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USE OF BRICK DUST AND FLY ASH AS A REPLACEMENT OF FINE AGGREGATE IN SELF COMPACTING CONCRETE

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ABSTRACT

In the present study focuses on the mechanical properties of hardened concrete i.e. compressive strength and split tensile strength test will be carried out on Brick kiln dust concrete and fly ash concrete. The percentage of bricks kiln dust that partially and fully replaced the fine aggregates by weights were 0%, 5%, 8%, 10% and 12%Similarly, for fly ash the percentage for partially and fully replacement of fine aggregate by weights were 0%, 5%, 8%, 10% and 12% Experiments were conducted for Ordinary Concrete, bricks kiln dust Concrete and fly ash concrete with different percentages.

1.0. INTRODUCTION

It is assumed that higher the compressive strength of concrete, better would be its durability. However, this assumption is not always true. A concrete mix satisfying the required strength may not necessarily be durable. Concrete, whether containing natural or artificial aggregates is relatively brittle, and its tensile strength is typically only about one tenths of its compressive strength. Ordinary concrete is therefore normally reinforced with steel reinforcing bars. For many applications, it is becoming increasingly popular to reinforce the concrete with small, randomly distributed fibers. Their main purpose is to increase the energy absorption capacity and toughness of the material. But also, the increase in tensile and flexural strength is often the primary objective. While steel fibers are probably the most widely used fibers for many applications, other types of fibers are more appropriate for special applications. Fiber addition in the concrete brings a better control of its cracking and improves its mechanical properties.

Brick dust is a waste product obtained from different brick kilns and tile factories. There is numerous brick kiln which have grown over the decades in an unplanned way in different part of the country. Tons of waste products like brick dust or broken pieces or flakes of bricks (brickbat) 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.

Table 1.1: Estimated numbers of kilns in major brick producing states in the Gangetic plains

S. No	*States*	*Typical Production Capacity of a Kiln* (Number of bricks/year)	*Total Number of kilns*
1	Punjab	4 – 8 Million	3000 – 4000
2	Haryana	4 – 8 Million	2000 – 3000
3	UP	2 – 8 Million	15000 – 18000
4	Bihar	2 – 5 Million	4000 – 6000
5	West Bengal	2 – 5 Million	3000 – 5000

Now a day's fly ash can directly be taken from coal fired power generation plants, so Fly ash coming from volcanoes is of no use. Before combustion, these power plants grind coal to powder fineness. After burning the coal huge amount of fine residue can be collected from the exhaust of power plants and these can be used further. Both Fly ash and Portland cement appears to be structurally similar but can be distinguished under optical microscope. Fly ash particles are almost spherical and can be allowed to move and blend freely n any admixtures. Fly ash possess excellent physicochemical and mechanical properties which includes low dense structure with high strength, negligible porosity and shrinkage, excellent thermal stability and durability, high surface hardness, and better fire and chemical resistance. Owing to these characteristics feature of fly ash, it can be used in different civil, mining and metallurgical applications like architectural sector, transportation and aerospace industry, as road sub base material, wear resistant ceramics and tiles, Geopolymers and many others. There is an extensive variation in the physical and chemical configuration of Indian fly ash. These variations are mostly due to the combustion chamber or incinerator efficiency. All the thermal related plants of India are governed and accomplished by a single unit i.e. NTPCs. Unavailability of decent quality of coal, below standard maintenance and non-renewal of different parts of combustors even after the completion of its ideal life are some of the features accountable for low incinerator efficiency.

2.0. LITERATURE REVIEW

The widespread research and development of SCC in the past two decades has led to a substantial and increasing number of publications of all types. In this chapter those considered most relevant to the current study are reviewed and summarized here. A brief introduction to the fresh and hardened properties is followed by a discussion of test methods, constituent materials and mix designs. A detailed review of Fly ash & Brick dust and silica fume as additions to concrete and SCC is demonstrated. Because this project focuses on laboratory experiments, concrete production and site practice are only briefly mentioned.

