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Evaluation Of Flexure Strength Behavior Of Over Burnt Brick Ballast Aggregate Concrete

Tariq Ali[1], Nouman Iqbal[1], Muhammad Ali Khan[1], Dr Mehboob Ali[1], Dr Khan Shahzada[2]
[1] *(Civil Engineering Department, the University of Lahore, Lahore, Pakistan).*
[2]*(Department of Civil Engineering University of Engineering & Technology Peshawar, Pakistan)*

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% (M_{05}, M_{10}, M_{15}, M_{20}) 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 value, compaction factor value, unit weight, flexural strength and Los Angeles abrasion value. From 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 Sargodha. It reduces the cost of concrete by reducing the aggregate cost and produces economical infrastructure system. The waste generated from the brick kiln is utilized efficiently, making environment friendly encouraging green construction.
Keywords: Over Burnt brick Ballast Aggregate, Kiln, Green construction

I. Introduction

With the passage of time due to infrastructure development, 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 perspective 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 the method of processing the used material for use in creating new product. With the help of recycling we can mitigate the loss of those materials which are potentially useful. Raw material consumption can be reduced which ultimately save time and energy. These will lessen the amount of green house gas generation as compared to natural virgin aggregate production (Recycling Dallas, 2008). The bricks which are near the fire in the kiln subjected to high heat more than 1000 degree centigrade (Ashfaq Hasan, 1987) ultimately shrink and loose its shape, color 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 percents of concrete is made up of aggregates (William P. Spence and Eva Kultermann, 3rd Edition). 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 regions 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"(C.V.S. Kameshwara Rao *et al*) so by taking advantage of the situation for the inhabitants, 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.

Table 1: Properties of Constituents

Aggregare Type	Bulk Specific Gravity C-127-04	Water Absorption C-127	Fineness Modulus	Unit Weight C-29/29m	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

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

3.1 Materials

All the materials were obtained from local resources. Table 1 demonstrates the prosperities of constituents which were used for the preparation of designed mix. Ordinary Portland Cement ASTM C-50 Type-1(Marek, C. R. Gallaway *et al*, 1971) was 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 1 which was sourced from Niazi Kiln Manga Mandi used as partial replacement of natural coarse aggregate. Local tap water was used in preparation of all concrete mixes.

Figure 1: Over Burnt Brick Ballast Aggregates

3.2 Proportioning Ratio

The mix designed was prepared according to the ACI recommendation (Barra *et al*, 1998) for concrete mix design. 1:2:2.4 mix proportioning ratio was determined for targeted strength of 21 MPa (Thomas Telford, 1991) For all cases 0.57 water/cement (w/c) ratio (by weight) was used.

3.3 Test Specimens

To carry out the experimental investigation a total of three standard beams of size 100mm x 150mm x 1200mm were casted and tested for flexural strength test respectively after 28 days of its curing.

3.4 Mix Preparation

The batching of all the ingredients was performed by weight (Sudhir Misra, 2006). 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.

3.5 Mix Casting

Fresh prepared mix were casted in 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 leveled with the help of a trowel and was lifted 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 Discussion

4.1 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.

4.1.1 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[10]. The test was performed immediately after mixing. Table 2 shows the slump values of concrete mix at defined replacements. Graphical representation of the slump test values illustrated in Figure 2. 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 2: Slump Test Values

Replacement (%)	Slump Value (mm)
0	69.85
5	57.15
10	50.80
15	38.10
20	19.05

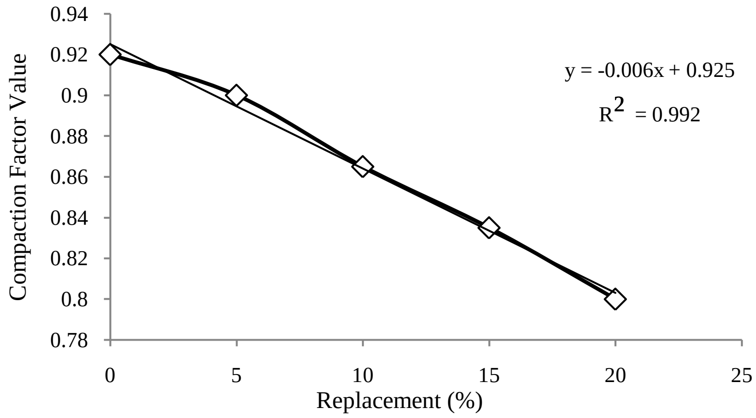

Figure 2: Slump Value Vs Replacement

4.1.2 Compaction Factor Test

Table 3 shows the compaction factor values of the concrete mix at defined replacements. Graphical representations of the compaction factor values illustrated in Figure 3.Trend clearly revealed that as the percentage of over burnt brick ballast aggregate in the concrete increases, compaction factor values decreases ultimately lessen the workability of concrete.

