Research Article

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Study of Concrete Strength made using Brick Kiln Dust as Partial Replacement of Fine Aggregate

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ABSTRACT

Concrete is a versatile and commonly used material in construction and is composed of cement, fine aggregate, coarse aggregate and water. Fast-growing population and changing lifestyles necessitate a rapid increase in construction work around the globe, causing a huge imbalance of natural resources. The use of waste materials and by-products obtained from different industries and construction and demolition waste from the construction field is a viable alternative. In this work, an experimental investigation has been conducted to determine the suitability and possible application of brick kiln dust as a partial substitute for fine aggregate in concrete. Specimens were cast for various replacement levels of brick kiln dust at a 5% interval to assess the workability, compressive strength and cracking tensile strength of concrete at various fine aggregate levels. The results have revealed that a 15% substitution with brick kiln dust was optimal.

Keywords: Brick kiln dust; Compressive strength; Fine aggregate; Split-tensile strength; Workability.

1. INTRODUCTION

Clay brick manufacturing is a much-unorganized sector in India. Disposal of garbage generated from this sector is a very terrible problem due to which the environment becomes polluted and people suffer from respiratory diseases. To save the environment and for effective disposal of this dust, the use of brick kiln dust in concrete is one of the solutions. Fast-growing population and changing lifestyles necessitate a rapid increase in construction work around the globe, causing a huge imbalance of natural resources. The use of waste materials and by-products obtained from different industries and construction and demolition waste from the construction field is a viable alternative. In this work, an experimental investigation has been conducted to determine the suitability and possible application of brick kiln dust as a partial substitute for fine aggregate in concrete. Workability, compressive strength and split-tensile strength of concrete at different percentage levels of fine aggregate with brick kiln dust were determined using specimens cast for different replacement levels at an interval of 5%.

2. MATERIALS AND METHODS

2.1. Cement

Ultratech brand Portland Pozzolana Cement (fly ash-based) conforming to IS 1489 (Part 1) - 1991 single lot was used in this investigation.

Table 1. Properties of cement

S. No.	Properties	Findings
1.	Standard consistency	31%
2.	Initial Setting Time	210 minutes
3.	Final Setting Time	315 minutes
4.	7 days Compressive Strength	33 N/mm^2
5.	28 days Compressive Strength	44 N/mm^2
6.	Specific gravity	2.9

2.2 Fine Aggregate

River sand from Prayagraj, UP, India, conforming to IS 383-1997, Zone III, was used in this analysis. The material's fineness modulus and specific gravity were 2.76 and 1.78, respectively.

2.3. Coarse Aggregate

Locally available coarse aggregate of 20 mm nominal size, individually sieved, was used in the study. The fineness modulus of coarse aggregate was 7.7 and its specific gravity was 2.67.

2.4. Brick Kiln Dust

A waste material obtained from brick kilns locally in Prayagraj, UP, India, conforming to IS 383-1997, Zone III, was used in this study. The fineness

modulus and specific gravity were 2.5 and 2.5, respectively.

M25 grade of concrete was used as a benchmark that was designed as per IS 10262 – 2009 guidelines. The proportion of materials was 1:1.2:2.5 with a water-cement ratio of 0.45. Totally 48 specimen cubes of size 150 mm and 36 specimen cylinders, 150 mm in diameter and 150 mm in height, were cast for this investigation.

Initially, 12 cubical specimens of 380 kg cement per cubic meter of concrete were cast for mix modelling calculations, with differing water-cement ratios. Then, at a different percentage, brick kiln dust was replaced with fine aggregate in 36 cubical and 36 cylindrical specimens. For each of the chosen percentage of replacement, 6 cubes and 6 cylinders were cast, 3 for 7 days and 3 for 28 days, for strength calculations. The cube and cylinder were filled in two parts with a manual mix and vibrated on a Table vibrator.

The workability of fresh concrete was measured by a slump cone. Uniformity and accuracy were maintained during mix preparations and tests. After 24 hours of casting, specimens were de-moulded and put in a water bath for curing. On a compression measuring system with a power of 2000 kN, the compressive and the fracturing tensile strengths of concrete were measured on the 7^{th} and 28^{th} days.

3. RESULTS AND DISCUSSION

3.1 Workability

The slump cone test was used to determine the workability of fresh concrete. The slump cone test shows how a compacted concrete cone behaves when subjected to gravitational forces. Slump values for different percentages of brick kiln dust in the concrete mix are presented in Table 2 and the graphical view is shown in Fig. 1.

The results have indicated that with the increment in the percentage of brick kiln dust in the place of natural sand, the workability of the mix gradually decreased and maximum workable concrete was obtained with no brick kiln dust in the concrete mix.

The decrease in workability of the mix can be overcome by using a dose of superplasticizer in the mix.

