International Conference on Innovative Research in Engineering, Management and Sciences
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2019 IJSRCSEIT | Volume 4 | Issue 9 | ISSN : 2456-3307

Experimental Studies on Utilization of Brick Waste as Coarse Aggregate in Concrete Mixes

Surendra B V, Vinay Kumar B M
Department of Civil Engineering, New Horizon College of Engineering, Outer Ring Road, Marathalli, Bengaluru, Karnataka, India

ABSTRACT

Crushed bricks as aggregates are of particular interest because their use can considerably reduce the problem of waste storage and simultaneously helps the preservation of natural aggregate resources. With this perspective, an experimental study is carried out to assess the possibility of using brick masonry waste as a partial replacement for natural coarse aggregate (NCA) in concrete mixes. Brick bats or brick masonry waste are crushed using hammer to recover coarse recycled brick aggregate (CRBA). M40 grade concrete mix is designed as per IS 10262:2009, by considering the properties of natural aggregates. NCA is partially replaced by CRBA at 10%, 20%, 30% and 40% in concrete mixes. Totally five concrete mixes (including control mix made of NCA and NFA) are considered in the study. The workability of the concrete mixes decreases with an increase in CRBA content. A marginal reduction in 28 days compressive strength is observed up to 20% replacement of NCA by CRBA. At 30% and 40% replacement level, the reduction in compressive strength is about 15% and 30% respectively. The tensile strength decreases with increase in CRBA content in concrete mix.

Keywords : Coarse recycled brick aggregate (CRBA), Control Mix, Natural coarse aggregate (NCA), Natural fine aggregates (NFA).

I. INTRODUCTION

In India, a large quantity of construction and demolition waste is generated every year. These waste materials need a large place to dump and hence the disposal of waste has become a severe issue in urban seector. On the other hand scarcity of natural resources is another major problem that results in changes in climatic conditions. Hence it becomes necessary to protect and preserve natural resources.

As per the Technology Information, Forecasting and Assessment Council (TIFAC) the construction industry contributes waste is between 12 to 14.7 million tons per annum. The waste that is generated from Construction Industry in India is estimated and given in Table I.

TABLE I CONSTITUENT OF CONSTRUCTION AND DEMOLITION WASTE IN INDIA

Constituent	Quantity Generated in million Tons p.a. (Range)
Soil, Sand & gravel	4.20 to 5.14
Bricks & Masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

Demand to supply of building material is in the range of of about 60,000 million cu.m. Reuse of aggregate material from construction and demolition debris certainly mitigate to a larger extent the demand-supply gap.

While retrievable items such as bricks, wood, metal, titles are recycled, the concrete and masonry waste, accounting for more than 60% of the construction and demolition debris, are not being presently reused in India.

Construction waste is being reused in many European Countries. More than 60% of the waste has been recycled in these countries and the recycling prospect in India constitutes only about 6-8%.

Concrete and masonry waste can be reused by sorting, crushing and sieving into recycled aggregate. Such recycled aggregate can be used to produce concrete for construction and building material.

The use of recycled concrete aggregate started almost 70 years ago just after the Second World War, during which many structures were demolished by bombing. Many researchers around the world endorse the use of recycled concrete aggregates in concrete mixes that can be used for structural and non-structural applications. However, very few experimental studies are conducted on use of brick masonry waste in concrete applications.

The sustainability in construction gained importance since the construction industry consumes large quantities of natural resources and produces huge quantities of waste. Concrete being a composite material (a binder, water, and aggregates) that is widely used, there exists a large scope of them being reused.

Hypothesis and objectives of the study

Natural aggregate resources can be preserved by reusing the bricks after crushing them into size of aggregates. This also addresses the issue related to disposal of construction debris thereby decreasing environmental pollution . Certain issues related to water absorption and impurities, if addressed properly results in utilization of brick waste in concrete mixes as an alternative solution.

With this backdrop, an experimental study is carried out to assess the practicability of using brick masonry waste as a partial replacement for natural coarse and fine aggregates in concrete mixes. The objective of the study is as follows:

To study the properties of concrete mixes in its fresh and hardened state by using coarse recycled brick aggregate (CRBA) partially in place of natural coarse aggregate (NCA) by 10%, 20%, 30%, and 40%.

