# Experimental Study on Properties of Concrete For Partial Replacement of Brick Ballast Aggregate

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***Abstract-*** *Brick waste is common in form of over burned bricks at the time of its manufacturing and also in form of broken bricks during its transportation at the time of construction work. To manage this brick waste, it can be used as partial replacement for stone aggregate in concrete. This research should provide optimum % of replacement. Analysis of both fresh and hardened concrete with partial replacement of brick waste can be studied from various tests like slump, compaction factor test, unit weight, compressive strength, tensile strength, flexural strength.*

***Keywords***- Brick, Broken bricks, Compressive strength, Tensile strength, Flexural strength

## I. INTRODUCTION

As the time is passing, the construction industry is growing rapidly and in the last decade we are seeing relatively huge constructions. With this rapid growth, a concern of its waste management also growing with the same speed every annum. This problem is not of some specific region but it is a global problem and raising his head high very fast. Dozens of materials are common in the construction industry and one of the materials is brick. Regular bricks are used in the construction of buildings either as main walls, partition walls or some other purposes. When we see the prospective of its manufacturing we find a lot of waste in the form of over burnt bricks. In every batch of brick manufacturing, a high number of over burnt bricks are produced which acts as a waste. (Recycling is a process to change materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution(from incineration) and water pollution (from land filling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production). The bricks which are near the fire in the kiln subjected to high heat more than 1000 degree centigrade ultimately shrink and loose its shape, colour becomes reddish and its appearance like reddish to blackish gradient stone. This over burnt brick serves as waste in the construction industry and has to accumulate somewhere in the process of recycling.

Concrete is a solid, hard material produced by combining Portland cement, coarse and fine aggregate (sand & stone), water and sometimes admixtures in proper proportions. It is one of the most widely used construction material and has a long history of use. Its constituent ingredients derive from a wide variety of naturally occurring materials that are readily available in the most parts of the world. Approximately 60 to 80 precent of concrete is made up of aggregates. The cost of concrete and its properties are directly related to the aggregates used. In aggregates, the major portion is of coarse aggregate i.e. stone or gravel which are obtained naturally either from river bed or by crushing rocks mechanically up to the required size. In plain areas of Pakistan like central Punjab, there are very less deposits of rocks. The construction cost increases in those regions due to transportation cost of coarse aggregates, ultimately it will become very difficult for most of the regional to construct low cost houses or buildings. An advantage is that, bricks manufacturing kilns are abundant in those regions and as we discussed earlier its exempts its waste in the form of over burnt bricks.

According to general definition—"concrete is a composite material so by taking advantage of the situation for the people, this paper presents the overview and research that is carried out on the concrete when natural coarse aggregate is partially replaced by over burnt brick aggregate".

## II. MATERIALS USED

### 1. Cement

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (Birla OPC) conforming to IS: 8112-1989 is used. The cement has uniform color i.e. grey with a light greenish shade and was free from any hard lumps.

### 2. Fine Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates.

The material which passes through BIS test sieve no. 480 is termed as fine aggregate. Usually natural sand is used as a fine aggregate, at places where natural sand is not available crushed stone is used as a fine aggregate. The sand used for the experimental work was locally procured and conformed to grading zone III.

**3. Coarse Aggregates**

The fractions from 80 mm to 4.75 mm are termed as coarse aggregate. The material which is retained on BIS test sieve no.480 is termed as a coarse aggregate. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having maximum size of 20 mm was used in the present work.

**4. Potable Water**

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked in to very carefully. In present work tap water is used for both mixing and curing.

**5. Brick Industry Waste i.e. Over Burnt Bricks**

The over burnt bricks was collected from nearby Taw are brick manufacturing industry located at Sangavi, Baramati - Phaltan road, Sangavi in Pune district. The representative samples of brick aggregate were tested in laboratory.

## III. MIX DESIGN

According to IS 10262:1982 and IS 456:2000 the design of concrete mix is done

TABLE I DESIGN MIX PROPORTION

| | Water | Cement | Fine aggregate | Coarse Aggregate |
|---|---|---|---|---|
| By weight (kg) | 203.34 | 445.53 | 518.98 | 1196.63 |
| By volume | 0.46 | 1 | 1.16 | 2.68 |

TABLE II Quantities in kg/ m3

| Mix | Brick agg. % | w/c Ratio | Water (kg /m$^3$) | Brick agg. (kg /m$^3$) | Cement (kg /m$^3$) | Fine Aggregate (kg /m$^3$) | Coarse aggregate (kg /m$^3$) |
|---|---|---|---|---|---|---|---|
| $M_{25}$ | 0 | 0.43 | 203.34 | 0 | 445.53 | 518.98 | 1196.63 |
| $M_{25}$ | 10 | 0.43 | 203.34 | 119.63 | 445.53 | 518.98 | 1077 |
| $M_{25}$ | 20 | 0.43 | 203.34 | 239.33 | 445.53 | 518.98 | 957.30 |
| $M_{25}$ | 30 | 0.43 | 203.34 | 358.99 | 445.53 | 518.98 | 837.64 |

## IV. EXPERIMENTAL PROGRAMME

**1. General**

The experimental programme consists of the tests on fresh concrete and hardened concrete. For this purpose concrete specimens of standard size and according to designed mix proportions were prepared. Then, the experiments are performed on them to check properties like slump, compacting factor and mechanical properties like compressive strength, split tensile strength and flexure strength.

