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# Red Brick Dust as a Partial Substitute to Cement in Conventional Concrete

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***Abstract:*** ***In emerging countries like India, the government plans for mega-infrastructure projects for the development of the country. These projects involve construction of high-rise buildings and high-speed rail and road networks. These constructions require higher quantities of concrete, which is a combination of cement, fine and coarse aggregate. The manufacturing process of cement results in emission of $CO_2$, a pollutant which causes serious health hazards to living beings. The adverse effects are not only limited to posing threat to living beings, but also result in depletion of natural resources which are used as key ingredients in manufacturing cement. This mandates the need to search for cement replacing materials which maintain the same strength or improve the strength of conventional concrete. Red brick Dust is a highly siliceous waste material which is available near brick kilns or while dismantling buildings. Improper handling of red brick dust causes silicosis disease in human beings, when inhaled. Hence there is a need to dispose it off safely. It is reported by various researchers that red brick dust when used as an additive in concrete, improved the strength and durability aspects. Hence, in the present study, it is aimed to improve the compressive strength of conventional concrete by substituting cement partially with red brick dust in conventional concrete. The study has revealed that upon substituting cement with red brick dust, the compressive strength of conventional concrete is increased by about 13%. The present study reveals that red brick dust can be effectively used as a partial substitute to cement in conventional concrete thereby addressing the adverse effects of cement manufacturing and health hazards of improper disposal of red brick dust.***

***Index Terms: Conventional concrete, Cement Substitute, Compressive Strength, Red Brick Dust.***

## I. INTRODUCTION

Concrete is the key material for the infrastructural development in countries like India, with the crucial constituents being cement, fine and coarse aggregates. In developing countries, mega-infrastructure projects require huge quantities of concrete which in turn require production of huge quantities of cement. It is projected that the quantity of cement produced in the financial year 2018-19 stood at 162.4 MT, which is about 14.4% higher than the previous financial year value of 142 MT [1]. But, production of cement emits $CO_2$ which accounts for about 7% of its worldwide emissions. Also, with the manufacturing of cement in huge quantities results in depletion of natural resources. These factors create an ecological imbalance [2,3]. Also, these mega-infrastructure projects require concrete for high rise buildings and high-speed transport systems of high strength and durability. This requires addition of other materials to conventional concrete to meet the required strength, durability and ecological aspects and this led to the need for search of additional materials. Various authors had carried out successful studies on use of different materials namely fly ash [4,5], rice husk ash [6], lead-zinc slag [7], waste glass powder [9], ceramic waste powder [10], silica fumes [11], polypropylene fibres [11], volcanic originated natural materials [12] etc., in concrete to improve strength and durability aspects as per required by the mega-infrastructure projects. Of these different materials, Red Brick dust is one such material which has potential for use in concrete making. Red Brick Dust, also known as brick powder, is a waste powder remains at the brick kilns and is also produced during the demolition of buildings. It consists of high amounts of silica along with traces of oxides of iron, aluminium, calcium, magnesium and sulphur. Brick dust, when left in atmosphere, causes Silicosis disease in human beings, when exposed to it, which effects the respiratory system especially lungs. Hence utilization of brick dust in other products will help not only in improvement of the properties but also addresses the health and environmental issues of its disposal. The practice of using brick dust in concrete as a stabilizer is being carried out for the past few years. It is conveyed that with use of 25% brick dust in concrete there is adequate improvement not only in the strength characteristics of concrete but also resulted in enhanced thermal resistance and cost effectiveness and drop in adverse effects to the environment [13]. Cement partially replaced with brick dust in mortar resulted in superior mortar-brick bond strength, which can be attributed to the rheological properties [14]. Partial usage of Brick dust in place of fine aggregate in concrete, showed a drop in concrete density and also enhanced the strength characteristics of concrete [15]. Not much literature is available on utilization of red brick dust as a partial reinstatement to cement in concrete. Red brick dust consists of high amounts of silica, a key mineral responsible for development of strength in concrete. Hence, the present study is intended to make an attempt in partially substituting cement in conventional concrete with red brick dust in order to improve the strength of conventional concrete.

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## II. CONVENTIONAL CONCRETE

### A. *Cement*

Portland cement is the most commonly used type of cement in majority of constructions. Ordinary Portland Cement of 53 grade, from local market, of standard brand is selected for use in the present study. The selected cement is tested as per Indian Standards Specifications IS:12269-1987 to assess its suitability for use in concrete and the results of the tests are tabulated in Table 1.

