Scientific Journal of Impact Factor (SJIF): 5.71

E-ISSN (O): 2348-4470
P-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 06, Issue 09, September 2019

Use of Over-Burnt Bricks as Coarse aggregate in Concrete

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ABSTRAC: *In modern construction industry number of materials are used and one of the materials is Brick. Regular bricks are generally used in buildings or in some other engineering applications. In manufacturing of these bricks, a lot of waste is produced in the form of over- burnt-bricks. The bricks being near to the fire in the furnace receives a temperature more heat and eventually shrink and loose its shape, its color becomes reddish. These bricks can't be used in construction, directly because of their distorted shape dark color. hose over-burnt brick could be a source of recycled coarse aggregate. The primary goal of this paper is to assess the suitability of incorporating over-burnt bricks in concrete, by the partial replacement of natural coarse aggregate (NCA) with overburnt brick aggregate (OBBA) in a ratio of 20%, 50%, and 100%. Initially, mix proportion of 1:2:4 and w/c of 0.57 was selected. By replacing NCA with OBBA while using mix proportion of 1:2:4 and w/c of 0.57, the resulting concrete was found non-mixable and non-workable. Thus, mix was designed (for targeted strength of 4ksi) for all replacement percentages. Slump test was conducted for each replacement and the results show that by increasing replacement percentage the workability of concrete decreases. the slump values are in between the range of 3–1.5 inches. For compressive strength the cylindrical specimens of 6" x 12" were tested at 3, 7, and 28 days. For 20% replacement, the loss in compressive strength is 42.16% for 3 days and for 7 and 28 days the loss is 46.96% and 61.37% respectively. For 50 % replacement, the loss in strength for 3, 7 and 28 days is 29.73%, 30.87% and 58.29% respectively. For 100% replacement, the loss in strength for 3, 7 and 28 days is 48.65%, 55.65% and 69.19%.*

Keywords: *Overburnt bricks, Compressive strength, Workability, Replacement.*

I. INTROUCTION

Construction industry is going rapidly with the passage of time as we seen in the last decade. With this rapid growth of construction, a concern of its waste management is also increasing with the same rate. Various materials are used in construction, and one of the materials is brick. Regular bricks are used in construction of buildings, however over burnt bricks, which are the waste produced in the manufacturing of bricks due to uneven temperature in the kiln, can't be used directly in construction because of their irregular shape and dark color. On a visit to bricks manufacturing kiln located in Peshawar, it was found that 10% - 15% over burnt bricks and 1.5% - 2% over burnt bricks blocks are produced in every batch of manufacturing of bricks. These over burnt bricks, act as a waste material in construction industry and has to accumulate somewhere in the process of recycling. Recycling is the method of processing the used material for 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.

Concrete is a composite construction material which is made by mixing Cement, aggregate and water. The targeted physical properties for the finished material can be attained by adding additives and Reinforcement to the concrete in required proportion. By mixing these ingredients in certain proportion, a solid mass that can be molded into any desired shaped can be formed. With time, a hard-solid mass is formed by cement, which binds the ingredients of concrete into a single rigid and durable material with many uses such as buildings, bridges, pavements, dams and tunnels etc. V Letelier et al (2017) concluded that the properties of concrete can be enhanced or the strength can be increased by replacing conventional ingredients of concrete by better ones. Since seventy-five (75) percent of the concrete volume is occupied by aggregate, so it is not surprising that its type, quality and other physical properties controls the quality of concrete. Many researches have been conducted to check the suitability of over-burnt bricks aggregate (OBBA) as a coarse aggregate in concrete. The studies show that higher strength concrete is achievable by replacing stone or gravel aggregates with OBBA. Patil and Autade (2015) Studied the effects of replacing Coarse aggregates by OBBA (Jhama-class brick) aggregate in concrete, and found 11.95% increase in strength for 40% replacement of coarse aggregate with OBBA. Tariq Ali et al (2014) conducted a research on evaluation of flexure strength behavior of concrete by replacing coarse aggregates with over burnt brick ballast aggregate in range of 0%-20%. From experimental results it is concluded that slump value decreases from 69.85 to 19.05 mm with the increment of OBBA from 0 to 20%. Furthermore, he concluded that Concrete formed with over burnt brick ballast aggregate showed beneficial performance as compared with the concrete made up of natural aggregate. It reduces the cost of concrete by reducing the aggregate cost and produces economical infrastructure system. N.S. Apebo et al (2013) studied the use of over-burnt bricks aggregates in concrete as an alternative of natural coarse aggregate. it was concluded that in production of high strength concrete as over-burnt brick can be used as coarse aggregate. concrete based on over burnt bricks aggregate has lower weight than normal concrete, thus by using these as aggregate, the dead load of concrete can be minimized. Kulkami S, Momin PAA (2015)