Table 3: Compaction Factor Test

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

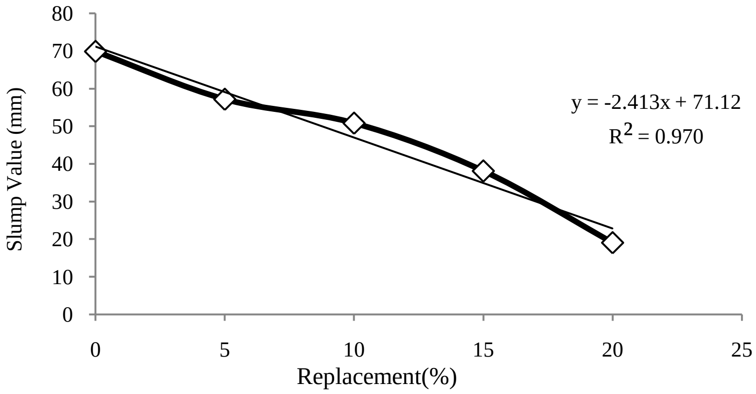

Figure 3: Compaction Factor Value Vs Replacement

4.2 Harden Concrete Analysis

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.

4.2.1 Unit Weight

Specific gravity is directly related to the weighing property of the materials. Table 1 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 2542kg/m^3 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 2481kg/m^3, 2385kg/m^3, 2364kg/m^3 and 2353kg/m^3 respectively. These results are illustrated in the Figure 4.