S Girish (2010) presented the results of an experimental investigation carried out to find out the influence of paste and powder content on self-compacting concrete mixtures. Tests were conducted on 63 mixes with water content varying from 175 l/m³ to 210 l/m³ with three different paste contents. Slump flow, V funnel and J-ring tests were carried out to examine the performance of SCC. The results indicated that the flow properties of SCC increased with an increase in the paste volume. As powder content of SCC increased, slump flow of fresh SCC increased almost linearly and in a significant manner. They concluded that paste plays an important role in the flow properties of fresh SCC in addition to water content. The passing ability as indicated by J-ring improved as the paste content increased.

Paratibha Aggarwal (2008) presented a procedure for the design of self-compacting concrete mixes based on an experimental investigation. At the water/powder ratio of 1.180 to 1.215, slump flow test, V-funnel test and L-box test results were found to be satisfactory, i.e. passing ability; filling ability and segregation resistance are well within the limits. SCC was developed without using VMA in this study. Further, compressive strength at the ages of 7, 28, and 90 days was also determined. By using the OPC 43 grade, normal strength of 25 MPa to 33 MPa at 28-days was obtained, keeping the cement content around 350 kg/m³to 414 kg/m³.

Felekoglu (2005) has done research on effect of w/c ratio on the fresh and hardened properties of SCC. According to the author adjustment of w/c ratio and super plasticizer dosage is one of the key properties in proportioning of SCC mixtures. In this research, fine mixtures with different combinations of w/c ratio and super plasticizer dosage levels were investigated. The results of this research show that the optimum w/c ratio for producing SCC is in the range of 0.84-1.07 by volume. The ratio above and below this range may cause blocking or segregation of the mixture.

Sri Ravindra rajah (2003) made an attempt to increase the stability of fresh concrete (cohesiveness) using increased amount of fine materials in the mixes. They reported about the development of self-compacting concrete with reduced segregation potential. The systematic experimental approach showed that partial replacement of coarse and fine aggregate with finer materials could produce self-compacting concrete with low segregation potential as assessed by the V-Funnel test. The results of bleeding test and strength development with age were highlighted by them. The results showed that Fly ash & Brick dust could be used successfully in producing self-compacting high-strength concrete with reduced segregation potential. It was also reported that Fly ash & Brick dust in self-compacting concrete helps in improving the strength beyond 28 days. Self-Compacting Concrete.

3.0. RESEARCH SCOPE

The scope of this research included an examination of:

- The effect of brick dust on SCC
- The effect of brick dust and fly ash on replacement of fine aggregate on splitting tensile, and compressive strengths of self-compacting concrete.

4.0. OBJECTIVE OF THE STUDY

The main objectives set for this research are to compare the mechanical properties of self-compacting and normal concrete specimens. The criteria used will be based on 7days, 28-day and 56 days compressive, splitting tensile and flexure strength and of conventional and self-compacting concrete for five Fly ash & Brick dust ratios as a replacement to fine aggregate. Accordingly, the present study is aimed to develop a concrete with good strength, less porous, so that good durability will be achieved. For this purpose, Brick kiln dust is used as a pozzolanic materials. Precisely;

- The influence on the strength (*in terms of compressive strength, splitting tensile strength and flexural strength*) with the addition of brick kiln dust *(at various percentage by weight*) as a partial replacement of fine aggregate will be investigated.
- The influence on the strength (*in terms of compressive strength, splitting tensile strength and flexural strength*) with the addition of Fly Ash *(at various percentage by weight*) as a partial replacement of fine aggregate will be investigated.
- Experiments for the initial surface absorption characteristics of concrete at different curing ages, have been performed.