investigated the properties of concrete made of OBBA as coarse aggregate and found a maximum strength of 47.54 MPa at w/c ratio 0.55 for the mixing ratio 1:1.5:2. Mohammad Abdur Rashid et al (2008) check the potential of over burnt bricks as the source of coarse aggregate. The practical experiences showed us that the maximum range of compressive strength of concretes made with bricks aggregate, without using any admixture is around 3000- psi. However, higher strength concrete (fc' much greater than 3000 psi) can be produced and used advantageously in compression members such as columns and piles.

In plain areas like central Punjab, where rocks deposits are less, and also in some local areas, where river aggregates are not available due to lack of rivers. The cost of construction increases in these localities due to cost of transporting aggregates (fine and coarse), eventually, it will be very tough in most plain areas to build low cost building. To avoid the problem of costly transportation of conventional aggregates, this research work focused on experimentally investigating locally available over burnt bricks as an alternative source of coarse aggregate in concrete.

II. Research Project

The main objective of the research project is to study the potential (In term of workability and compressive strength) of using crushed-overburnt bricks as a coarse aggregate replacement. Slump test and compressive strength test were conducted on fresh and hardened concrete respectively. Four batches of concrete incorporating over-burnt bricks coarse aggregate in ratio of 0%, 20%, 50% and 100% were prepared. They were labelled as CA0, CA20, CA50, and CA100. CA represent replacement of coarse aggregate and subscript represent the replacement percentage.

III. Materials Used

3.1 Cement

Ordinary Portland Cement ASTM C-50 Type-1(Marek, C. R. Gallaway et al, 1971) was used as a binding material throughout the investigation.

Table 1: Physical properties of ordinary Portland cement

S. No	Properties	Test Results	ASTM
1	Fineness	95 % Passing	Not less than 90%
2	Normal Consistency	27.66%	26 – 30 %
3	Initial Setting Time	160 min	Not less than 45 min
4	Final Setting Time	325 min	Not more than 375 min
5	Specific Gravity	3.14	-
6	Compressive Strength		
	3 days Strength	2200 psi	1800 psi
	7 days Strength	2900 psi	2800 psi
	28 days Strength	4300 psi	4000 psi

3.2 Fine Aggregate

Sand is mainly comprising of well divided rocky and mineral materials. in concrete sand is generally utilized as fine-aggregates. Locally available river sand was used in this research. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust.

Table 2: Properties of natural fine aggregate

S. No	Test Description	Test Results
1	Specific gravity	2.30
2	Water absorption	11%
3	Natural moisture content	4%
4	Fineness Modulus	2.44

3.3 Natural Coarse Aggregate

The broken stones are normally used as a coarse aggregate in concrete. The nature of work generally decides the maximum size of coarse aggregate being used. Natural Coarse aggregate used in this work was locally procured, with maximum size of 20mm. The aggregates were washed, for the purpose to remove dust and dirt and were dried to surface condition before use.

Table 3: Natural coarse Aggregate properties

S. No	Test Description	Test results
1	Specific gravity	2.67
2	Bulk Density	97 lb/ft3
3	Water absorption	1.05%
4	moisture content	0%

3.4 Over Burnt Bricks Coarse Aggregate

Over burnt bricks used in this research were obtained from local bricks manufacturing kiln located at Peshawar. The first step for preparing over burnt bricks coarse aggregate is the crushing process. After crushing of over burnt bricks the resulting material was sieved through a set of sieves. Particles whose size was less than 20mm and were retained on sieve #4 (4.75mm), were used as CA replacement.

