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A STUDY ON LOW QUALITY FLY ASH AS AN OPPORTUNITY FOR SUSTAINABLE AND ECONOMICAL CONCRETE

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As concrete usually has been produced by using high quality fly ash and without fly ash (standards IS 456:2000 and IS 10262:2009)

Fly ash, low quality, utilization in concrete.

مقدمة

	130	2008-09
	138	2009-10
	145	2010-11
		2011-12
	154	
	163	2012-13
		Projected values of fly ash utilization
	173	2013-14

Source : Prof. Jayesh R Pitroda, Thesis, "Techno-Economical Study of Fal-G Bricks in Central Gujarat Region of India", S.P. University Vidhyanagar, Gujrat, June 2009

ABLE: 2T

COUNTRY V/S FLY ASH PRODUCTION: SCENARIO OF C WORLD

Annual Ash Production (Million Tonnes)	Country	Sr. No.
75	USA	1
100	CHINA	2
112	INDIA	3
40	GERMANY	4
15	UK	5

PROPERTIES OF LOW QUALITY FLY ASH

ABLE: 3T

CHARACTERISTICS OF LOW QUALITY FLY ASH

Property	Value	Property
Total: SiO2 + AL2O3	0.	Moisture (%)
Na2O (%)	7.03	Loss on Ignition (%)
K2O (%)	27.53	Fineness > 45 µm
MgO (%)	14.30	Fineness > 75 µm
SO3 (%)	0.00	Free CaO (%)
Chloride (%)	2.25	Total CaO (%)
P2O5 (%)	58.46	Ash use in MT
TiO2 (%)	21.47	SiO2 (%)
Specific Gravity	7.81	Al2O3 (%)
		Fe2O3 (%)

ABLE: 1T

FLY ASH PRODUCTION IN INDIA

During 2005-06 about 112 million tonnes of ash has been generated in 125 such power stations. With the present growth in power sector, it is expected that ash generation will reach to 175 million tonnes per annum by 2012. To increase the use of fly ash, and to improve the properties of concrete, many investigations on high-volume flyash concrete have been made but for using low quality fly ash very less research is done. In general, some classified high-quality fly ash has been used in concrete. Many other kinds of fly ash, due to their low quality, are still unused. The total usage rate of fly ash in concrete is very low. It is, therefore, necessary to investigate and develop concrete incorporating large quantities of low quality fly ash (LVLQFA) to increase considerably the utilization of fly ash. In order to reduce the overall costs of production, it was decided to use high percentage of fly ash to replace OPC.

S OF FLYASHTYPE

Three types of fly ash are Class N, C or F. It is true that Class F fly ash is more effective in increasing concrete's resistance to Alkali Silica Reaction (ASR) and sulfate attack. However, rather than disallowing Class C fly ash, durability can be ensured through a performance specification. In some regions, a good quality Class N pozzolana, such as calcined clay, is also used. Slag cement may be the preferred supplementary cementitious material in some markets.

PRODUCTION OF FLY ASH IN INDIA AND WORLD The Indian Scenario

Fly ash is produced when coal is consumed by power plants. Fly ash can be used beneficially in numerous applications. The highest value application is replacing cement in production of concrete. Fly ash use improves concrete quality and creates significant environmental benefits. The analysis on fly ash production from coal based thermal power stations indicates that 82 power stations, as of today, produce about 155 million tonnes per year by 2012 A.D. with 20% annual rise in the thermal power generation slated for the decade. In India, it is estimated that 130-145 million tons of fly ash is generated by 70 major thermal power plants of which only 6-10 % is utilized by cement, construction and road industries.

Ash produced in	Year
116	2006-07
123	2007-08

- construction.
- Manufacture of ash bricks and other building products.
- Construction of road embankments, structural fills, low lying area development.
- As a soil amender in agriculture and wasteland development.

LIMITATION

- Fly ash is black, yellow and red in color. In some concretes, this may cause the finished concrete to have a grayish/black tint, which may not be desirable.
- A replacement with fly ash produces a minimal color change.
- Also, the fly ash must be able to meet the quantity requirements of the precast manufacturer.
- Fly ash increases workability of concrete.
- It is possible to replace up to 40% of cement by low quality fly ash with carbon content up to and slightly higher than 7%.