**Table I Properties of Cement used in the study**

| Properties | Test Results |
|---|---|
| Normal consistency | 32% |
| Setting time<br>a) Initial setting time<br>b) Final setting time | <br>145 minutes<br>330 minutes |
| Specific gravity | 3.12 |
| Fineness of cement by sieving through sieve No 9. | 8% |
| Soundness (Le-Chatlier Exp.) | 1.28 mm |
| Compressive strength of cement (28 days) | 53 MPa |
| Specific surface area | 320 $m^2$/kg |

### B. *Fine Aggregate*

The sand passing through 4.75 mm IS sieve and retaining on 600 µm IS sieve and which is in compliance to Zone-II as per IS:383-1970, is selected as fine aggregate. The sand is cleared off from clay, silt and other impurities. The aggregate is tested for its physical requirements such as gradation, fineness modulus and specific gravity in accordance with IS: 2386-1963, and the results are presented in Table II.

**Table II Properties of Fine Aggregate**

| Property | Value |
|---|---|
| Specific Gravity | 2.56 |
| Bulk Density (kg/$m^3$) | 1714.58 |
| Fineness Modulus | 2.94 |
| Zone | II |

### C. *Coarse Aggregate*

Machine crushed angular aggregate of granite origin having particle size of 20mm and 12.5mm available locally is used as coarse aggregate. It is cleaned to have neither impurity such as dust, clay particles nor any organic matter etc. The cleaned coarse aggregate is then tested to determine its properties and the results are presented in Table III.

**Table III Properties of Coarse Aggregate**

| Property | Value |
|---|---|
| Specific Gravity | 2.68 |
| Bulk Density (kg/$m^3$) | 1720.69 |
| Fineness Modulus | 7.55 |

### D. *Superplasticizer*

Use of super plasticizer reduces the water-cement ration and also improves the slump and workability of the concrete mix. Conplast SP430, which is free from chlorides and manufactured based on selected sulphonated naphthalene polymers, is used as superplasticizer in the present study. About 0.7% by weight is taken as the proportion of superplasticizer in the present study. The properties of the super plasticizer are tabulated in Table IV.

**Table IV Properties of Conplast SP430**

| Property | Value |
|---|---|
| Appearance | Brown Liquid |
| Specific gravity | 1.2 o 1.21 @ $30^0$C |
| Water soluble chloride | Nil |
| Alkali content | Typically, less than 55gm $Na_2O$ equivalent/ liter of Admixture |

Mixing of ingredients is carried out in pan mixer. Ordinary Portland cement, selected fine and coarse aggregates are thoroughly blended, followed by systematic addition of water and thorough mixing. Super plasticizer, Conplast SP430 is also added to the above blend. Wet mixing is carried out till even colour and consistency are attained which indicates the readiness of concrete for casting. The iron moulds used for casting cubes are cleaned thoroughly and oil is applied to the inner surface of the mould. Then the moulds are placed on a level platform. The uniformly blended concrete mix is then filled into the moulds by applying vibrations with the help of needle vibrator. The samples are then allowed for initial setting for a duration of 24 hours. The cubes are then removed from moulds and placed in curing tank for 7, 14 and 28 days curing. After the curing period the cubes are removed from curing tank. The surfaces of the cubes are cleaned and are made ready for testing. The compressive strength of the concrete is determined by testing the samples in compression testing machine after 7, 14 and 28 days of curing and the results are presented in Table V.

**Table V Compressive Strength of Conventional Concrete for 7, 14 and 28 Days**

| 7 Days | | 14 Days | | 28 Days | |
|---|---|---|---|---|---|
| Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) |
| $B_0$-01 | 25.5 | $B_0$-04 | 35.0 | $B_0$-07 | 44.5 |
| $B_0$-02 | 24.0 | $B_0$-05 | 34.2 | $B_0$-08 | 43.3 |
| $B_0$-03 | 26.0 | $B_0$-06 | 32.0 | $B_0$-09 | 42.7 |
| Average | 25.2 | Average | 33.8 | Average | 43.5 |

$B_0$ – Conventional concrete sample

## III. PARTIAL SUBSITUTION OF CEMENT WITH RED BRICK DUST

Red brick dust is added to concrete as a partial substitute to ordinary Portland cement in conventional concrete. Cement is substituted in 5%, 10%, 15% and 20% by weight with red brick dust. The mixing is done in similar manner as that of conventional concrete and curing is done for 7 days, 14 days and 28 days. The compressive strength of concrete with cement substituted by red brick dust are determined using compression testing machine and the test results are tabulated in Tables VI, VII, VIII and IX.