(a) (b)

Figure 1: Over Burnt Bricks

Table 4: Properties of crushed OBB used as NCA

S. No	Test Description	Test results
1	Specific gravity	2.06
2	Bulk Density	71.42 lb/ft3
3	Water absorption	7.90%
4	Natural moisture content	0 %

3.5 Proportioning Ratio

For 0% replacement (conventional concrete) mixture proportion of 1:2:4 by weight with w/c ratio of 0.57 was used. For coarse aggregate replacement with over-burnt bricks aggregate, w/c of 0.57 was found insufficient for mixing and required workability. Thus, for coarse aggregate replacement, mix design was prepared according to the ACI recommendation (Barra et al, 1998) for the targeted strength of 4000 psi with 3" slump. Mix proportion by weight for each case are given below.

Table 5: Mix proportion (All weights are in lbs)

S. No	Designation	Ratio	W/C ratio
1	CA0	1:2:4	0.57
2	CA20	1:2.81:3.35	0.85
3	CA50	1:3.10:3.07	0.92
4	CA100	1:3.59:2.60	1.03

3.6 Test Specimens

To conduct experimental investigation cylindrical specimens of standard dimensions (12” height and 6” diameter) were prepared. These specimens were tested for compressive strength at 3, 7 and 28 days. For each single test three cylindrical specimens were casted.

3.7 Mixing, casting and specimens curing

Mixing process was carried out in an electrically driven rotary mixer. The batching of ingredients was carried by weight to a high precision. The sand was dried before use. The mixer drum, was damped on inner side with water before pouring of concrete ingredients into the mixer. The dried aggregates of each batch were mixed initially in mixing machine until a homogenous mix were achieved. After dry mixing, cement was poured into to the mixer and water was introduced slowly

into the mixer as per w/c ratio. After all the ingredients were in the mixing drum, the mixing was carried out for at least 3 minutes.

Freshly prepared concrete mix was cast in standard dimensions cylinders (6 inches diameter and 12 inches height) in 3 different layers of almost same depth. Every layer after pouring was stroked 25 times with a standard tamping rod. The uppermost surface of mould, containing concrete, were leveled and were lifted for twenty-four (24) hours at ambient temperature to set. After twenty-four hours, the molds were removed from specimens and all the specimens were cured by in a laboratory.

IV. Results and Discussion

4.1 Workability test

Fresh concrete workability was measured by using 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

Table 6: Slump test results for Normal and NCA replaced concrete

Replacement %	Designation	Slump (inch)
0%	CA0	2
20%	CA20	3
50%	CA50	2
100%	CA100	1.5

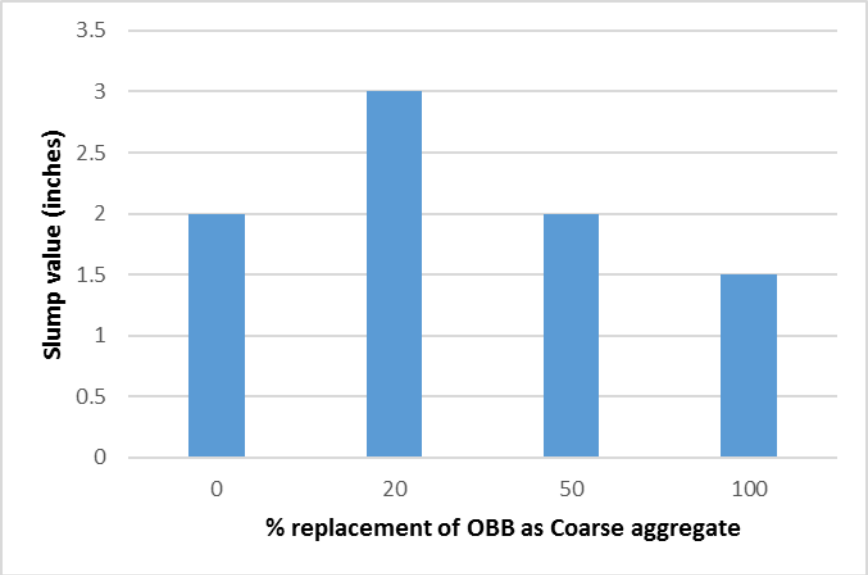

Figure 2: Slump test results for normal and Coarse aggregate replaced concrete.