3.2 Compressive strength test

The average compressive strength of three specimens was used for strength calculations. The average compressive strengths of concrete for 7 days and 28 days were tested as per IS 516-2004 and results are presented in Table 3 and shown graphically in Fig. 2. The compressive strength of the cube increased at first and attained a maximum strength. After that, the strength decreased rapidly with an increase in the percentage of brick kiln dust as a partial replacement of natural sand in the concrete mix. At 15%, partial replacement of brick kiln dust with natural sand attains maximum strength for 7 days and 28 days, which is 16.5% and 16.6% more in comparison of concrete with no brick kiln dust.

Table 2. Workability of concrete

S. No.	Percentage of brick kiln dust in concrete	Slump value
1	0	75
2	5	68
3	10	62
4	15	57
5	20	54
6	25	54

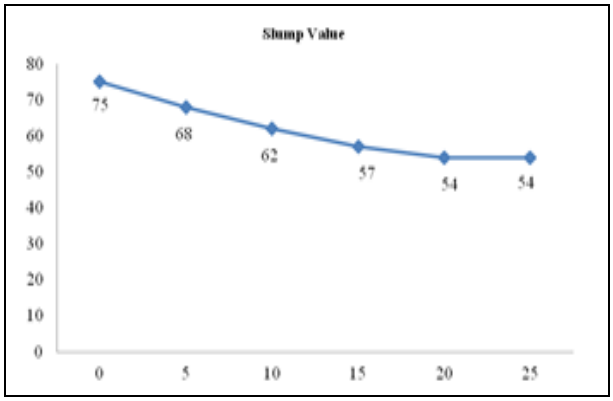


Fig. 1: Workability of concrete

Table 3. Compressive strength of concrete

S. No.	Percentage of brick kiln dust in concrete	Compressive strength of concrete	
		7 days	28 days
1	0	24.8	33.0
2	5	25.5	34.0
3	10	27.0	36.0
4	15	28.9	38.5
5	20	24.8	33.0
6	25	23.3	31.0

3.2. Split-tensile Strength

The average split-tensile strength of three specimens was used for strength calculation. The average splitting tensile strengths of concrete for 7 days and 28 days were tested as per IS 5816-1999 and the results are given in Table 4 and graphically shown in Fig. 3.

Fig. 3: Split-tensile strength

The split-tensile strength of the cubes first increased and attained maximum strength. After that, the strength decreased rapidly with further increase in the percentage of brick kiln dust. At 15%, the partial replacement of natural sand with brick kiln dust attained a maximum strength both for 7 days and 28 days, which were 16.8% and 16.6% more in comparison to concrete with no brick kiln dust, respectively.

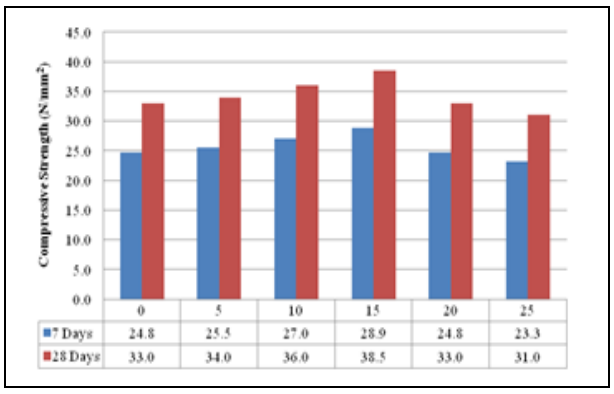
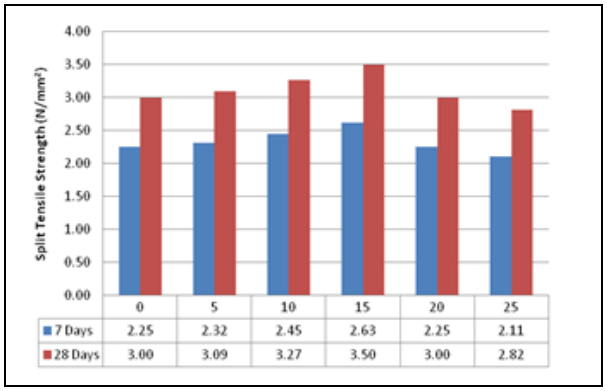


Fig. 2: Compressive strength of mortar mix

Table 4. Split-tensile Strength

S. No.	Percentage of brick kiln dust in concrete	Split-tensile strength of concrete	
		7 days	28 days
1	0	2.25	3.00
2	5	2.32	3.09
3	10	2.45	3.27
4	15	2.63	3.50
5	20	2.25	3.00
6	25	2.11	2.82



4. CONCLUSION

Based on the experimental investigations, the following conclusions were derived:

- The workability of concrete mix decreased rapidly with an increase in partial replacement of natural sand with brick kiln dust.
- The strength of concrete made using brick kiln dust as a partial replacement of fine aggregate first increased, attained a maximum at 15% replacement level and then decreased gradually.
- At 15%, the partial replacement of natural sand with brick kiln dust attained a maximum strength both for 7 days and 28 days, which were 16.8% and 16.6% more in comparison to concrete with no brick kiln dust, respectively.
- The decrease in workability of the mix can be overcome by using a dose of superplasticizer in the mix.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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