**2. Tests**

2.1 Test on brick aggregate

i. Impact value test
ii. Water absorption test

2.2 Tests on concrete

a) Fresh concrete i. Slump cone test

i. Compaction factor test
ii. Hardened concrete

b) Compressive strength test.

i. Split tensile strength test
ii. Flexural strength test

## V. RESULTS

### 1. Impact value test

Fig.1 Impact Value Test Apparatus

Fig. 2 Sieve for Impact Test

Table III Observation Table

| Sr. No. | Details | Sample 1 |
|---|---|---|
| 1. | Total weight of dry sample taken = $W_1$ gm. | 247 |
| 2. | Weight of impacted aggregate passing 2.36 mm sieve= $W_2$ gm. | 102 |
| 3. | Aggregate impact value(percent) $=(W_2*100)/W_1$ | 41.2% |

### 2. Water absorption test

Table IV Observation Table

| Sr. No. | Details | Sample 1 |
|---|---|---|
| 1. | Weight of saturated surface dry aggregate in air = $W_1$ gm. | 2000 |
| 2. | Weight of oven dried aggregate in air = $W_2$ gm. | 1700 |
| 3. | Water absorption = $\frac{(W_1 - W_2)100}{W_2}$ percent | 17.65 |

### 3. Slump cone test

Fig. 3 Slump of fresh concrete

Table V Observation Table

| Sr. No. | % Replacement | Slump value (cm) |
|---|---|---|
| 1 | 0 | 29 |
| 2 | 10 | 28.7 |
| 3 | 20 | 28.5 |
| 4 | 30 | 28 |

Degree of workability:-Low

### 4. Compaction factor test

Fig. 4 Compacting Factor Apparatus

**Observations:**

1) Weight of empty cylinder + base plate, W1 = 9 kg
2) Weight of cylinder + base plate + partially compacted concrete, W2 = 25.4 kg
3) Weigh of cylinder + base plate + fully compacted concrete W3 = 27.2 kg

Compaction factor = (W2-W1) / (W3-W1)

Table VI Observation Table

| Sr. No. | % Replacement | Compaction factor |
|---|---|---|
| 1 | 0 | 0.9 |
| 2 | 10 | 0.86 |
| 3 | 20 | 0.83 |
| 4 | 30 | 0.8 |

**5. Compressive Strength of concrete**

Fig. 5 Concrete cube under compression

**Calculations:**

Compressive Strength = Crushing load of specimen/Cross sectional area.

=500/ (150×150)
=22.22 N/mm2

Table VII Compressive Strength Result for the cubes at 7 days

| Sr No. | Partial replacement of brick ballast agg. (%) | Failure load in (kN) | Compressive strength ($N/mm^2$) | Average compressive strength ($N/mm^2$) | % Value Decreased |
|---|---|---|---|---|---|
| 1 | 0 | 500 | 22.22 | 22.11 | 0 |
| | | 495 | 22.00 | | |
| 2 | 10 | 494 | 21.95 | 22.08 | 0.14 |
| | | 500 | 22.22 | | |
| 3 | 20 | 495.31 | 22.01 | 21.99 | 0.54 |
| | | 494.71 | 21.98 | | |
| 4 | 30 | 496.70 | 22.07 | 21.87 | 1.08 |
| | | 487.60 | 21.67 | | |

TableVIII Compressive Strength Result for the cubes at 28 days

| Sr No. | Partial replacement of brick ballast agg. (%) | Failure load in (kN) | Compressive strength ($N/mm^2$) | Average compressive strength ($N/mm^2$) | % Value Decreased |
|---|---|---|---|---|---|
| 1 | 0 | 800 | 35.55 | 33.88 | 0 |
| | | 725 | 32.22 | | |
| 2 | 10 | 765 | 34.00 | 32.55 | 3.92 |
| | | 745 | 31.11 | | |
| 3 | 20 | 725 | 32.22 | 32.11 | 5.22 |
| | | 720 | 32.00 | | |
| 4 | 30 | 715 | 31.77 | 31.21 | 7.88 |
| | | 690 | 30.66 | | |

