

# Study of the Effect of Replacing of Refractory Brick Residues Instead of Coarse Aggregate in Concrete Mixes

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**Abstract** - The aim of this study is to obtain lightweight concrete by replacing different percentages of refractory brick residues instead of coarse aggregate (15%, 25%, 35% and 45%) in a standard concrete mixture and to observe the extent of the impact on the properties of concrete (weight, workability and compressive strength). It was noted that 35% is the optimal ratio, as it reduced the weight by 3.34% of the standard mixture and obtained a resistance of (24.00 N/mm<sup>2</sup>) less than the design resistance (25 N/mm<sup>2</sup>), and that 25% reduced the weight by 2.55% of the standard mixture and gave a resistance of (20.08 N/mm<sup>2</sup>) less than the design resistance (25 N/mm<sup>2</sup>) and that 15% reduced the weight by 1.53% of the standard mixture and gave a resistance of (21.15 N/mm<sup>2</sup>) less than the design resistance (25 N/mm<sup>2</sup>) and that 45% reduced the weight by 5.89% of the standard mixture and gave a resistance (21.03 N/mm<sup>2</sup>) less than the design resistance (25 N/mm<sup>2</sup>), and it was noted that the higher the addition ratio, the less workability. We recommend using ratios close to optimal to obtain more accurate results, taking into account the good immersion of the cubes and immersing the refractory brick residues until saturation before use

**Key Words:** Concrete, Refractory brick, Workability, Compressive strength.

## 1. INTRODUCTION

Several million tons of solid waste is produced each year due to construction and demolition activities worldwide. Most of waste materials are left as a landfill material or illegally dumped. Environmental impact can be reduced by making more sustainable use of this waste [1,11]. And brick waste is one of the widest wastes. Recently, a growing number of studies have been conducted on using recycling brick waste (RBW) to produce environmentally friendly concrete. [3]

Brick is considered the second most common building material after concrete, and if there is damage occurs during its production, construction, and demolition activities. It is regarded as C and D waste. The ability to recycle the brick waste in the manufacture of the concrete is considered an environmentally friendly substitutional. That solution will not only decrease the problem of its disposal and moreover helps to minimize the consumption of natural materials. In addition, brick production does not involve the use of

chemicals, so it considers safe and stable construction materials [13].

Due to many countries having restrictive construction laws regarding recycled aggregates (RAs), the use of RA is mainly focused on nonstructural purposes; therefore, its recycling as a partial natural aggregate replacement in masonry mortar mixtures represents a feasible option]. In this way, one obstacle to RFA recycling has been the characteristics of the material itself: high porosity and high-water absorption [5,6].

Wencui Yang et al investigated the mechanical properties and durability of concrete with recycled clay brick as fine aggregate. The results showed that the compressive strength, the flexural strength and the impermeability of concrete decreased with the increasing of the replacement percent of recycled clay brick. However, the permeability of concrete with the water to cement ratio of 0.35 was still at the "Low" level when the replacement percent was less than or equal to 75%. The carbonation resistance of concrete using recycled clay bricks as fine aggregate was degraded. [2, 9, 12, and 14]

Concrete cubes made with local recycled bricks are cast and tested for overall weight of concrete, moisture content, dynamic modulus of elasticity and compressive strength (nondestructive and destructive methods). The results showed that concrete derived from recycled aggregates attained lower strength than regular concrete [3,7 and 10]

## 2. E Experimental Work:

This study was carried out in few stage. on the initial stage, all the material and equipment's needed must be gathered or check for availability. Then the concrete mixes according to the predefined proportions. Concrete samples were tested through concrete tests such as cube test. Finally, the results obtained were analyzed to draw out conclusion.

