A Survey on Fly Ash, Brick Kiln Dust Powder & Silica Fume as Partial Replacement of Cement

Rajesh Kumar Bharti
Assistant Professor
Department of Civil Engineering
ITM Gida, Gorakhpur, U.P., India

Abstract— The mix proportions should be prepared in such a way that the coarse aggregate participation in volume should be reduced and the fine aggregate in the powder form is to be increased. In present work, cement is a permanent agent, the replacement of cement by Silica Fume in percentages namely(0% ,5%,10%and 15%) and Fly ash in percentages namely (0%, 5%,10% and15%) with W/C ratio of 0.52 the study on fresh properties of cement; Compressive strength and split tensile strength of cube were made. it was found that the replacement of cement by15% silica fume and 10% Fly ash gives maximum compressive strength and split tensile strength respectively Dumping of fly ash and other waste ash particles, flakes etc., not only occupy land but also create environmental problems. This study presents the effect of incorporating silica fume and fly ash (SF, FA) on the mechanical and durability properties of high strength concrete for a constant water/binder ratio of 0.3. Silica fume and fly ash mixtures with cement replacement of 0, 5, 10 and 15% were designed for target strength and slump of 32.25 MPa and 100 ± 25 mm. various percentages of Silica Fume (SF) and Fly Ash (FA) were added at different water/cementations (w/cm) ratios. Concrete specimens were tested and compared with plain concrete specimens at different ages. Optimum replacement percentage is not a constant one but depends on the w/cm ratio of the mix. SF contributed to both short and long-term properties of concrete, whereas, FA showed its beneficial effect in a relatively longer time. Adding of both SF and FA did not increase compressive strength in the short-term, but improvements were noticed in the long-term. Compared with compressive strength, flexural strength of SF concretes has exhibited greater improvements. Relationships between the 28-day flexural and compressive strengths have been developed using statistical methods. It is concluded that local concrete materials, in combination with mineral admixtures, can be utilized in making High Strength Concrete in India and such concrete can be effectively used in structural applications.

Key words: High Strength Concrete, Silica Fume, Fly Ash, Compressive & Flexural Strengths

I. INTRODUCTION

It is always a search for concrete with higher strength and durability. The physic chemical properties of brick-kiln dust were found to be similar to those of fly ash, though with slightly lesser values. India is the second largest producer of clay fired bricks, accounting for more than 10 percent of global production. This study is one of the two research components aimed at developing strategies for the introduction and promotion of cleaner walling materials in India .Concrete are probably the commonly used construction material in the world . For desired characteristics of concrete, many research and modifications has been made in concrete. There is always a requirement for concrete with high durability and strength. For, blended cement concrete has been introduced, also known as cementitious materials, are used in concrete constituent with normal cement as replacement materials. The term cement was associated with calcined earth and volcanic ashes which normally react with lime in the presence of water at ambient temperature. Nowadays, this term covers all aluminous/siliceous materials which are in fine powder form and react with calcium hydroxide in the presence of water to form compounds which have cementations properties. Concrete is a mixture of cement, aggregates (Coarse and fine), and water, with or without addition of admixtures. It is main constituent of concrete. The use of cement in concrete is increasing with time, but there have been some environmental. These are spirit of economic freedom, is now stirring in the country, bringing sweeping changes in its wake. A series of ambitious economic reforms aimed at deregulating the country and stimulating foreign investment have been moved .These are ranks of the rapidly growing Asia Pacific region and unleashed the latent strengths of a complex and rapidly changing nation. The main reason for this is the increasing emphasis on involving the private sector infrastructure development through public-private partnerships and mechanisms like build-operate-transfer (BOT), private sector investment has not reached the expected levels.

It is well being known that the current road infrastructure is a serious constraint to the economic growth of a country as a large and diversified as India. The government of India has accordingly, decided to embark on an ambitious & aggressive program of improvement/construction. The development of National Highways is the responsibility of the Government of India. The Government of India has launched major initiatives to upgrade and strengthen National Highways through various phases of National Highways Development Project (NHDP). For the development of nation’s growth, National Highway Authority of India is encouraging Private Sector to take up major highway projects on basis of BOT Model (Build, operate and transfer) system.