For coarse aggregate replacement, initially for 20 percent replacement the workability of concrete increases and then decreases for 50 and 100 percent replacement as shown in figure 4.4. Most workable concrete was obtained at 20% replacement.

4.2 Compressive strength test

As discussed in foregoing sections, total 36 cylinders of standard size were cast and were tested, to investigate compressive strength of concrete in which natural coarse aggregate were replaced with over burnt bricks in level of 0%, 20%, 50%, and 100%. Compressive strength test was performed as per ASTM C39. The test results were rounded to the closest 10psi as specified by ASTM C 39. The compressive strength of concrete is tabulated in Table 5 with corresponding percentages of OBBA.

Table 7: Compressive Strength Test results for Normal and OBBA based concrete

Replacement %	Designation	Age (days)	Strength (psi)
0%	CA0	3	1850
		7	2300
		28	4220
20%	CA20	3	1070
		7	1220
		28	1630
50%	CA50	3	1300
		7	1590
		28	1760
100%	CA100	3	950
		7	1020
		28	1300

With reference to 3 days strength for 0% replacement, the increase in compressive strength is 24.32% and 128.10% at the age of 7 and 28 days respectively. For 20% replacement the percentage increase in compressive strength is 14.02% and 52.34% for 7 and 28days. For 50% replacement the percentage increase in compressive strength is 22.31% and 35.38% for seven and twenty-eight days and similarly for 100% replacement the percentage increase in compressive strength is 7.37% and 36.84% for seven and twenty-eight days. Figure 6a represents the variation of compressive strength with respect to the OBBA content of concrete.

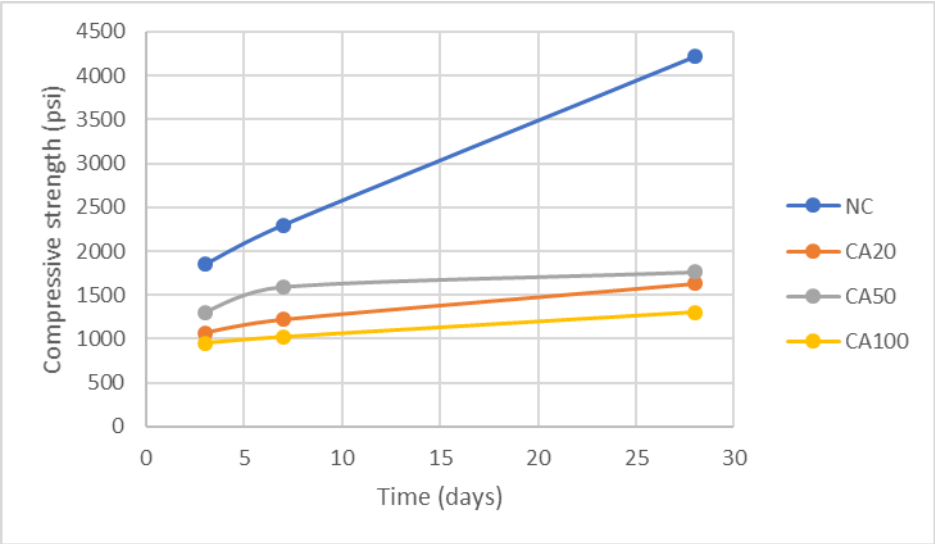

Figure 3: Compressive strength development comparison

By replacing natural coarse-aggregates with crushed over burnt bricks aggregate the strength decreases. The percentage loss in strength is different for each replacement. The loss is greater for 100% replacement as compared to other two replacements. 50% replacement gives better results than 20% and 100% replacement.

For 20% replacement, the loss in compressive strength is 42.16% for 3 days and for 7 and 28 days the loss is 46.96% and 61.37% respectively. For 50 % coarse aggregate replacement, the loss in strength for 3, 7 and 28 days is 29.73%, 30.87% and 58.29% respectively. For 100% coarse aggregate replacement, the loss in strength for 3, 7 and 28 days is 48.65%, 55.65% and 69.19%. The effects of strength by percentage replacement content of coarse-aggregate is shown in figure 4.

