Effect of Crushed Over-burnt Brick on the Compressive Strength of Concrete by Partially Replacing Coarse Aggregate

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***Abstract*: Normal concrete contains 70-80% natural aggregate by volume, which has drastically raised the use of coarse aggregate resulting into diminishing of natural resources and affecting environment. So, it is necessary to use an alternate material which will also reduce the cost. This research investigates the effect of 20%, 25% and 30% replaced natural coarse aggregate with locally available crushed Over-burnt brick aggregate (OBA) on workability and compressive strength of concrete. The experimental tests showed non-linear results for workability as well as compressive strength. OBA concrete has density of 2270-2300 kg/m^3 which lies in the range of medium lightweight concrete as compared to normal concrete having 2400 kg/m^3 density. The slump value in 20%, 25% and 30% OBA concrete was 53mm, 55mm and 47mm respectively, whereas, slump value of normal concrete was 69mm. Plain concrete compressive strength (M25) was found to be 34.9MPa at 28 days of curing, whereas, compressive strength of 20%, 25% and 30% OBA concrete, at 28 days, was found to be 28.666 MPa, 26.600 MPa and 27.470 MPa respectively. This shows that over-burnt brick aggregates can be used for structural concrete when natural coarse aggregate is not easily available.**

***Keywords*: Coarse-aggregate, Compressive Strength, Over-burnt Brick, Slump.**

I. INTRODUCTION

Concrete is the main structural development material. Concrete production contains constituents like Cement, Sand, Crushed gravel, water and sometime admixtures. Aggregates form the main share for the aggregates, which is about 60-75% [1]. It is important to know the amount of each ingredients for mixing in making of concrete to make sure that the concrete that will be produced is of good quality. Normally, Concrete with the compressive strength of 20Mpa or N/mm^2 and above is suited for structural use such as columns, shear wall and slab and concrete having strength less than 17 MPa or N/mm^2 are suited for non-structural role [2].

Bricks are handmade molded clay units. Brick manufacturing makes 1.5 percent of Pakistan's Gross Domestic Product. Pakistan is the 3rd biggest brick making country in South-Asia. Making greater than 45 billion bricks/year and country has 19000 brick making kilns [3]. Bricks which are burnt at more temperature than normally required are called 4th class bricks or over-burnt bricks. They are not used in the walls because of irregular shape and blackish grey color. Sometimes, Over-burnt bricks can have more strength than first class brick because of more densely compacted mass because they are burnt more higher temperature than normal first-class bricks. [4]

As, Concrete production consists 60-75% coarse aggregates, because of that coarse aggregate is being used at a very high rate. Normally, coarse aggregate is extracted from natural deposits by using heavy machinery. Furthermore, quarrying process causes negative effect to environment because of machinery smoke, fuel, noise and air pollution. Quarrying process strips the land and depletes natural resources. Therefore, aim of this research is to check the compressive strength of concrete using over-burnt brick as an alternative of natural coarse aggregate in the mix.

Fig 1: Crushed Over-burnt Bricks

II. MATERIAL PROPERTIES

A. Cement

Ordinary Portland cement (commercially available as lucky cement) was used in this research.

Table 1: Cement Tests

No.	Tests	Code	Results
a)	Consistency Test(w/c)	ASTM C187	0.32
b)	Initial and	ASTM C403	40 min
	Final Setting time		8 hours and 10 mins
c)	Fineness of Cement (%)	ASTM C786	1.65

B. Aggregates

The coarse aggregate was obtained from Nooriabad pit near Karachi, Sindh, Pakistan and fine aggregate was obtained from the Bolari pit near Karachi, Sindh, Pakistan. Coarse aggregates of maximum 20 mm size were used for concrete. Fine aggregates were conforming to zone-II.