5.0. EXPERIMENTAL PROGRAM

5.1. Mix Proportions

Table 1.2: Mix Proportions of SCC

Mix design	Normal mix	Mix 1	Mix 2	Mix 3	Mix 4
Cement (Kg/m^3)	440	440	440	440	440
Fly ash	00	53	85	107	128
Brick Dust	00	53	85	107	128
Coarse Aggregate	720	720	720	720	720
Fine Aggregate	1067	961	897	854	811
Super Plasticizer	1.25%	1.25%	1.25%	1.25%	1.25%
Water/Cement	0.40	0.40	0.40	0.40	0.40

6.2. Experimental Testing

The experimental study comprised of four parts:

1. Testing of fresh properties of cement and concrete.
2. Workability of concrete by slump test
3. Testing of mechanical properties of concrete
   a. Compressive strength

b. Split tensile strength

Table 1.3. Fresh Concrete Properties

Mixture ID	Slump (mm)	V-funnel (seconds)	L-Box (H2/H1)	U-box(H1-H2)
Normal mix	687	9	0.9	30
Mix 1	590	13	-	-
Mix 2	704	11	-	35
Mix 3	740	12	0.9	35
Mix 4	720	9	1.0	-

Table 1.4. compressive strength of SCC mix

MIX	Compressive Strength (N/mm^2)			Average (N/mm^2)	Compressive	Strength
	7 days	28 days	56 days	7 days	28 days	56 days
Normal mix	38.96	51.19	67.34	38.36	51.99	66.35
	37.78	52.14	65.23			
	38.34	52.65	66.49			
Mix 1	39.98	53.98	68.83	39.92	54.29	69.01
	39.67	54.12	69.89			
	40.12	54.78	68.32			
Mix 2	41.21	55.65	69.89	41.54	55.44	69.41
	41.20	54.89	69.02			
	42.23	55.78	69.34			
Mix 3	43.12	56.78	71.67	43.43	57.96	71.29
	43.85	58.67	70.97			
	43.34	58.45	71.23			
Mix 4	44.89	61.78	73.20	44.63	62.70	74.15
	44.45	62.89	74.02			
	44.56	63.45	75.23			

Table 1.5. Tensile Strength Properties

MIX	Tensile Strength (N/mm^2)			Average Tensile strength (N/mm^2)		
	7 days	28 days	56 days	7 days	28 days	56 days
Normal mix	2.74	3.45	4.21	2.72	3.45	4.19
	2.45	3.67	4.15			
	2.98	3.23	4.23			
Mix 1	2.88	3.67	4.44	3.00	3.77	4.38
	3.10	3.76	4.49			
	3.02	3.88	4.23			
Mix 2	3.31	3.89	4.56	3.22	3.85	4.68
	3.21	3.69	4.78			
	3.15	3.97	4.71			
Mix 3	3.56	4.11	4.89	3.59	4.25	4.95
	3.78	4.21	4.95			
	3.43	4.45	5.01			
Mix 4	3.87	4.62	5.23	3.92	4.61	5.37
	3.92	4.78	5.34			
	3.97	4.45	5.55			

7.0. EFFECT OF PERCENTAGE OF FLY ASH & BRICK DUST ON COMPRESSIVE STRENGTH OF SELF-COMPACTING CONCRETE

The compressive strength tests results of SCC mixes are given in 1.4. With the increase in Fly ash & Brick dust content from 5–20%, SCC mixes developed compressive strengths between 38.36 and 44.63 MPa at 7 days; between 51.99 and 62.70 at 28 days; between 66.35 and 74.15 at 56 days. The compressive strength increased with an Increase in the percentage of the Fly ash & Brick dust. An increase of about 37% strength at 7 days, 15% strength at 28 days and 8% at 56 days was observed with the increase of Fly ash & Brick dust content from 5% (SCC MIX1) to 20% (SCC MIX4). It was observed that the percentage increase in compressive strength was more predominant at early ages. The strength was increased at later ages also but not so quickly because the pozzolanic reaction of the fly ash is faster at early ages and the brick dust acts as a filler also along with pozzolanic activity against the fine aggregate which acts as a filler product only.