High performance concrete was designed by using BSI curing method. Trail control mixes for 28 days with replacing refractory brick residues of coarse aggregate with different percentages 15%, 25%, 35 and 45% respectively from coarse aggregate. The results of laboratory experiments were analyzed and discussed to investigate the refractory brick residues on workability of fresh concrete and compressive strength of hardened

**2.1 Material Used:**

**2.1.1 Cement:** Portland cement is the most commonly used type of cement in majority of constructions. Ordinary Portland cement of 45 grades, from local market, of standard brand is selected for use in the present study. The selected cement is tested conforming to IS: 12269-1987 to assess its suitability for use in concrete and the results of the tests are tabulated in table 1 and figure 1

**Table 1:** Results of cement tests

Type of testing	Results of testing	Ref.BS12:1996
Standard of cement paste	31.75%	W/C ≥ 26% and ≤ 33%
Initial setting time	105 min	≥ 60 min
Final setting time	7 hrs (420 mins)	≤ 10 hrs
Fineness of cement	3.05%	≤ 10%
Soundness of cement	5mm	≤ 10 mm
Compressive strength (28) days (standard)	48 N/mm <sup>2</sup>	≥ 42.5 N/mm <sup>2</sup> ≤ 62.5 N/mm <sup>2</sup>



**Fig -1:** cement and tests equipment's

**2.1.2 Fine Aggregate:** The sand used for experimental program was locally procured. The fine aggregates were tested as per British Standard Specification BSI: 882-1997. The specific gravity of sand was found out to be 2.75. (Figure 2)

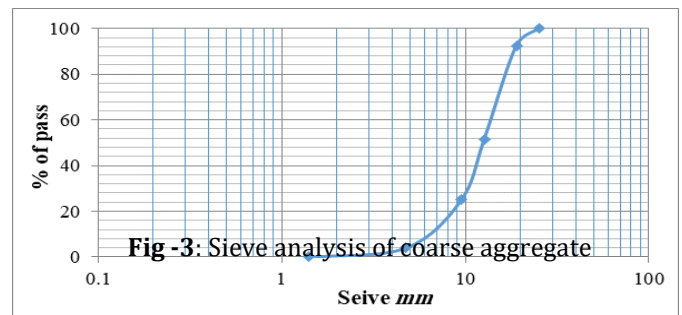
**2.1.3 Coarse Aggregate:** The natural broken stone (coarse aggregate) used for the study was of 20mm size maximum. It is conforming BSI: 882-1997. It was retrieved from a local quarry. The shape and quality of aggregate was uniform throughout the project work and the specific gravity was found to be 2.60. Table 2 shows the results of tests of impurities, specific gravity and water absorption of coarse and fine aggregates (Figure 2)

**Table 2:** Properties of aggregates

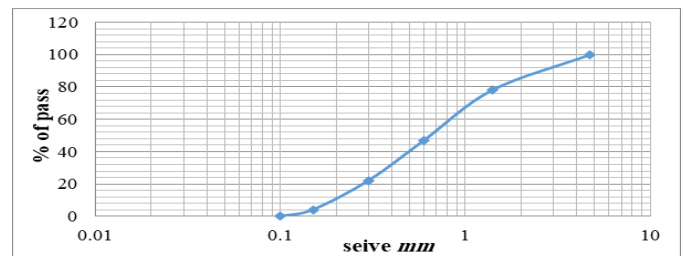
Experiment name	Fine aggregate	Coarse aggregate
Impurities	% 28	-
Specific gravity	2.63	2.60
Water Absorption	10%	5.3%



**Fig -2:** Coarse and fine aggregate



**Fig -3:** Sieve analysis of coarse aggregate



**Fig - 4:** Sieve analysis of fine aggregate

**2.1.4 Water:** The used water from Khartoum city water distribution system

**2.1.5 Refractory brick residues:** Fig 3 presents the refractory brick residues. The Water Absorption of refractory brick residues was found equal to 19.09 %



**Fig - 5:** refractory brick aggregate

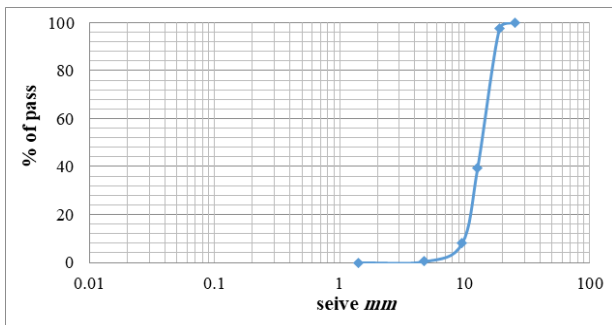


Fig - 6: Sieve analysis of refractory brick

brick residues, result for 15%, 25%, 35% and 45% are shown in tables 5 to 17 and depicted graphically in Figures 4 to 6.