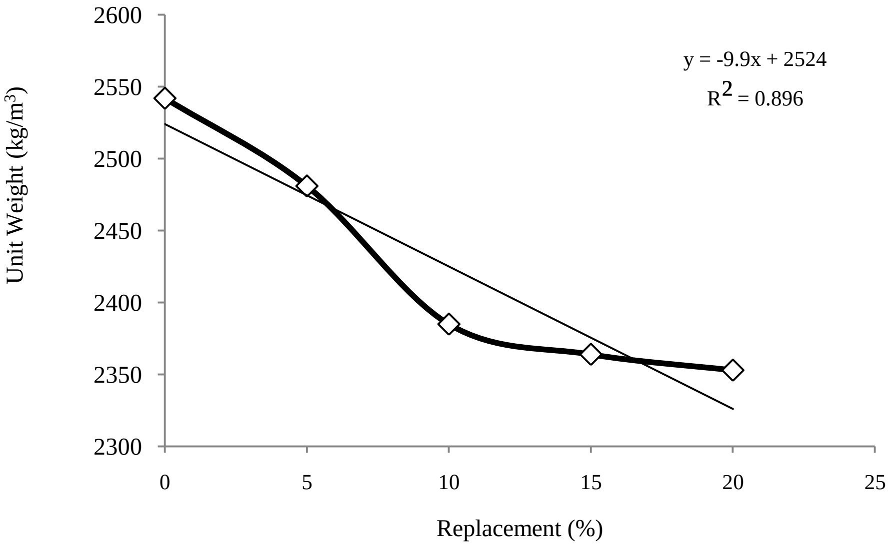

Figure 4: Unit Weight Vs Replacement

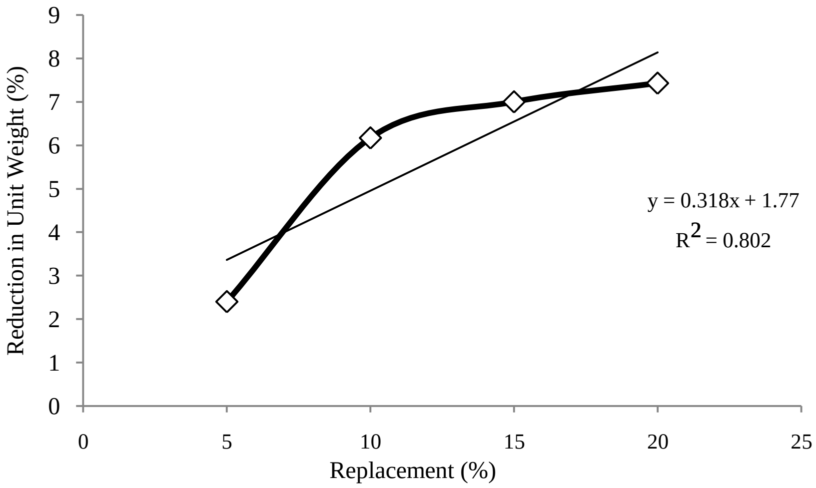

Figure 5: Reduction in unit weight Vs Replacement

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 5 illustrates the decreasing pattern of the concrete incorporating over burnt brick ballast aggregate.

4.2.2 Flexural Strength Test

Figure 6 illustrate the Flexural strength test

result at 28 days strength of control mix (M_0) and mix incorporating over burnt brick ballast aggregate. The result demonstrated that flexural strength increased compared to control mix (M_0) for over burnt brick ballast aggregate upto 20 percent.

The Figure 7 shows the percentage increase in the splitting tensile strength of M_{05}, M_{10}, M_{15} and M_{20} concrete relative to control mix are found to be 1.9, 7.1, 29 and 30 percent respectively. This increasing trend become more marked as the brick ballast aggregate content increases. The over burnt brick ballast aggregate concrete beams shows the same behavior like normal concrete beams i.e. control mix concrete beams.

Figure 8 & 9 are of the test samples which are under flexural loading. It can be observed that failure occurred at the center of the specimen's length.

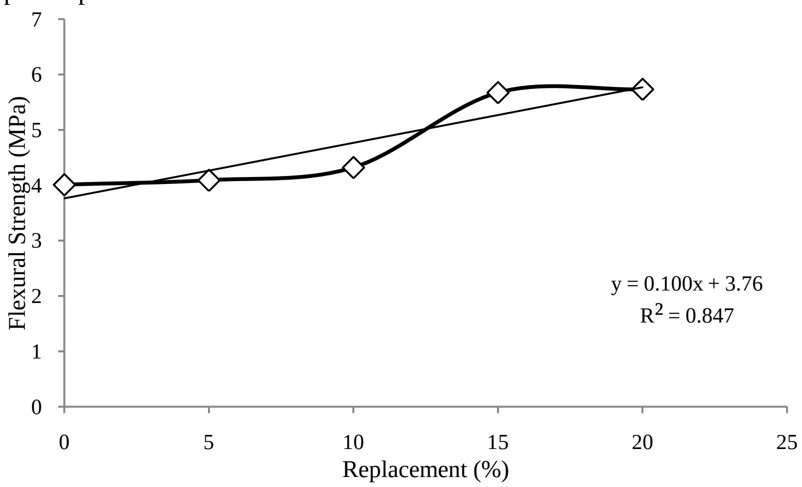

Figure 6: Flexural Strength Vs Replacement

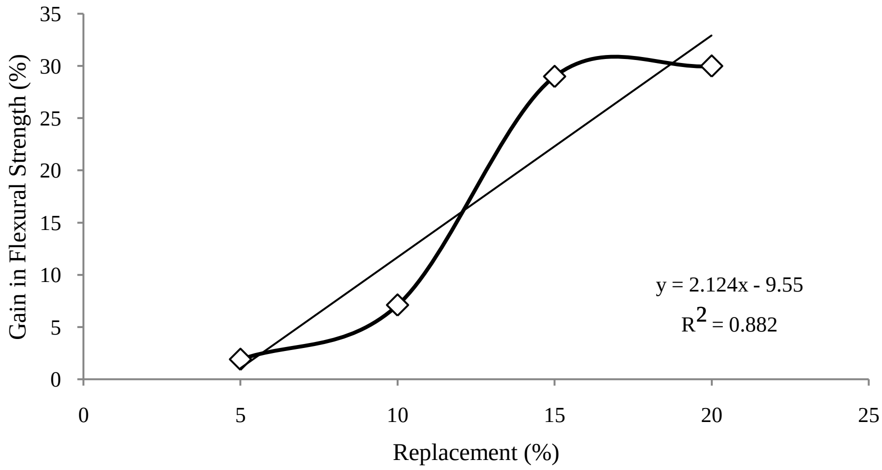

Figure 7: Gain in Flexural Strength Vs Replacement

Figure 8 & 9: Samples under Flexural Loading

4.2.3 Los Angeles Abrasion Test

The investigation was conducted in accordance with ASTM C-131[10] "Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine".