Literature review

Debieb and Kenai [1] attempted to determine the possibility of using crushed brick as coarse and fine aggregate in concrete mixes and opined that brick aggregates can be used up to 25% and 50% for the coarse and fine aggregates, respectively.

Cachim [2] concluded that a 15% replacement of natural coarse aggregate by brick aggregate results in same property as that of that of concrete made with natural aggregates.

Yang et al… [3], ascertained the influence of crushed clay bricks (as coarse aggregate) on properties of recycled aggregate concrete, the concrete mix with 50% of crushed clay bricks and 50% of recycled concrete aggregates yields satisfactory results in terms of durability.

Ge et al…. [4], emphasized the use of recycled clay brick powder as replacement to cement in concrete mixes partially. They also proposed an optimal mix design through experimentation and orthogonal analysis.

Aliabdo et al… [5], explored several possibilities of using crushed clay brick in the concrete industry, the experimental evidence encourages the use of brick waste in many applications where the temperature resistance, economy, and environmental aspects are considered.

Bektas et al… [6], advocated the use of 10% and 20% of crushed clay brick fine aggregate in mortar specimens, by considering the strength and durability aspects.

Poon and Chan [7], concluded the use of 25% crushed clay brick satisfies the strength requirements for Grade B paving blocks as prescribed by ETWB of Hong Kong

Sadek [8] investigated the feasibility of using crushed brick aggregates in making solid cement bricks. He found that the parameters such as size and replacement level of the crushed bricks have a detrimental effect on the compressive strength.

Materials and Methods

Concrete mixes are prepared by using cement, NFA, NCA, and CRBA.CRBA is obtained by manual crushing of brick bats using a hammer.

Ordinary Portland cement (OPC) of 53 grade is used throughout the experimental study. aFor NCA Crushed stone is used and for NFA river sand <4.75 mm is used. The physical properties of materials are evaluated in compliance with the codes.

Properties of Ingredients

The physical properties of cement were evaluated in compliance with the IS 4031 [9–14]. The outcomes are listed in Table II. The physical properties of NCA, CRBA, NFA are evaluated in compliance with the IS: 2386 [15, 16]. The outcomes are listed in Table III.

TABLE II. PHYSICAL PROPERTIES OF CEMENT

Sl.No	Parametres	Cement
1	Specific gravity	3.08
2	Fineness (%)	3.06
3	Standard consistency (%)	31
4	Initial setting time (min)	60
5	Final setting time (min)	220
6	Compressive strength, N/mm^2	56

TABLE III. PHYSICAL PROPERTIES OF AGGREGATES

Sl.No.	Parameters	Aggregates		
		NCA	CRBA	NFA
1	Specific Gravity	2.65	1.83	2.6
	Water absorption	0.25	12.9	-
2	Fineness Modulus	6.6	6.52	3.52
5	Impact test (%)	16.5	57	-
6	Crushing test (%)	28.5	60.3	-

Mix design

The mix proportion adopted is 1:2:3.3 having 0.8% of SP, and 0.45 water cement ratio. The concrete mixes were prepared using two fractions of coarse aggregates. The coarse aggregate passing 20 mm and retained on 10 mm IS sieve is used as 60% while, the remaining 40% is the fraction passing 10 mm and retained on 4.75 mm IS sieve. The natural coarse aggregate is used in SSD state and natural fine aggregate are used in ambient dry state.

Casting and curing of test specimens

In compliance with IS: 10086 [18] 150 mm size concrete cubes and conforming to IS: 5816 [19] cylinders of size 150 mm dia. and 300 mm height are prepared. The specimens are removed from moulds After 24 hours,the specimens are removed from the moulds and immersed completely in the curing tank for curing. Compressive strength is evaluated using 4 Cube specimens each at seven and twenty eight days , while the split tensile strength is found out using 3 cylinder specimens.

Tests performed on concrete mixes

The main purpose of this experimental study is to evaluate the properties of concrete mixes by partially replacing NCA by CRBA. In view of this, experiments are performed to evaluate the fresh and hardened properties of the concrete.