Civil Engineering is all about finding solution to help shape a perfect world around us. It is evident that transportation is the key component of a nation’s progress. Structural engineering systems need to cope with this process. The role of transportation engineer is to develop efficient transportation system that fulfills the needs

A. Civil Engineering Research Foundation (CERP)

Works were the earlier research: first being the study of physical and mechanical properties of brick masonry and its assemblages classified into two different categories; second the effect of in-plane shear behavior of the masonry wall elements and the wall capacity for un-reinforced and reinforced brick masonry elements with analysis

a) Ease of placement
b) Long term mechanical properties
c) Early age strength
d) Toughness
e) Volume stability
f) Extended service life in severe environments.

B. Properties of material

India coals are mainly used for the production of electricity. The production of electricity powdered coals are burnt which results in the production of fly ash. ash is generated from Indian coal .Fly ash can be utilize in concrete which was first investigated and published a paper telling that fly ash shows excellent pozolanic properties. For ordinary construction 30% fly ash and for heavy construction 50% of fly ash can be replaced by cement. Fly ash in concrete as a supplementary cementations material. When fly ash or bottom ash or both mixed in any proportion is conveyed in the form of water slurry is deposited in pond or lagoon. When fly ash in any proportion is conveyed or carried in dry form and deposited dry,

Fly ash is a fine grained material consisting mostly of spherical, glassy particles. Ashes also containing irregular or angular particles. Fly ash is the pulverized fuel ash extracted from the fuel gases by any suitable process like cyclone separation or electrostatic precipitation.

C. Chemical Composition

These are Chemical composition of fly ash depend on the sources of coal and also on operating parameters of boilers thus the quality various from source to source

Sr. No.	Particular	Requirement as per	Test Results in %
		IS:3812 in %	
01	SiO2	35.0 Min.	60.21
02	Al2O3	Not Specified	26.08
03	Fe2O3	Not Specified	4.80
04	SiO2+Al2O3+Fe2O3	70.0 Min.	91.09
05	CaO	Not Specified	1.00
06	MgO	5.0 Max.	0.25
t07	Total alkali as Na2O	1.5 Max.	0.86
08	SO3	3.0 Max.	0.25
09	Cl	0.05 Max.	0.005
10	LOI(Loss in Ignition)	5.0 Max.	1.71

Table 1:

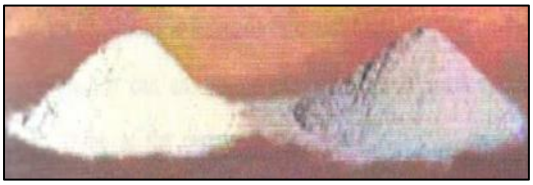

Fig. 1: Typical Ash Colors

D. Reaction Mechanism

It is size of particles varies depending on the sources. Some ashes may be finer or coarser than port land cement particles. Fly ash consists of silt sized particles which are generally spherical, typically ranging in size between 10 to 100 micron. Whereas other larger particles appear to be portions of thin, hollow spheres containing many smaller particles

E. Color of Fly ash

Content. A dark gray to black color is typically attributed to an elevated unburned content Fly ash can be dark gray, depending on its chemical and mineral constituents. Tan and light colors are typically associated with high lime content. A brownish color is typical Associated with the iron c.

F. Specific Gravity of Fly Ash

The specific gravity ranged from a low value of 1.90 for a sub-bituminous ash to a high value of 2.96 for an iron-rich bituminous ash. Some sub-bituminous ash had a comparatively low specific gravity of 2.0, and this shows that hollow particles, such as ceno spheres or plero spheres, were present in significant proportions in the ashes. It is very little relationship between the specific surface as measured by the Blaine and the fineness as determined by percentage retained on a 45ɥm sieve.

Fig. 2: Mix material
Sf+Bkd+Flyash+Cement+Aggregate+Water

G. Physical Properties

Fly ash is a fine grained material consisting mostly of spherical, glassy particles. Ashes also containing irregular or angular particles. Fly ash is the pulverized fuel ash extracted from the fuel gases by any suitable process like cyclone separation or electrostatic precipitation.

H. Classification of Fly Ash

According to IS 3812-1981, there are two grades of Fly Ash

1) Grade I fly ash, which are derived from bituminous coal having fraction SiO2+Al2O3+Fe2O3 greater than 70 %.
2) Grade II Fly ash, which are derived from lignite coal having fractions SiO2+Al2O3+Fe2O3 greater than 50 %.