CASE STUDY

In the present study, effects of low quality fly ash as cement replacement on the compressive strength of concrete having mix proportions as per table:5 was investigated. Compressive strength of concretes replacing 0%, 20%, 40%, and 60% of Port- land cement by ‘as received’ fly ash. Tests were performed for compressive strength for all replacement levels of low quality fly ash at different curing periods (3, 7, 28 & 56-days).

ABLE: 5T

PROPORTION OF CONCRETE

Sand 1	Sand 2	Gravel	Fly Ash	Cement	Mix
516	306	863	0	500	FA 0
469	327	857	100	400	FA 20
423	349	851	200	300	FA 40
374	370	850	300	200	FA 60

Source: “Low cost high performance concrete using low qual- ity fly ash” by Aires Camões, Patrício Rocha, J.C. Pereira, J.B. de Aguiar, Said Jalali

ABLE: 6T

ONCRETE: SLUMP TEST AND COMPRESSIVE C STRENGTH

ive Strength (MPa)	Slump (cm)	Mix
3 days		
53.3	0	FA 0
44.7	3.5	FA 20
33.4	6.0	FA 40

Source: “Low cost high performance concrete using low qual- ity fly ash” by Aires Camões, Patrício Rocha, J.C. Pereira, J.B. de Aguiar, Said Jalali

ABLE: 4T

LOSS ON IGNITION OF FLY ASHL

L.O.I. (%)	Fly Ash
7	Total ‘as received’
26.5	Particles > 75µm
3.5	Particles < 75µm (enhanced fly ash)

Source: “Low cost high performance concrete using low qual- ity fly ash” by Aires Camões, Patrício Rocha, J.C. Pereira, J.B. de Aguiar, Said Jalali

Source: Journal of engineering and technology, S.P.U., Vol-19, Dec.2006

DEFINATION OF LOW QUALITY FLY ASH

Most standards limit the carbon content of fly ash to 5% while few admit values as high as 7%. As the percentage of carbon content increases then it is known low quality fly ash.

HOW FLY ASH WORKS WITH CEMENT IN CONCRETE?

Ordinary Portland Cement (OPC) is a product of four principal mineralogical phases. These phases are Tricalcium Silicate-C3S (3CaO.SiO2), Dicalcium Silicate – C2S (2CaO.SiO2), Tricalcium Aluminate- C3A (3CaO.Al2O3) and Tetracalcium aluminoferrite

– C4AF(4CaO. Al2O3Fe2O3). The setting and hardening of the OPC takes place as a result of reaction between these principal compounds and water. The reaction between these compounds and water are shown as under

3CH	+	C3S2H3		6H	+	2C3S
Calcium hydroxide		C-S-H gel		water		tricalcium silicate
3CH	+	C3S2H3		4H	+	2C2S
Calcium hydroxide		C-S-H gel		water		dicalcium silicate

The hydration products from C3S and C2S are similar but quantity of calcium hydroxide (lime) released is higher in C3S as compared to C2S.

ADVANTAGES OF FLY ASH

- In road Embankments
- In Road way construction
- As Soil reinforcement
- In cement concrete
- In cement construction

OTHER ENGINEERING APPLICATION:O

- Manufacture of Portland Pozzolana Cement & Performance improver in Ordinary Portland Cement (OPC).
- Part replacement of OPC in cement concrete.
- High volume fly ash concrete.
- Roller Compacted Concrete used for dam & pavement