Slump and compaction factor test were conducted to evaluate the fresh state of concrete. These tests were performed as per IS: 1199 [20].

The compressive strength of the concrete is tested as per the guidelines outlined in IS: 516 [21]. IS: 5816 [19] is followed for testing tensile strength of concrete.

Results and Discussions

Fresh properties

Table IV represents slump and compacting factor test results. With increase in CRBA content, the workability of the concrete decreases.

TABLE IV. SLUMP AND COMPACTION FACTORS OF CONCRETE MIXES

Brick bats as	Mix Designation	Slump in mm	CF
	CM	120	0.93
Partial replacement for NCA	10 CRBA	90	0.93
	20CRBA	70	0.92
	30 CRBA	60	0.89
	40 CRBA	50	0.87

Compressive Strength

The compressive strength of the concrete mixes with partial replacement of NCA by CRBA is listed in Table V. The compressive strength of CM at 7 and 28 days is found to be 43.0 and 55.0 MPa respectively. Fig 1 represents the variation in compressive strength with partial replacement of NCA by CRBA.

The compressive strength at 7 days for the concrete mixes CM, 10CRBA, 20 CRBA, 30 CRBA and 40 CRBA are 0.78, 0.79, 0.66, 0.61 and 0.79 times that of 28 days compressive strength of the respective mixes.

TABLE V. COMPRESSIVE STRENGTH OF CONCRETE MIXES

Mix Designation	Compressive Strength in MPa			
	7 days	Average	28 days	Average
CM	37	43	53.9	55
	44.9		56.7	
	45.1		52.9	
	44.9		56.7	
10 CRBA	43	42.6	52	53.9
	42.4		53.6	
	40.1		54	
	44.9		56.1	
20 CRBA	36	34	46.7	51
	32.7		52	
	34.5		51.8	
	32.8		53.6	
30 CRBA	30	29	42.1	46.9
	25.3		49.9	
	31		46.4	
	29.7		49	
40 CRBA	29	29	38.2	36.4
	28.1		37.9	
	28.1		36.9	
	30.7		32.7	

A marginal reduction in 28 days' compressive strength is observed up to 20% replacement of NCA by CRBA. The percentage reduction corresponds to 2% and 6% respectively. At 30% replacement level, the compressive strength is 46.9 MPa and the reduction is about 15%, as compared to CM. Nearly 30% reduction in the compressive strength is observed at 40% replacement level.

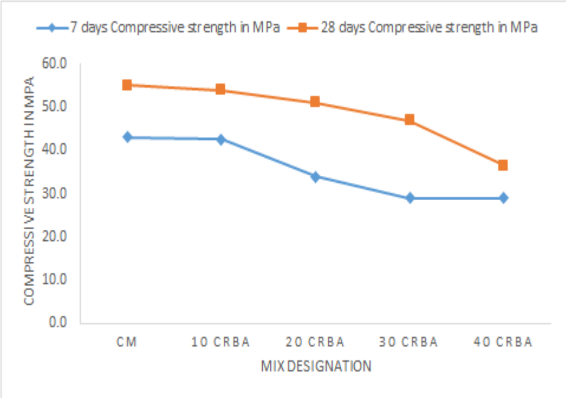

Fig. 1. Variation in compressive strength with partial replacement of NCA by CRBA

Split tensile strength

The split tensile strength of the concrete mixes with partial replacement of NCA by CRBA are given in Table VI

TABLE VI. TENSILE STRENGTH OF CONCRETE MIXES

Mix Designation	**Tensile strength at 28 days**	**Average**
CM	3.746	3.8
	3.84	
	3.88	
10 CRBA	3.82	3.7
	3.42	
	3.95	
20 CRBA	2.94	3.6
	3.9	
	3.83	
30 CRBA	3.45	3.2
	2.84	
	3.29	
40 CRBA	2.75	3.1
	3.54	
	3.05	

Conclusion

The experimental study resulted in the following conclusion:

i. The workability of the concrete mixes decreases with an increase in CRBA and FRBA content.

ii. A marginal reduction in 28 days compressive strength is observed up to 20% replacement of NCA by CRBA. The percentage reduction corresponds to 2% and 6% respectively. At 30% replacement level, the compressive strength is 46.9 MPa and the reduction is about 15%, as compared to CM. A nearly 30% reduction in the compressive strength is observed at 40% replacement level.

iii. The tensile strength decreases with increase in CRBA content in concrete mix

II. REFERENCES

[1]. F. Debieb, S. Kenai, “The use of coarse and fine crushed bricks as aggregate in concrete”, Constr. Build. Mater. Vol.22, pp.886–893,2008.