Fig - 7: Slump test

## 2.2 Mix Design Method

BSI curing method of mix design was used for mix design for concrete cubes test. concrete specimens with various percentages of refractory brick residues were prepared. The details of various mix proportions for different ratios of refractory brick residues at 7 and 28 days.

The aggregate dry density used was  $1209 \text{ kg/m}^3$ , and the maximum aggregate size use in all mixes was  $20 \text{ mm}$ . using standard cubes moulds ( $150 \times 150 \times 150 \text{ mm}^3$ ) cubes representing each ratio, were casted and tested at age 7 and 28 days.



Fig - 8: Concrete cubes

### 2.2.1 Components of mix materials:

The concrete mix to resist compression design ( $25 \text{ N/mm}^2$ ), the quantities of materials for all the mixtures as illustrated table3: Mix design: (density of  $2435 \text{ kg/m}^3$ ).and table 4.

Table 3: Amounts of the mixture of design

Mix Materials	Weight( $\text{kg/m}^3$ )
Cement content	320
Fine aggregate content	610
Coarse aggregate content	1240
Water content	195

Table 4: the quantities of materials

Mix	% of replacement	Course Agg (kg)	Fine Agg (kg)	Cement (kg)	Water (L)	R. brick (kg)
$M_1$	00	11.16	5.49	2.88	1.755	00
$M_2$	15	9.486	5.49	2.88	1.755	1.674
$M_3$	25	8.370	5.49	2.88	1.755	2.790
$M_4$	35	7.254	5.49	2.88	1.755	3.906
$M_5$	45	6.138	5.49	2.88	1.755	5.022

## 3. Results of Experiments of Fresh and Hardened Concrete:

Slump and Compressive Strength (cubes moulds) Tests were conducted for fresh and hardened concrete presented in figures 7,8 and 9, by adding different ratios of refractory



Fig - 9: Compressive Strength Test

Table 5 Results of Compressive Strength Tests of the Control Mix at 7 days

C. NO	Age	Weight (g)	Strengt ( $\text{N/mm}^2$ )	Average strength ( $\text{N/mm}^2$ )
1	7 days	2550	24	22.78
2		2550	23.788	
3		2530	20.557	

**Table 6:** Results of Compressive Strength Tests of the Control Mix at 28 days

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	28days	2565	28.385	29.52
2		2565	27.724	
3		2545	32.469	

**Table 7:** Results of Compressive Strength Tests at 7 days (15 % of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	7days	2505	14.83	15.47
2		2510	14.81	
3		2490	16.77	

**Table 8:** Results of Compressive Strength Tests at 28 days (15 % of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	28days	2535	21.62	21.12
2		2510	20.89	
3		2520	20.95	

**Table 9:** Results of Compressive Strength Tests at 7 days (25 % of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	7days	2480	17.90	17.99
2		2465	18.92	
3		2475	17.15	

**Table 10:** Results of Compressive Strength Tests at 28 days (25% of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	28days	2475	19.51	20.81
2		2520	19.84	
3		2500	23.07	

**Table 11:** Results of Compressive Strength at 7 days (35 % of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	7days	2495	14.83	15.47
2		2510	14.81	
3		2490	16.77	

1	7 days	2495	20.62	20.09
2		2465	20.50	
3		2440	19.17	

**Table 12:** Results of Compressive Strength Tests at 28 days (35 % of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	28days	2565	23.21	24.00
2		2460	23.51	
3		2470	25.28	

**Table 13:** Results of Compressive Strength Tests at 7 days (45 % of refractory brick residues)

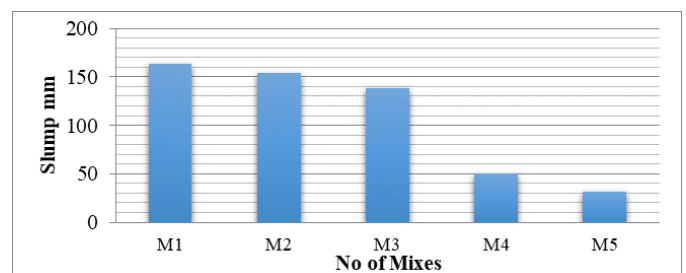
C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	7days	2425	15.74	17.33
2		2395	18.18	
3		2405	18.09	

