Evaluation of the Compressive strength of Concrete for partial replacement of Over Burnt Brick Ballast Aggregate

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Abstract- Regional conditions enforced engineers to generate a study on concrete which incorporate Over Burnt Brick Ballast Aggregate partially due to their abundance. 5%, 10%, 15%, and 20% (M05, M10, M15, M20) incorporation was used as partial replacement of natural coarse aggregate in concrete. Analysis of incorporated concrete was done in fresh state as well in hardened state to evaluate different properties of concrete i.e. slump , compaction factor test, unit weight, and compressive strength are evaluated. From all the results and experimental approach it is concluded that Concrete formed with over burnt brick ballast aggregate showed beneficial performance as compared with the concrete made up of natural aggregate obtained from local resources. The over burnt brick ballast aggregate showed 14.75% increase in Compressive strength for 20% replacement. It reduces the cost of concrete by reducing the aggregate cost and produces economical infrastructure system..

Keywords: Over Burnt brick Ballast Aggregate, Kiln, Compressive strength.

I. INTRODUCTION

As the time is passing, the constrution 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 speicific 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 prespective of its manufacting we find a lot of waste in the form of over burnt bircks. 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 landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production)[1].

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The bricks which are near the fire in the kiln subjected to high heat more than 1000 degree centigrade [2] ultimately shrink and loose its shape, color becomes redish and its appearance like redish to blackish gradient stone. This over burnt brick serves as waste in the construction industry and has to accumulate some where 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 occuring materials that are readily available in the most parts of the world. Approximately 60 to 80 percents of concrete is made up of aggregates [3]. 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.

Table 01

AGGREGARE TYPE	BULK SPECIFIC GRAVITY C-127-04	WATER ABSORPTION C-127	FINENESS MODULUS	UNIT WEIGHT C-29/29 M	MOISTURE CONTENT C-566
FINE (SAND)	---	---	2.43		---
COARSE (GRAVEL)	2.65	1.43	---	1528	0.7
COARSE (BRICK)	1.9	2.7	---	1123	0.1

In plain areas of Pakistan like centeral 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 regionals 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”[4] 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. RESEARCH PROJECT

The main objective of the research project is to determine the properties of concrete by replacing natural coarse aggregate with over burnt brick ballast aggregate.
Different tests were carried out on fresh concrete as well as on hardened concrete. Four batches of concrete incorporating over burnt brick ballast aggregate were prepared. The replacement was 5%, 10%, 15% and 20% and represented as M_{05}, M_{10}, M_{15} and M_{20} respectively. Here M denotes the concrete mix and subscript designates the percentage replacement by natural coarse aggregate to over burnt brick ballast aggregate.

III. MATERIALS AND MIX

1.1. Materials

All the materials were obtained from local resources. Table 01 demonstate the properities of consitituents which were used for the preparation of designed mix. Ordinary Portland Cement ASTM C-50 Type-1was used as a binding material throughout the investigation.

Lawrencepur sand as a fine aggregate were used in the preparation of mix. 20mm and 10mm crushed gravel of irregular shape sourced from Sargodha were used partially as a coarse aggregate.

Long, irregular in configuration, over burnt brick ballast aggregate of 20mm maximum sized is illustrated in Figure 01 which was sourced from Niazi Kiln; Manga Mandi used as partial replacement of natural coarse aggregate.

Figure 01 — Over Burnt Brick Ballast Aggregates

Local tap water was used in prepration of all concrete mixes.

1.2. Proportioning Ratio

The mix designed was prepared according to the ACI recommendation for concret mix design. 1:2:2.4 mix proportioning ratio was determined for targeted strength of 21 MPa For all cases 0.57 water/cement (w/c) ratio (by weight) was used.

1.3. Test Specimens

To carry out the experimental investigation a total of nine 150mm (3 for 7 days, 3 for 14 dyas and 3 for 28 days) standered cubes were casted and tested in compression after 3, 7 and 28 days of curing in the portable water. Similarly three standard cylinders of size 150mm x 300mm and three standard beams of size 100mm x 150mm x 1200mm were also casted and tested for splitting tensile test and flexural strength test respectively after 28 days of its curing.

1.4. Mix Preparation

The batching of all the ingredients was performed by weight. The sand was air dried in the laboratory before mixing. First the surface of the mixer was damped with water then all the aggregates were added into the mixer till the aggregates mingle with each other. After thorough mixing of aggregates cement was introduced into the mixer and water were added slowly as per W/C ratio. The concrete was mixed for approximately three (3) minutes after the water was added.