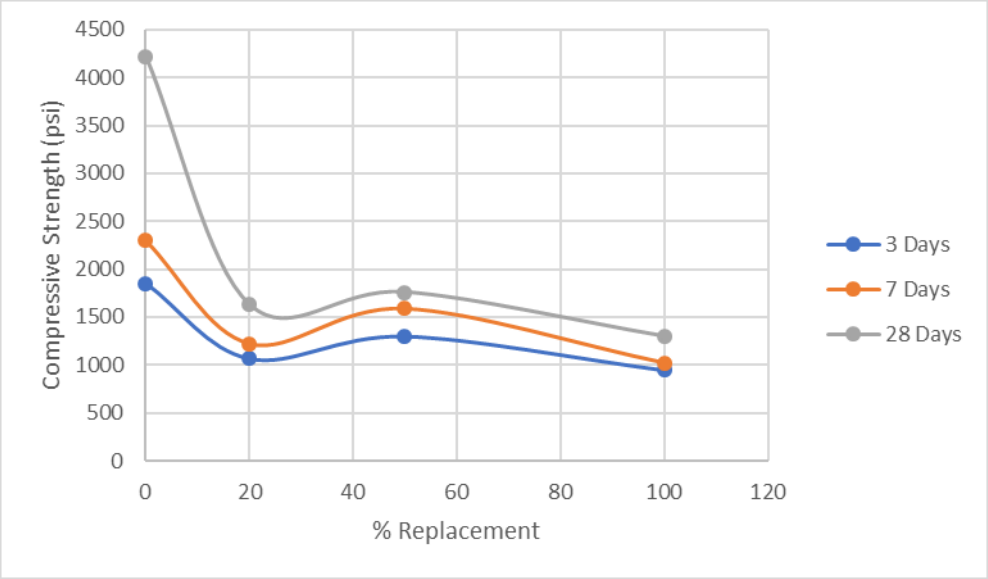

Figure4: Compressive strength vs %age replacement

The compressive strength loss pattern is similar for all replacement percentages., by increasing substitution percentage the strength of concrete decreases. The higher loss is for 100% replacement. For 20% substitution the decrease in strength is 42.16%, in case of 50% replacement the loss in compressive strength is 29.73% and for 100% cement replacement the decrease in strength is 48.65% for 3 days test.

For 7 days, the decrease in strength for 20%, 50% and 100% is 46.96%, 30.87% and 55.65% respectively. Similarly, for 28 days the decrease in strength is 61.37%, 58.29%, and 69.19% for 20, 50, and 100 percent replacement respectively.

V. Conclusion

Investigations have been made to study the behavior of concrete which includes the compressive strength, of hardened concrete and slump value of fresh concrete. The variable parameter of the study was the percentage replacement of coarse aggregate with OBBA. Within the scope of this study, it can be concluded that.

(1) By replacing natural coarse aggregate with OBB aggregate workability increases for 20% replacement only and decreases for all other replacement. Maximum slump value of 3 in was obtained at 20% replacement.
(2) For coarse aggregate replacement. The concrete strength decreases for replacement percentage at all ages
(3) At 3 days, Maximum loss of 48.65 in strength was observed at 100% replacement.
(4) At 7 days, Maximum loss of 55.65% in strength was observed at 100% replacement.
(5) At 28 days, Maximum loss of 69.19% in strength was observed at 100% replacement. Optimum results were obtained at 50% replacement.

VI. RECOMMENDATIONS

After the thorough study following areas will be recommended.

(6) Evaluate Mechanical properties for the optimum content of Over Burnt Brick Aggregate in Concrete by using different incorporations up to 100% (M100).
(7) Evaluate Mechanical properties by fluctuating W/C ratio.
(8) Evaluate Mechanical properties and its effects on concrete by using different sizes of Over Burnt Brick Aggregate.
(9) Conduct Microstructure study of the Over Burnt Brick Aggregate Concrete to evaluate its bonding pattern with other constituents.

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