## 6. Flexural test on hardened concrete

Fig. 6 Flexural test setup

Table IX Observation Table

| Sr. No. | Replacement of natural coarse agg. by brick agg. (%) | Load of rupture (kN) | Flexural strength (N/mm) | % Value Decreased |
|---|---|---|---|---|
| 1. | 0 | 8.30 | 4.15 | 0 |
| 2. | 10 | 8.10 | 4.05 | 3.97 |
| 3. | 20 | 8.00 | 4.00 | 16.96 |
| 4. | 30 | 7.80 | 3.90 | 30.32 |

## 7. Split tensile Strength of concrete

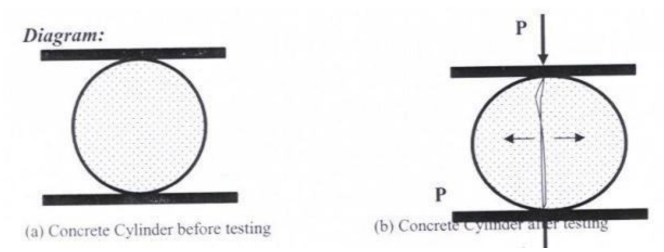


Fig. 7 Split Tensile test setup

Table X Split Tensile Strength Result for the cylinders at 28 days

| Sr. No. | Replacement of natural coarse agg. by brick agg. (%) | Age of cylinders in days | Dimensions in mm | | Failure Load (P) in kN | Split tensile Strength in MPa | Avg. Split tensile Strength in MPa |
|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | |
| 1 | 0 | 28 | 300 | 150 | 182 | 2.57 | 2.77 |
| | | 28 | 300 | 150 | 210 | 2.97 | |
| 2 | 10 | 28 | 300 | 150 | 190 | 2.68 | 2.66 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 28 | 300 | 150 | 188 | 2.65 | |
| 3 | 20 | 28 | 300 | 150 | 156 | 2.2 | 2.30 |
| | | 28 | 300 | 150 | 172 | 2.4 | |
| 4 | 30 | 28 | 300 | 150 | 124 | 1.75 | 1.93 |
| | | 28 | 300 | 150 | 150 | 2.12 | |

## VI. DISCUSSION

From above results, if the % replacement in coarse aggregate increases then compressive strength of 7 days decreases. It is expressed as follows

1. For 0% replacement compressive strength is 22.11 N/mm²
2. For 10% replacement compressive strength is 22.08 N/mm² and it is decreased by 0.14%.
3. For 20% replacement compressive strength is 21.99 N/mm² and it is decreased by 0.54%.
4. For 30% replacement compressive strength is 21.87 N/mm² and it is decreased by 1.08%.

28 days Compressive strength decreases. It is expressed as follows

1. For 0% replacement compressive strength is 33.88 N/mm²
2. For 10% replacement compressive strength is 32.55 N/mm² and it is decreased by 3.92%.
3. For 20% replacement compressive strength is 32.11 N/mm2 and it is decreased by 5.22%
4. For 30% replacement compressive strength is 31.21 . N/mm2 and it is decreased by 7.88%.

28 days Flexural strength decreases. It is expressed as follows

1. For 0% replacement flexural strength is 4.15 N/mm²
2. For 10% replacement flexural strength is 2.4 N/mm² and it is decreased by 3.97%.
3. For 20% replacement flexural strength is 3.61 N/mm² and it is decreased by 16.96%.
4. For 30% replacement flexural strength is 6.02 N/mm² and it is decreased by 30.32%.

28 days Split Tensile strength decreases. It is expressed as follows

1. For 0% replacement spilt tensile strength is 2.77 N/mm²
2. For 10% replacement split tensile strength is 2.66 N/mm² and it is decreased by 3.97%.
3. For 20% replacement split tensile strength is 2.30 . N/mm² and it is decreased by 16.96%.
4. For 30% replacement split tensile strength is 1.93 . N/mm² and it is decreased by 30.32%.

## VII. CONCLUSION

1. The core objective of the research was to investigate the effects of over burnt brick ballast aggregate on the properties of concrete. The investigation discovered decrease in the unit weight, compressive strength, split tensile strength and flexural strength.
2. The incorporated concrete does not require any particular attention regarding mixing, placing, and finishing.
3. It serve economical and behave light in weight because of less unit weight.
4. A good bond can be achieved between the brick aggregates and the cement paste, this is because the brick aggregates are angular that means they have a large surface area to bond with the paste.
5. Up to 20% brick aggregate replacement for natural coarse aggregate was found feasible and economical.
6. The waste material of brick industry was efficiently used for the manufacturing of concrete.
7. It is observed that Replacement of brick ballast is not feasible for very Important buildings.

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