1.5. Mix Casting

Fresh prepared mix were casted in nine standard cube moulds of dimension 150mm, three cylinderical moulds of dimension 150mm x 300mm and 3 beams of dimension 100mm x 150mm x 1200mm in three equivalent layers. After pouring a single layer, 25 strokes were forced with a standard tamping rod with each layer rodded one stroke for approximately 1280mm^2, after that moulds were vibrated on a vibrating table to force out the entrapped layer in the mix. The top surface of the fresh concrete was levelled with the help of a trowel and was lefted for 24 hours allowed the fresh concrete to set. Note that over burnt brick ballast aggregate concrete didn't pose any difficulties in terms of finishing. The specimens were demoulded after 24 hours. All the moulds were cured by immersing in a curing tank in the lab. The specimens were brought out from water approximately 24 hours before testing and kept at room temperature till testing.

IV. EXPERIMENTAL ANALYSIS AND DISCUSSIONS

1.6. Fresh Concrete Analysis

Slump test and compaction factor test were performed on the Control Mix (M_0) concrete and concrete incorporating over burnt brick ballast aggregate to analyze the workability of concrete.

1.6.1. Slump Test

The workability of fresh concrete was measured with standard slump cone. The test was carried out in accordance with ASTM-C-143/143-M-03. The test was perfomed immediately after mixing. Table 02 shows the slump values of concrete mix at defined replacements. Graphical representation of the slump test values illustrated in Figure 02. Facts revealed that the slump value deceases with the increase in the quantity of recycled over burnt brick ballast aggregate. This decreasing pattern of slump directly affects the workability of concrete and ultimately reduces the workability of concrete wit increase in the over burnt brick ballast aggregate.

Table 02 – Slump Test

Replacement (%)	Slump Value (unit)
0	2.75
5	2.25
10	2.00
15	1.50
20	0.75

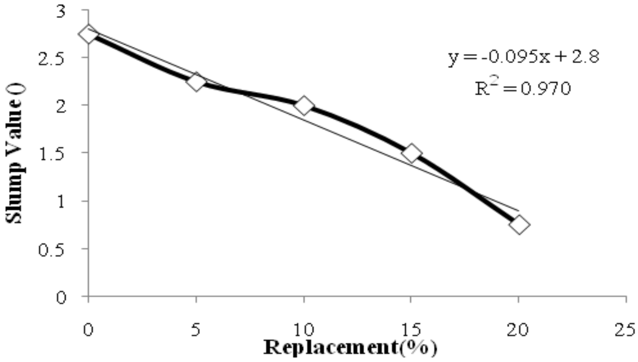

Figure 02 — SlumpValue Vs Replacement

1.6.2. Compaction Factor Test

Table 03 shows the compaction factor values of the concrete mix at defined replacements. Graphical representations of the compaction factor values illustrated in Figure 03.Trend clearly revealed that as the percentage of over bornt brick ballast aggregate in the concrete increases, compaction factor values decreases ultimately lessen the workability of concrete.

Table 03 – Compaction Factor Test

Replacement (%)	Compaction Factor Value ()
0	0.92
5	0.90
10	0.865
15	0.835
20	0.800

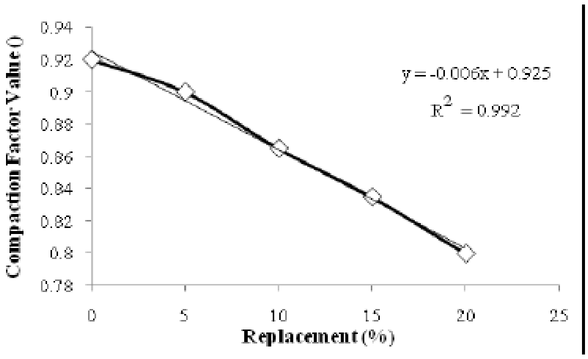

Figure 03—Compaction Factor Vs Replacement

1.7. HARDEN CONCRETE ANALYSIS

Compressive strength test, splitting tensile strength test, flexural strength test and Los Angeles Abrasion Test were performed on the hardened concrete {control mix (M_0) and mix incorporating over burnt brick ballast aggregate} to analyze the properties of concrete.

1.7.1. Unit Weight

Specific gravity is directly related to the weighing property of the materials. Table 01 demonstrates lower specific gravity of the over burnt brick ballast aggregate which ultimately implies lower unit weight of the prepared concrete from over burnt brick ballast aggregate. The recorded unit weight of control mix M_0 was 2542 and as the replacement introduced the unit weight showed decreasing pattern. At M_{05}, M_{10}, M_{15} and M_{20} the recorded unit weight was 2481, 2385, 2364 and 2353 respectively. These results are illustrated in the Figure 04