[2]. P.B. Cachim, “Mechanical properties of brick aggregate concrete”, Constr. Build. Mater. Vol 23, pp.1292–1297, 2009.

[3]. J. Yang, Q Du, Y Bao, Concrete with recycled concrete aggregate and crushed clay bricks, Constr. Build. Mater. Vol 25, pp. 1935–1945, 2011.

[4]. Z. Ge, Z. Gao, R. Sun, L. Zheng, “Mix design of concrete with recycled clay-brick-powder using the orthogonal design method”, Constr. Build. Mater. Vol.31,pp 289–293,2012.

[5]. A .A. Aliabdo, Abd-Elmoaty M. Abd-Elmoaty, H.H. Hassan, “Utilization of crushed clay brick in concrete industry”, Alex. Eng. J. Vol. 53, pp. 151–168, 2012.

[6]. F. Bektas, K. Wang, H. Ceylan, “Effects of crushed clay brick aggregate on mortar durability”, Constr. Build. Mater, Vol 23, pp. 1909–1914, 2009.

[7]. C. S. Poon, D. Chan, “Paving blocks made with recycled concrete aggregate and crushed clay brick”, Constr. Build. Mater. Vol. 20, pp.569–577, 2011.

[8]. D.M. Sadek, “Physico-mechanical properties of solid cement bricks containing recycled

aggregates", J. Adv. Res. Vol. 3, pp. 253–260,2012.

[9]. IS 4031- 1:1996, "Methods of Physical Tests for Hydraulic Cement, Part-1: Determination of Fineness by Dry Sieving", Bureau of Indian Standards, New Delhi, India.

[10]. IS 4031- 2:1999, "Methods of Physical Tests for Hydraulic Cement, Part-2: Determination of Fineness by Specific Surface by Blaine Air Permeability Method", Bureau of Indian Standards, New Delhi, India.

[11]. IS 4031- 4:1988, "Methods of Physical Tests for Hydraulic Cement, Part-4: Determination of consistency of standard cement paste". Bureau of Indian Standards, New Delhi, India.

[12]. IS 4031- 5:1989, "Methods of Physical Tests for Hydraulic Cement, Part-5: Determination of Initial and Final setting times", Bureau of Indian Standards, New Delhi, India.

[13]. IS 4031- 6:1988, "Methods of Physical Tests for Hydraulic Cement, Part-6: Determination of Compressive strength of Hydraulic Cement", Bureau of Indian Standards, New Delhi, India.

[14]. IS 4031- 11:1988, "Methods of Physical Tests for Hydraulic Cement, Part-11: Determination of Density", Bureau of Indian Standards, New Delhi, India.

[15]. IS 2386-1:1963, "Methods of Test for Aggregates for Concrete, Part-1: Particle size and shape". Bureau of Indian Standards, New Delhi, India.

[16]. IS 2386 -3:1963, "Methods of Test for Aggregates for Concrete, Part-3: Specific gravity, Density, Voids, Absorption and Bulking",, Bureau of Indian Standards, New Delhi, India.

[17]. IS: 10262-2009, "Concrete Mix Proportioning – Guidelines", Bureau of Indian Standards, New Delhi, India.

[18]. 1S 10086:1982, "Specification for moulds for use in tests of cement and concrete, Bureau of Indian Standards", New Delhi, India.

[19]. IS 5816: 1999, Splitting Tensile Strength of Concrete-Method of test", Bureau of Indian Standards, New Delhi, India.

[20]. IS 1199:1959,"Methods of Sampling and Analysis of Concrete", Bureau of Indian Standards, New Delhi, India.

[21]. IS 516: 1959, "Methods of tests for Strength of Concrete", Bureau of Indian Standards, New Delhi, India.