As reported by Xie et al. (2000) the strength values at 28 days age of curing. SCC4 (20% Fly ash & Brick dust) attained strength of 23.98 MPa, 30.66 MPa, at 7 and 28, days, respectively. Similarly, SCC3 (15% Fly ash & Brick dust) attained strength corresponding to 25.52 MPa, 31.47 MPa, at 7 and 28 days, respectively Because of the extreme fineness and very high amorphous silicon dioxide content, fly ash is a very reactive pozzolanic material. As the Portland cement in concrete begins to react chemically, it releases calcium hydroxide. The fly ash reacts with this calcium hydroxide to form additional binder material called calcium silicate hydrate, which is very similar to the calcium silicate hydrate formed from Portland cement. It is an additional binder that gives silica-fume concrete its improved properties.

Mechanism of fly ash and brick ash in concrete can be studied basically under three roles:

Pore-size Refinement and Matrix Densification: The presence of fly ash and brick ash inthe Portland cement concrete as a replacement of fine aggregate mixes causes considerable reduction in the volume of large pores at all ages. It basically acts as filler due to its fineness and because of which it fits into spaces between grains in the same way that sand fills the spaces between particles of coarse aggregates and cement grains fill the spaces between fine aggregates grains.

Reaction with Free-Lime (From Hydration of Cement) CH crystals in Portlandcement pastes are a source of weakness because cracks can easily propagate through or within these crystals without any significant resistance affecting the strength, durability and other properties of concrete. Fly ash which is siliceous and aluminous material reacts with CH resulting reduction in CH content in addition to forming strength contributing cementitious products which in other words can be termed as Pozzolanic Reaction ‘‘.

Cement Paste–Aggregate Interfacial Refinement In concrete the characteristicsof the transition zone between the aggregate particles and cement paste plays a significant role in the cement-aggregate bond. Fly ash and brick ash addition as replacement of fine aggregate influences the thickness of transition phase in concrete and the degree of the orientation of the CH crystals in it.

Hence mechanical properties and durability is improved because of the enhancement in interfacial or bond strength. Mechanism behind is not only connected to chemical formation of C–S–H (i.e. pozzolanic reaction) at interface, but also to the microstructure modification (i.e. CH) orientation, porosity and transition zone thickness) as well.

CONCLUSIONS

Taking into account the findings from this study, previously presented, the following conclusions can be drawn:

It has been verified, by using the slump flow and U-tube tests, that self-compacting concrete (SCC) achieved consistency and self-compact ability under its own weight, without any external vibration or compaction. Also,

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because of the special admixtures used, SCC has achieved a density between 2400 and 2500 kg/m^3, which was greater than that of normal concrete, 2370-2321 kg/m^3. Self-compacting concrete can be obtained in such a way, by adding chemical and mineral admixtures, so that it's splitting tensileand compressive strengths are higher than those of normal vibrated concrete.

1. The properties such as slump flow, V-funnel flow times, L-box, U- box. In terms of slump flow, all SCCs exhibited satisfactory slump flows in the range of 590–740 mm, which is an indication of a good deformability.
2. The compressive strength increased with an Increase in the percentage of the Fly ash & Brick dust. An increase of about 37% strength at 7 days, 15% strength at 28 days and 8% at 56 days was observed with the increase of Fly ash & Brick dust content from 5% (SCC MIX1) to 20% (SCC MIX4).
3. It was observed that the percentage increase in compressive strength was more predominant at early ages.
4. The strength was increased at later ages also but not so quickly because the pozzolanic reaction of the fly ash is faster at early ages and the brick dust acts as a filler also along with pozzolanic activity against the fine aggregate which acts as a filler product only.

The split tensile strengths of SCC after 7 days are comparable to those obtained after 28 days for NC. This was possible because of the use of Fly ash & Brick dust as fine aggregate replacement, which usually tend to increase the early strength of concrete

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