Table 2: Properties of fine aggregate

No.	Properties	Standards	Result
a)	Specific gravity	ASTM C-127	2.59
b)	Water absorption	ASTM C-127	0.55%
e)	Fineness modulus	ASTM C-786	2.9

Table 3: Properties of coarse aggregate

No.	Properties	Standards	Result
a)	Specific gravity	ASTM C-127	2.61
b)	Water absorption	ASTM C-127	1.27%
e)	Fineness modulus	ASTM C-786	7.6

C. Over-burnt Brick

Over-burnt bricks were obtained from Tando Hyder kiln near Hyderabad, Sindh, Pakistan. Over-burnt bricks are used in the mix after breaking them into desired sizes ranging from 4.75mm to 19.5mm and they were soaked in water for 24 hours before mixing in the mixture machine for casting so that water-cement ratio is not affected.

Table 4: Properties of over-burnt brick aggregate

No.	Properties	Standards	Result
a)	Specific gravity	ASTM C-127	2.15
b)	Water absorption	ASTM C-127	4.4%
e)	Fineness modulus	ASTM C-786	7.7

III. RESEARCH METHODOLOGY

Concrete mix design was aimed for 25 MPa at 28 days curing period. To obtain required strength, the mix design ratio determined was 1:2.064:2.85 at 0.55 w/c ratio. The workability test by the slump cone method was conducted on freshly prepared concrete. In this research, Total 36 cubes were casted, which included 9 cubes(4”x4”x4”) each for plain concrete, 20% OBA concrete, 25% OBA concrete and 30% OBA concrete. Compressive strength test was checked at 7,14 and 28 days of curing in Universal Testing Machine (UTM).

IV. RESULTS AND DISCUSSION

A. Workability

As per ASTM code C143 [7], this test is useful to measure the consistency of concrete and change the concrete ingredients into uniform mix. The workability of control and fiber made mixes was computed by the slump cone test method. The results showed that slump decreased varyingly with increase in OBA percentage, as shown in figure 2 below.

Table 5: Percentage decrease in Slump

Sr. No.	Type	Percentage Replaced	Slump (mm)	Percentage Decrease in Slump
1	Plain Concrete	0	69	-
2	OB Concrete	20%	53	23.18%
3	OB Concrete	25%	55	20.29%
4	OB Concrete	30%	47	31.88%

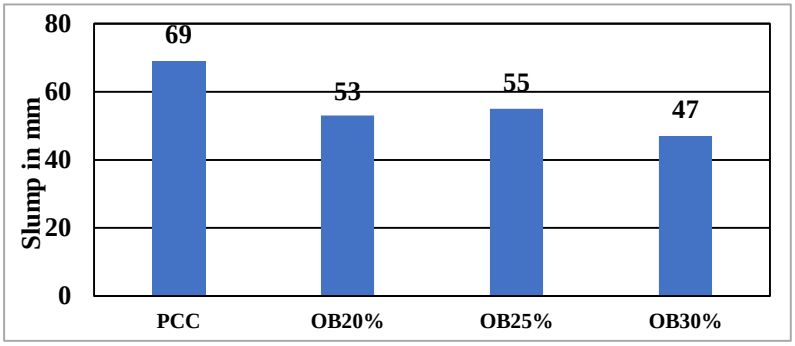

Fig 2: Slump vs Replacement in Concrete

B. Compressive Strength

At each proportion of over-burnt brick, 3 cubes each were casted to check compressive strength at curing periods of 7,14 and 28 days. Results show that compressive strength also decreased varyingly with increase in OBA percentage.

Table 6: Compressive Strength of Cubes

Concrete Mix	7 DAYS		14 DAYS		28 DAYS	
	Strength (MPa)	% Decrease	Strength (MPa)	% Decrease	Strength (MPa)	% Decrease
Plain Concrete	**25.04**	-	**31.17**	-	**34.850**	-
20% OB	**21.65**	13.40	**26.21**	15.91	**28.666**	17.73
25% OB	**20.04**	19.84	**24.55**	21.23	**26.580**	23.73
30% OB	**20.47**	18.12	**25.69**	17.58	**27.470**	21.17