**Table VI Compressive Strength of Concrete with 5% Red Brick Dust substitution for 7, 14 and 28 Days**

| 7 Days | | 14 Days | | 28 Days | |
|---|---|---|---|---|---|
| Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) |
| $B_5$-01 | 34.5 | $B_5$-04 | 41.5 | $B_5$-07 | 45.5 |
| $B_5$-02 | 32.5 | $B_5$-05 | 40.0 | $B_5$-08 | 44.5 |
| $B_5$-03 | 36.5 | $B_5$-06 | 45.0 | $B_5$-09 | 53.5 |
| Average | 34.5 | Average | 42.1 | Average | 47.8 |

$B_5$ – 5% red brick dust substituted sample

**Table VII Compressive Strength of Concrete with 10% Red Brick Dust substitution for 7, 14 and 28 Days**

| 7 Days | | 14 Days | | 28 Days | |
|---|---|---|---|---|---|
| Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) |
| $B_{10}$-01 | 36.0 | $B_{10}$-04 | 40.0 | $B_{10}$-07 | 59.0 |
| $B_{10}$-02 | 36.0 | $B_{10}$-05 | 45.0 | $B_{10}$-08 | 44.0 |
| $B_{10}$-03 | 34.5 | $B_{10}$-06 | 42.0 | $B_{10}$-09 | 42.0 |
| Average | 35.5 | Average | 42.3 | Average | 48.3 |

$B_{10}$ – 10% red brick dust substituted sample

**Table VIII Compressive Strength of Concrete with 15% Red Brick Dust substitution for 7, 14 and 28 Days**

| 7 Days | | 14 Days | | 28 Days | |
|---|---|---|---|---|---|
| Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) |
| $B_{15}$-01 | 37.5 | $B_{15}$-04 | 42.5 | $B_{15}$-07 | 48.5 |
| $B_{15}$-02 | 37.0 | $B_{15}$-05 | 41.0 | $B_{15}$-08 | 46.5 |
| $B_{15}$-03 | 38.0 | $B_{15}$-06 | 46.5 | $B_{15}$-09 | 53.0 |
| Average | 37.5 | Average | 43.3 | Average | 49.4 |

$B_{15}$ – 15% red brick dust substituted sample

**Table IX Compressive Strength of Concrete with 20% Red Brick Dust substitution for 7, 14 and 28 Days**

| 7 Days | | 14 Days | | 28 Days | |
|---|---|---|---|---|---|
| Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) | Sample No. | Value ($N/mm^2$) |
| $B_{20}$-01 | 28.0 | $B_{20}$-04 | 32.5 | $B_{20}$-07 | 37.0 |
| $B_{20}$-02 | 29.0 | $B_{20}$-05 | 35.0 | $B_{20}$-08 | 42.0 |
| $B_{20}$-03 | 29.0 | $B_{20}$-06 | 37.0 | $B_{20}$-09 | 36.0 |
| Average | 28.6 | Average | 36.8 | Average | 39.3 |

$B_{20}$ – 20% red brick dust substituted sample

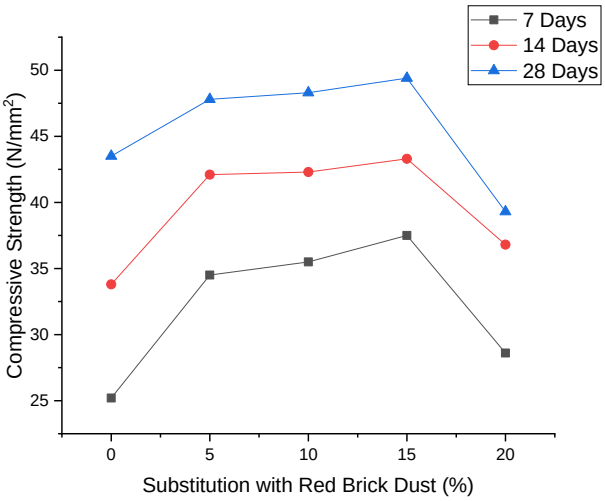


**Fig 1 Variation of Compressive strength of concrete with partial substitution of cement using Red Brick Dust for 7, 14 and 28 days**

## IV. DISCUSSION

Fig 1 shows the variation of compressive strength of conventional concrete with varied substitution of cement by red brick dust. It can be observed that with the increase in substitution of cement with red brick dust in conventional concrete from 0% to 15%, the compressive strength of concrete increased from 43.5 $N/mm^2$ to 49.4 $N/mm^2$ and thereby decreased to 39.3 $N/mm^2$ for 20% substitution of cement with red brick dust in conventional concrete for 28 days curing. Similar trend of increase and decrease of compressive strength of red brick dust substituted concrete are observed for both 7 days and 14 days curing period. Substitution of cement with 15% red brick dust has increased the strength of conventional concrete by about 13.6%. This increase in strength can be attributed to the higher silica content of red brick dust.

## V. CONCLUSION

From the study carried out on conventional concrete with cement replaced partially by red brick dust, it can be concluded that:

- Replacement of cement with red brick dust up to 15% showed up an improved compressive strength of conventional concrete.
- Replacement of cement with red brick dust addresses the environmental issues of cement production to some extent.
- It also helps in effective disposal of red brick dust, thereby reducing health issues arising from its inhaling.

Hence, red brick dust can be effectively used as a partially substitute to cement in conventional concrete.

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