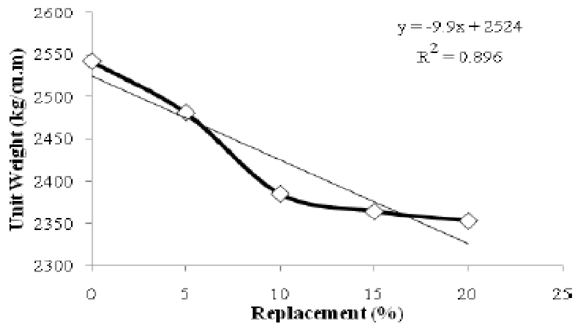

Figure 04—Unit Weight Vs Replacement

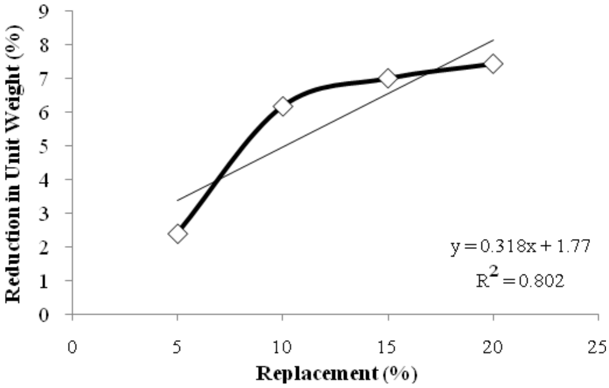

Figure 05—Reduction in unit weight Vs Replacement

The percentage decrease in the unit weight at M_{05}, M_{10}, M_{15} and M_{20} was 2.4, 6.17, 7.00 and 7.43 percent respectively. Figure 05 illustrate the decreasing pattern of the concrete incorporating over burnt brick ballast aggregate.

1.7.2.Compressive Strength Test

Figure 06 illustrates the compressive strength test results at different ages of control mix and mix incorporating over burnt brick ballast aggregate. The result demonstrated that as the percentage of over burnt brick ballast aggregate increase, compressive strength relative to control mix (M_0) also shows significant increment. The percentage increase in the compressive strength of M_{05}, M_{10}, M_{15} and M_{20} concrete relative to control mix are found to be 9.82, 10.49, 14.70 and 14.75 percent respectively. The Figure 07 shows the graphical representaion of the percentage increase in the compressive strength.

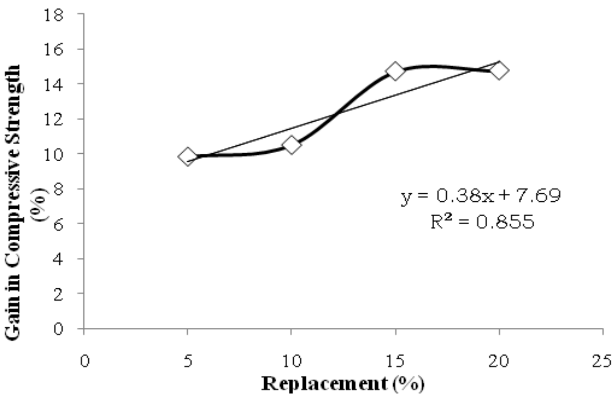

Figure 07—Gain in Compressive Strength Vs Replacement

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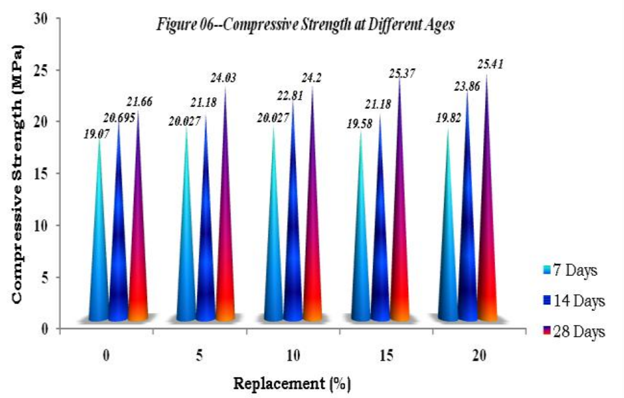
Figure 08 is of the test samples are shown below. It can be observed that, as for the compressive strength test, the over burnt brick ballast concrete does not exhibits typical compression failure behaviour.

Figure 08—Samples Under Compressive Loading



V. CONCLUSIONS AND RECOMMENDATIONS

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 decline in the unit weight, adequate gain in Compressive Strength. Therefore Split Tensile strength and Flexural Strength of concrete incorporating over burnt brick ballast aggregate need to be evaluated.

The incorporated concrete does not require any particular attention regarding mixing, placing, and finishing. It serve economical to the constructor without compromising on the strength and behave light in weight because of less unit weight. After the thorough study it will be recommended to use incorporated concrete to such structures where compressive strength up-to 21Mpa is required.

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