I. Brick Kiln Dust

The construction materials are brick, which were first used in South Turkey .According to there are two major ingredients from which building bricks are made, one is clay and other is sand. Brick kiln dust is the waste product which comes from the field where bricks are made and from the demolition waste of the building. As Brick is composed of clay which contains sufficient silica and alumina finely ground brick kiln dust when combined with lime .Brick is majorly used construction material .it is a major problem to dispose such a large amount of Brick kiln Dust. If Brick kiln dust is used as a replacement for a percentage of cement then is will not only reduce the problem of disposing this waste, it will also reduce the environmental impact which is caused by the CO2 emission from the manufacturing of the cement. Lucknow is known as city of Nawabs.. Lucknow is surrounded by many district like Sitapur, Barabanki, Hardoi, Raebareli and Unnao. In past 17-18 years city has experienced lot of infrastructural development. Large number of private developers like Ansal, Sahara, Eldeco and DLF has entered in this infrastructural development. Lucknow metro Project has also started its construction in the year 2014. According to Lucknow is one of the next top ten cities in India with enormous real estate potential Brick Dust is a waste product obtained from different brick kilns and tile factories. Now day's construction work is on large scale so demand of brick also increases so due to this brick kiln industries all over the world also increased. There are numerous brick kiln which have grown over the decades in an unplanned way in different part of Lucknow. Tons of waste products like Brick Dust or broken pieces or flakes of bricks (brick bat) come out from these kilns and factories. So far, such materials have been used just for filling low lying areas or are dumped as waste material.

J. Indian Brick Industry

- Annual brick production growth: 5-10%
- 2nd largest brick producer after China.
- 74% of total production through BTKs and 21% through Clamps (100K).
- Stack Emission
- Fugitive Emission
- During charging of fuel
- Crushing of coal
- Clay excavation
- Loading and unloading of bricks
- Laying and removal of dust/ash layer 'keri' over brick setting
- Cleaning of bottom of trench/side flues
- During high winds

K. Background

The uses of mineral admixtures have been studied by many researchers. Among many additives, Mineral Admixtures (MAs) were utilized for the production of HSC. It has been possible to produce concrete mixes in laboratory conditions using such MAs that produced a compressive strength which exceeded 180 MPa. The in place strength in some tall buildings has attained a compressive strength of approximately 125 MPa (Haqueand Kayali, 1998). The most often used MAs in the production of HSC are SF and FA. These MAs are either pozzolanic or both pozzolanic and self-cementations to degree. Fortunately, most of these MAs are industrial by products, so their utilization not only produces economically and technically very superior concrete but also prevents environmental contamination by means of proper waste disposal. SF has a high content of silicon

Dioxide (SiO2) and consists of very small solid spherical particles. FA can improve concrete properties such as workability, durability and ultimate strength in hardened concrete. FA with high fineness exhibits high pozzolanic activity and can be used to produce HSC (Haque and Kayali, 1998

	Kiln dust"	Kaolinite"
Loss on Ignition	26%	13.32%
Si0 2	13.94%	46.29%
AlzO,	4.74%	35.67%
TiOz		2.52%
FezO,	2.36%	0.72%
CaO	45.9%	0.83%
MgO	,2.15%	0.15%
S03	2.14%	
NA20	1.03%	0.38%
KzO	1.71 %	0.12%
Total	99.97%	100%
FreeCaO	5.33	
SO:		0.38%
cr	2.48%	0.14%
Fi ness (4900%)	6.0%	
Blaine cmz/gm	3303	

Table 2: Chemical analysis of kiln dust and pure kaolinite

II. DISCUSSION

A. Workability

From the results of workability tests namely, slump and flow, it is observed that slump and flow values of all the grades of High performances concrete mixes significantly increase with increase in humidity at a constant temperature.

B. Silica Fume Products

Silica fume (SF) is a byproduct of the smelting process in the silicon and ferrosilicon industry. The reduction of high-purity quartz to silicon at temperatures up to 2000 produces Si vapors, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica. By-products of the production of silicon metal and the ferrosilicon alloys having silicon contents of 75% or more contain 85–95% non-crystalline silica. The by-product of the production of ferrosilicon alloy having 50% silicon has much lower silica content and is less pozzolanic. Therefore, Si content of the silica fume is related to the type of alloy being produced. Silica fume is also known as micro silica, condensed silica fume, volatilized silica or silica dust.