**Table 14:** Results of Compressive Strength Tests at 28days (45 % of refractory brick residues)

C. NO	Age	Weight (g)	Strengt (N/mm <sup>2</sup> )	Average strength (N/mm <sup>2</sup> )
1	28days	2420	19.68	21.03
2		2375	21.47	
3		2380	21.94	

**Table 15:** Average for Results of slump Tests using (% of refractory brick)

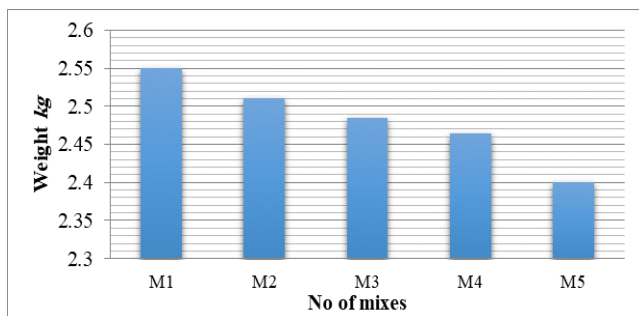
Mix	% of refractory brick	Slump (mm)
M <sub>1</sub>	00	163
M <sub>2</sub>	15	154
M <sub>3</sub>	25	138
M <sub>4</sub>	35	50
M <sub>5</sub>	45	31



**Fig - 10:** Relation between slump and number of mixes

**Table 16** Average for Results of weight at 28 days

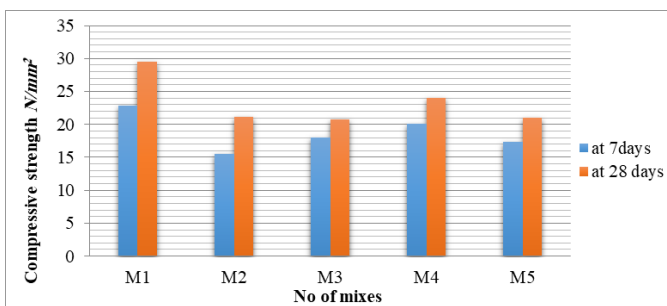
Mix	% of refractory brick	Weight (kg)
M <sub>1</sub>	00	2.550
M <sub>2</sub>	15	2.511
M <sub>3</sub>	25	2.485
M <sub>4</sub>	35	2.465
M <sub>5</sub>	45	2.4



**Fig - 11:** Relation between Weight and number of

**Table 17:** Average for Results of Compressive Strength at 7 and 28 day

Mix	% of refractory brick	Compressive Strength at 7days (N/mm <sup>2</sup> )	Compressive Strength at 28days (N/mm <sup>2</sup> )
M <sub>1</sub>	00	22.78	29.52
M <sub>2</sub>	15	15.47	21.15
M <sub>3</sub>	25	17.99	20.81
M <sub>4</sub>	35	20.09	24.00
M <sub>5</sub>	45	17.33	21.03



**Fig - 12:** Relation between compressive strength and number of mixes

### 3.0 Discussion of Results

The results obtained from the different tests are summarized and discussed as following:

**Fresh Concrete:** Table 15 and figure 4 present that the slump decreased with increasing the amount of refractory brick residues

Hardened Concrete: Tables 16, 17 and Figures 6, 7 shows the results of average Compressive strength of concrete at ag 7 and 28 days. The compressive strength decreased with increasing amounts of refractory brick residues and also shows the weight of concrete decreased with increasing the refractory brick residues the reduction percentage of weight are (1.53, 2.55, 3.34 and 5.89 respectively for replacement ratios (15, 25, 35 and 45%)

### 4.0 Conclusion and Recommendation

In this study the refractory brick residues were used as a replacement of coarse aggregate to investigate its effect on Concrete through the measure of workability for fresh concrete and compressive strength for hardened concrete in 7 and 28 days. Based on the results it can be concluded that:

- Increase in the refractory brick residues content in concrete mixes reduces the compressive strength of concrete. And decreased the workability of concrete
- Obtained results suggest that using the refractory brick residues for another application for example concrete blocks

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