5000 gm of over burnt brick ballast aggregate of gradation passing 3/8 inch sieve and retained on ¼ inch sieve with required abrasive mediums was rotated in Los Angeles Machine for the required number of revolutions. Oven dried washed out materials retained on #12 sieve was used in comparison with original sample. The computed value of Los Angeles Abrasion was 15%.

V. Conclusions

Figure10 illustrate the relative strength (ratio of strength of over burnt brick ballast aggregate concrete to the strength of control mix M_0 concrete) S_R of the concrete mixes at defined incorporations of over burnt brick ballast aggregate. It is evident from the test results that:

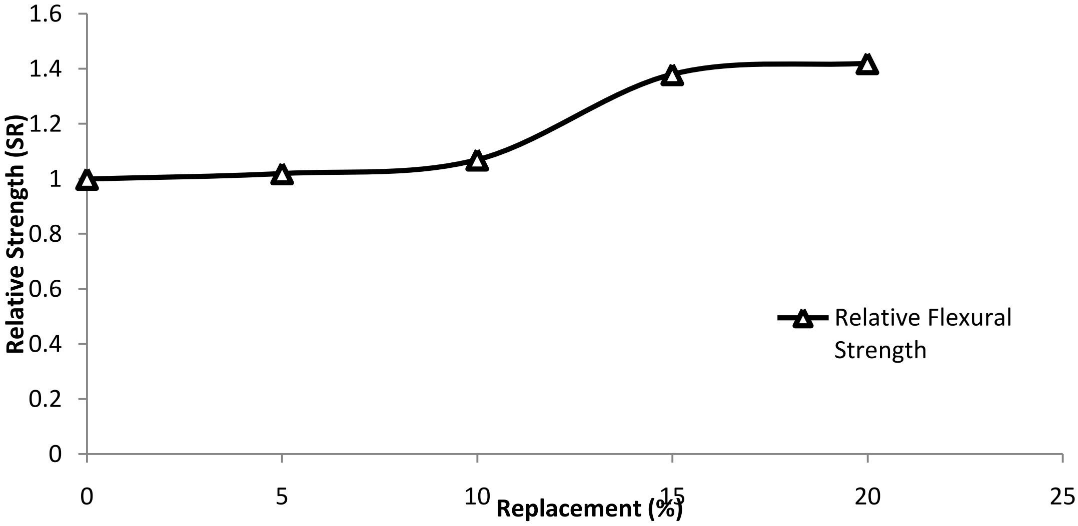

Figure 10: Relative Comparison of Flexural Strength

- Incorporating over burnt brick ballast aggregate in the control mix (M_0) of concrete has patent effect on the flexural strength of concrete.
- The ultimate increment revealed *30% increase* in the Flexural Strength relative to the control mix (M_0).
- The Abrasion value for over burnt brick ballast aggregate was found to be *15%* and concrete produced by this showed superior performance, even better than natural coarse aggregate sourced from Sargodha.
- It serve economical to the constructor without compromising on the strength and behave light in weight because of less unit weight.
- The incorporated concrete does not require any particular attention regarding mixing, placing, and finishing.

VI. Recommendations

After the thorough study following areas will be recommended:

- It should be used in high strength concrete with appropriate admixtures.
- Evaluate Mechanical properties for the optimum content of Over Burnt Brick Ballast Aggregate in Concrete by using different incorporations upto 100% (M_{100}).
- Evaluate Mechanical properties by fluctuating W/C ratio.
- Evaluate Mechanical properties and its effects on concrete by using different sizes of Over Burnt Brick Ballast Aggregate.
- Microstructure study of the Over Burnt Brick Ballast Aggregate Concrete to evaluate its bonding pattern with other constituents.

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