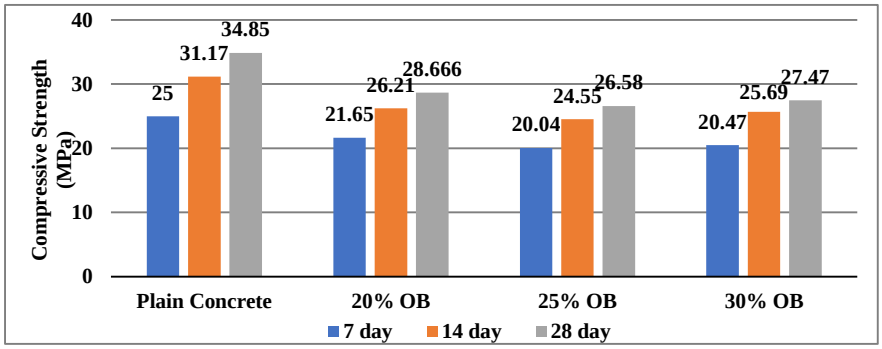

Fig 3: Compressive Strength vs Over-burnt Brick Aggregate Replacement

C. Dry Unit Weight

It was measured after weighing dry weight of a cube and by weight/volume ratio of cube. Results of dry unit weights of various type of concrete cubes are given below in table and figures.

Table 3: Obtained Dry Unit Weights

Sr. No.	Concrete Type	Percentage Replaced	Unit Weight (kg/m^3)	Percentage Decreased
1	Plain	0%	2410	-
2	OB	20%	2317.5	3.83%
3	OB	25%	2293	4.85%
4	OB	30%	2272.5	5.70%

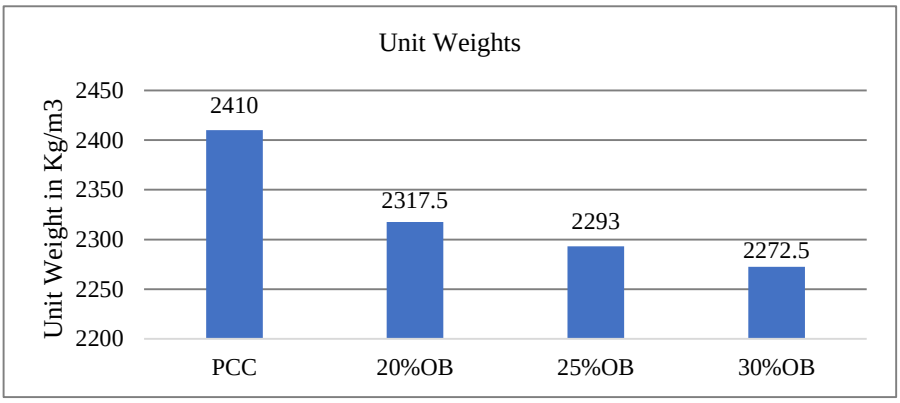

Fig 4: Unit Weights vs Replacements

V. CONCLUSIONS

Observing above results, following conclusions can be drawn:

1. Crushed over-burnt brick can be used as a partial replacement of natural coarse aggregate in concrete production for structural role.
2. Crushed over-burnt brick can be used whenever there is scarcity of natural coarse aggregate.
3. Crushed over-burnt brick can be used to produce concrete with lower self-weight.

VI. RECOMMENDATIONS

Following are the recommendations for successor researchers who are interested in this area.

1. In this research work, only 0.55 water cement ratio was used in all concrete types, so it is suggested to use different ratio.
2. In this research work, characteristic strength was 25 MPa, so others can do research on different characteristic strength.
3. In this research, maximum crush aggregates size is 19.5mm. Other researchers can work on different sizes.
4. This research includes replacement of coarse aggregate at 20%OB, 25%OB and 30%OB, other researchers can work on different percentages.
5. No any admixture was used in this research, successor researchers can use plasticizers for maintaining workability, etc.
6. No any supplementary cementitious material was used in this research, so other researchers can work on other supplementary cementitious material, such as fly ash, rice husk, silica, etc.
7. No any experimental work on chemical properties of over-burnt brick is done in this research, so it recommended for successor researchers to evaluate its chemical properties.

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