C. Compressive Strength

From the results of compressive strength test it is observed that the compressive strength of HPC mixes is significantly affected by the variation in temperature and humidity. The results indicate that the compressive strengths of HPC mixes decreases for increased relative humidity levels under a specific constant temperature. This implies that the combined effect of humidity and temperatures on HPC mixes is necessary to be taken into account while proportioning HPC mixes at site, particularly in the context of tropical countries.

III. PROPOSED MIX DESIGN METHOD FOR HPC

A. 2009 As Per Is 10262:

- Type of cement: OPC43 grade
- Type of BKD: BKD type conforming to IS121298
- Indian Code IS 3812:2003 part I and II.1,2
- Max size of aggregate: 20mm

- Minimum cement content contact: 400kg/m^3
- Max w/c ratio: 0.50
- Workability: 100mm slump
- Exposure condition: severe(IRC)
- Degree of Supervision: good
- Specific gravity of cement: 3.25
- Specific gravity of fine aggregate: 2.69
- Specific gravity of coarse aggregate(20mm): 2.71
  Specific gravity of coarse aggregate (10mm): 2.78

IV. TEST RESULTS AND DISCUSSION

A. *OMC Test of Brick Kiln Dust*

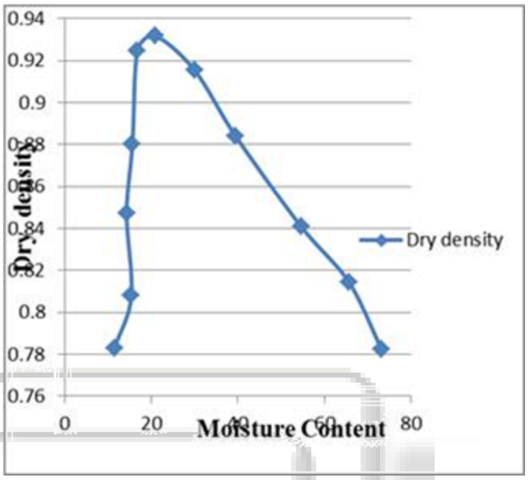

Fig. 2: OMC Test of Brick Kiln Dust Curv

V. PRISIM TEST

Fig. 3: Prisim Test

VI. TEST RESULT

%SF/fly ash/BKD	7days	14days	28days
0%	33.55	35.95	33.16
5/5%	29.11	30.21	33.27
5/10%	28.77	29	31.1
5/15%	30	31.12	31.96
10/5%	28.77	29.14	31.1
10/10%	29.88	29.58	31.51
10/15%	27.55	29.55	29.25
15/5%	31	31.67	32.88
15/10%	28.43	29.16	33.56
15/15%	30.5	31.15	33.19

Table 3: Variation compressive strength with SF, Fly ash and BKD at 7, 14 and 28 days

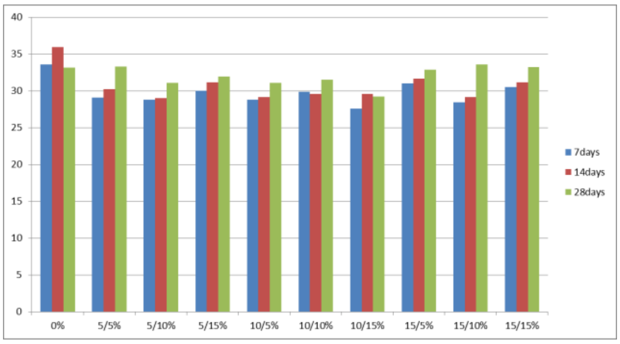

Fig. 4:

%SF/flyash/BKD	7days	14days	28days
0%	3.93	3.95	4.96
5/5%	3.64	3.71	3.98
5/10%	3.68	3.76	4.84
5/15%	3.83	3.9	3.95
10/5%	3.78	3.81	4.94
10/10%	3.86	3.8	3.96
10/15%	3.67	3.74	4.98
15/5%	3.89	3.93	4.01
15/10%	3.83	3.88	4.05
15/15%	3.8	3.84	3.97

