of mortor at different percentage of flyash. It is clear from the table that mixing within 5-to10 percentages will give better and satisfactory result.

Table 5. Comparison table for tensile strength of shah special cement, shah special cement with 5% , 10% and 15% fly ash respectively

Types of cement Age (Days)	Stress (PSI) of Shah special cement	Stress (PSI) of Shah special cement with 5% Fly ash	Stress (PSI) of Shah special cement with 10% Fly ash	Stress (PSI) of Shah special cement with 15% Fly ash
3	291.37	215.68	213.71	218.03
7	299.60	302.54	303.13	296.86
28	414.11	378.82	407.84	374.12

Using above values in computer program for development of relationship between tensile and compressive strength, the resulting equation is:

$$\text{Compressive strength} = 11.3971 \text{ X tensile strength}^{0.9775}$$

3.4 Leach ability and toxicity of heavy metals from fly ash

The sequential chemical extraction (SCE) was carried out at six fractions using multiple extractions of the fly ash [9, 10]. The six fractions are identified

1) Water-soluble metal ions.
2) Exchangeable 1M $MgCl_2$ at P^H 7.
3) Carbonate bound (1M Na-OAC at PH 5)
4) Fe- Mn bounded (0.04M NH_2OH, HCl in 25% acetic acid)
5) Organically bounded (0.02 M nitric acid and 30% H_2O_2 at P^H 2 and 90 degree centigrade followed by 1.2m ammonium acetate in 10% nitric acid)
6) Residual metal ions (HNO_3 and $HClO_4$ acid digestion until dryness)

Table 6 shows the result of leaching test and it is clear that there is possibility of contamination of ground water if it is used in foundation design.

Table 6. Different Type Of Heavy Metal In Fly Ash

	Zn	**Ni**	**Cu**	**Fe**	**Mn**	**Pb**
Water soluble %	0.16	0.08	0.07	0.21	0.01	0.50
Exchangeable	0.98	0.91	0.75	1.52	2.27	0.77
Carbonate bound	3.78	4.28	1.47	0.35	4.72	11
Fe-Mn bound	2.20	3.59	0.14	41.44	9.77	4.43
Organically bound	10	2.72	0.55	40.08	24.40	5.60
Residual	78.23	90.28	89.4	16.80	58.31	

3.5 Splitting tensile strength

The splitting tensile strength decreases with the increases in flyash content. From table 7, it can be seen that beyond 5% of flyash, the fall in splitting tensile strengths is steeper.

Table 7. Effect of flyash content on splitting strength of mortor

Flyash amount	Splitting strength, Mpa
0	3.82
5	3.72
10	3.54
15	3.28
20	3.11

3.6 Flexural strength

It is observed from the Table 8 that flexural strength decreases with the increases in the flyash content as in the case of compressive strength. It was found that the increases of percentage of flyash have negative impact on the flexural strength. Similar result was reported by Rao [6].

Table 8. Effect of flyash content on strength of mortor

Flyash amount	Flexural strength, MPa
0	1.53
5	1.42
10	1.28
15	1.13
20	0.94

4. CONCLUSIONS

From the study, the following conclusion can be made

- It can be concluded that power plant waste is extensively used in concrete as a partial replacement for cement and an admixture and used as a suitable for conventional materials in road construction.
- From test result it is observed that 5%-10% barapukaria fly ash was successfully blended with ordinary Portland cement without sacrificing strength and durability characteristics.
- From the study on the fly ash, it is observed that geotechnical properties of fly ash are suitable for the use of conventional materials in building construction and road construction.
- From the chemical analysis of fly ash it is also observed that some heavy metals such as (Pb, Ni, Cr etc) are present in fly ash. If we use that type of cement in the construction of sub structure such as footing, by leaching it can be polluted the ground water table. So it can be only used in super structure such as column, beam, slab etc.
- Fly ash is actually a solid waste. So, it is priceless. If it can be used for any purpose than it will be very good for both environment and economy. Use of this fly ash as a raw material in Portland cement is an effective means for its management. It can obviously reduce the production cost of cement manufacture.

REFERENCES

1. Nath, S., Constraints in the utilization of flyash, *Indian Journal of Environmental protection,* 17(2), (1997) 103-106.
2. Rao, M.V.S., Janardhana, M., Kumar, B.R. and Rao, K.R.M. High flyash concretes with rice husk flyash as an admixture, *Journal of the Institution of Engineers (India),*

80, (1999) 57-63.

3. Sharma, R.S. Flyash as a resource material, Indian Highway, **34**(1), (2006) 3-4.
4. Islam, S., *A study on local power plant flyash,* A undergraduate thesis, Civil and Environmental Engineering Department, Shahjalal University of Science and Technology, Sylhet, Bangladesh, 2006.
5. Kumar, B.R. *Study of High flyash cement concrete with rice Husk as an admixture*, M. Tech. Thesis, Jaharlal-Naheru University, New Delhi, India, 1997.
6. Rao, M.V.S. *Study of rice husk ash cement concrete as a structural materials*, Ph.D. thesis, Jaharlal-Naheru University, New Delhi, India, 1992.
7. Aziz, M.A. Engineering Materials, Hafiz Publisher, Dhaka, 1988.
8. Shetty, M.S., Concrete Technology, Khanna Publisher Ltd., New Delhi, 1992.
9. Panda, B.C., BIS (IS 3812-1981) specification of fly ash: a critical review", The Civil Engineer-an annual issue "*Journal of the Civil Engg. Society*" Department of Civil Engg., IIT, Kharagpur, May-1999.
10. TIFAC, Fly ash disposal and utilization, International Conference, Organized by fly ash mission, TIFAC, New Delhi, India; 1998.