<p>, Modelling the Overall Rate of Reaction in Lime-Fly Ash Systems, Proceedings of the 10th International Congress on the Chemistry of Cement, Vol. 3, pp 3ii084, Gothenburg, Sweden, June 2-6, 1997. </p> <p>, Ph.D., P.E. by "Specifying Fly Ash for Use in Concrete." </p> <p>, Chloride Transport in Concrete - Measurement and Prediction, PhD Thesis, Chalmers University of Technology, Gotenborg, Sweden 1996. </p> <p>, Yiqun Ye "Durability of concrete incorporating large volumes of low-quality fly ash" </p> <p>, Hohai Department of Materials Science and Engineering University, Nanjing 210098, People's Republic of China Received 8 August 2003; accepted 30 December 2003 </p> <p>Gutierrez, Composicion y Dosificacion de los Hormigones de Alta Resistencias y sus Aplicaciones, Cemento Numero 709, Agosto 1992. </p> <p>Chatterjee B and Singh K K (1999), "Fly Ash- an emerging alternative building material", proceedings of National Seminar, 26-27 February 1999, pp. 59. </p> <p>Fly Ash For Cement Concrete Resource For High Strength and Durability of Structures at Lower Cost" </p> <p>Bhatt Rajiv and Bhatt Darshana,(2008) "Fly ash: A Green construction material and use of FAL-G Bricks in institution structures - A Case Study", Journal of Engineering and Technology S P University, December 2006, Vol 19, pp. 23-34. </p> <p>M.F. Canovas, High-Performance Concrete: Requirements for Constituent Materials and Mix Proportioning, ACI Materials Journal, Vol. 93, N.3, May-June 1996. </p> <p>-Thesis, "Techno-Economical Study Of Fal-Bricks In Central Gujarat Region Of India" , S.P. University Vidyannagar, Gujarat, June 2009 </p> <p>Fly Ash and Slag: Standards and Specifications - Help or Hindrance?, Materials and Structures, Vol. 26, 1993. [7] Roy H. Keck, Eugene H. Riggs, Specifying Fly Ash for Durable Concrete, Concrete International, April 1997. [8] J. Faury, Le Beton, Editions Dunod, Paris, 1958 </p> <p>"Extract from paper "Technology: Fly ash Disposal and Utilization: The Indian Scenario" , Department of Civil Engineering, IIT Kanpur </p> <p>on High Strength Concrete, Reported by Committee 363, American Concrete Institute, 1992. </p> <p>, Dr. Akshaya Kumar Sabat "A study of nalco fly ash on compressive strength for effective use in high volume mass concrete for a sustainable development" by, KIIT university, Bhubaneswar-751024,Orissa 3rd & 4th Septem-ber, 2010 </p> <p>, Tara Chandra Kandpal, "Potential of fly ash utilisation in India" Centre for Energy Studies, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110 016, India Received 12 June 2000 </p> <p>. Ramezianpour, Fly Ash in Concrete, 2nd Edition, Canmet, Ottawa, Canada, 1994. </p> <p>and Ketan Bajaj, "Performance of Fly Ash and High Volume Fly Ash Concrete in Pavement Design" UG Student, University of Petroleum and Energy Studies,Dehradun, IACSIT 2012 </p>	<p>3.5</p>	<p>FA 60</p>
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Source: "Low cost high performance concrete using low quality fly ash" by Aires Camões, Patrício Rocha, J.C. Pereira, J.B. de Aguiar, Said Jalali.

It is noted that the strength gain of concretes with fly ash replacing Portland cement is slower for early ages, i.e. up to 7 days, due to the induction period for the pozzlanic reactions. It is noted that at 56 days the strength is around 90% of the reference batch, with no fly ash, but with a tendency to increase further. This confirms the well - known fact that the strength gain of fly ash concretes is slower than the comparable refer- ence concretes with no fly ash. No significant difference is noted when comparing results from concretes using 'as received' fly ash, i.e. FA 20 and FA 40.

استنتاج

It is possible to produce low cost HPC, with 90 day strength in the range of 70 MPa, using low quality fly ash. It is possible to replace up to 40% of cement by low quality fly ash with carbon content up to and slightly higher than 7%. Separation of fly ash and eliminating the coarser size particles, thus, lowering the carbon content by 50% did have significant effect on the strength gain of the concrete. This may well indicate that the limit of carbon content for acceptance of fly ash could be in- creased from the present 5 or 7%. So, we can say that low quality fly ash utilized for economical and sustainable development of concrete. Uses of low quality fly ash in concrete can save the thermal waste disposal costs and produce a greener concrete for construction. This study concludes that fly ash can be innovative supplementary cementitious Construction Material but judicious decisions are to be taken by engineers.

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