Table 4: Flexural strength at 7, 14 and 28days

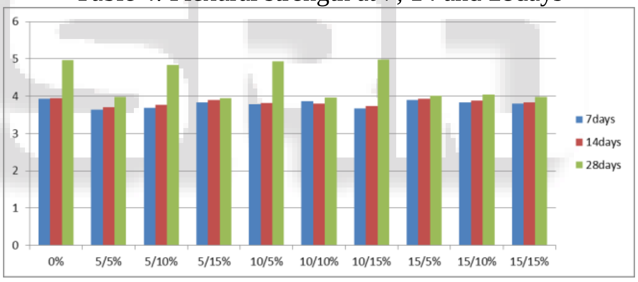

Fig. 5:

A. *Methods for achieving High Performance*

In general, better durability performance has been achieved by using high strength, low w/c ratio concrete. Though in this approach the design is based on strength and the result is better durability, it is desirable that the high performance, namely, the durability, is addressed directly by optimizing critical parameters such as the practical size of the required materials. Two approaches to achieve durability through different techniques are as follows.

1) Reducing the capillary pore system such that no fluid movement can occur is the first approach. This is very difficult to realize and all concrete will have some interconnected pores.
2) Creating chemically active binding sites which prevent transport of aggressive ions such as chlorides is the second more effective method

B. *Discussion*

1) *Workability*

From the results of workability tests namely, slump and flow, it is observed that slump and flow values of all the grades of

HPC mixes significantly increase with increase in humidity at a constant temperature.

2) Compressive Strength

From the results of compressive strength test it is observed that the compressive strength of HPC mixes is significantly affected by the variation in temperature and humidity. The results indicate that the compressive strengths of HPC mixes decreases for increased relative humidity levels under a specific constant temperature. This implies that the combined effect of humidity and temperatures on HPC mixes is necessary to be taken into account while proportioning HPC mixes at site, particularly in the context of tropical countries.

C. Proposed Mix Design Method for HPC

The proposed mix design method for HPC mixes is based on the principles of existing IS Code method of mix design (IS 10262-1982 [12] and IS 10262-2009) [13]. In the development of this proposed method, the basic mix proportions were obtained for making HPC mixes using w/c ratio’s worked out by extrapolating the established relationships between free water cement ratio and concrete strength for different cement strengths given in IS Code (IS:10262-1982) [12]. The quantities of fine aggregate and coarse aggregate were determined using the equation given in IS Code method (IS: 10262-1982) [12]. The basic mix proportions thus obtained by following the guidelines of existing IS Code method were used in making trial HPC mixes by incorporating desirable contents of micro silica and SP in view of achieving the desired workability and strength properties. Further, based on experimental observations and results of compressive strengths of various grades of HPC mixes, the curves given in IS Code method are modified so as to arrive at w/b ratios best suited to different grades of HPC mixes (Figure2 to 4). From the experimental observations, the basic mix proportions adopted for making trial HPC mixes were modified by altering coarse aggregate to fine aggregate ratio and incorporating appropriate micro silica and SP contents so as to get desired workability and compressive strengths for different combinations of humidity and temperature.

VII. CONCLUSIONS

Based on the experimental investigation on low performance concrete with cement replacement by silica fume and Brick kiln Dust the following conclusions were made: Optimum W/C ratio is taken as 0.50 due to fresh state performance, ratio beyond and less gives poor performance in fresh state of concrete. At the w/c ratio of 0.50, slump flow test, V-funnel test, T-50cm, U-box test and L-box test results were satisfied only for the following mixes SF 0%, SF5%, SF10%, SF15% ,Fly ash 0%, Fly ash 5%, Fly ash 10%, Fly ash 15% and BKD 0%, BKD 5%, BKD 10%, BKD 15%... Compressive strength of high performance concrete increases with the amount of quarry dust and brick dust by 20% and 10% as a replacement for fine aggregate respectively. Optimum compressive strength is obtained for SF 60% and BKD 30% replacement levels, based on the idea of more replacement. After that strength gradually slips while increasing Silica fume and Brick kiln Dust. Peak compressive strength obtained at SF 15% is 33.39 MPa & BKD 10% is 31MPa and maximum split tensile strength obtained at SF 15% is 4.84 MPa & BKD 10% is 4.98 MPa respectively.

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