International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 3, March 2018, pp. 1028–1036, Article ID: IJCIET_09_03_103
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=3
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

A DETAILED STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE WITH BRICK DEBRIS

R. Veerakumar
Assistant Professor, Vel Tech Rangarajan Dr. Sagunthala R & D Institute of Science and Technology, Avadi, Tamilnadu, Chennai, India

R. Saravanakumar
Assistant Professor, Vel Tech Rangarajan Dr. Sagunthala R & D Institute of Science and Technology, Avadi, Tamilnadu, Chennai, India

ABSTRACT

Concrete is the most material being used in infrastructure development throughout the world. Fine aggregate is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. Fine aggregates are weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. Now-a-days fine aggregate is not readily available, it is transported from a long distance. Those resources are also exhausting very rapidly. The non-availability or shortage of fine aggregate will affect the construction industry, hence there is a need to find the new alternative material to replace the fine aggregate, such that harm to environment is prevented. Many researchers are finding different materials to replace fine aggregate. This study aimed to investigate the suitability of using brick debris in concrete in place of fine aggregate. Brick debris originated from demolished masonry walls crushed in the laboratory and added in partial fine aggregate replacement. Four replacement levels, 5%, 10%, 15%, and 20%, were compared with the control. The tests on concrete showed that the mechanical properties (compressive strength test) of concrete containing brick debris were well comparable to those of the concrete without ground brick.

Keywords: Compressive strength, Brick debris, Fine aggregate.

Cite this Article: R. Veerakumar and R. Saravanakumar, A Detailed Study on Partial Replacement of Fine Aggregate with Brick Debris, International Journal of Civil Engineering and Technology, 9(3), 2018, pp. 1028–1036.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=3

1. INTRODUCTION

Concrete is the mixture of various materials coarse aggregate, fine aggregate, cement & water, each of them is mixed in various proportions to achieve specific strength (Animesh et al 2017). Huge quantities of construction and demolition wastes are generated not only in

India but all over the world. These wastes are increasing every year predominantly The annual concrete production is estimated as 11 billion metric tons, 70–75% of the number is fine aggregate (mostly natural rock); 15% is water; and 10–15% is cementations binder. With increasing environmental pressure to reduce solid waste and to recycle as much as possible, the concrete industry has adopted a number of methods to achieve this goal by replacement of different waste materials instead of fine aggregate and coarse aggregate (Sharifi et al 2013; Animesh et al 2017). Importantly, the need for fine aggregate also increases rapidly as the present world is constantly focused on bigger and better infrastructure and the demand for fine aggregate is enormous.

One of the existing problems is that the increasing use of natural fine aggregate creates an ecological imbalance as we are constantly extracting from the natural resources. Thus, partial replacement of fine aggregate is vital in construction industries. Various researchers and scientists are already working and also have come out with their own ideas to decrease or fully replace the use of fine aggregate and use recent innovations such as M-Sand (manufactured sand), robot silica or sand, brick debris, filtered sand, treated and sieved silt removed from reservoirs as well as dams besides sand from other water bodies Use of construction debris as fine aggregate is an alternative for the replenishing quarry and river sand. The present study presents an overview of other efforts for the replacement of fine aggregate and also to evaluate the utility of crushed brick as a partial replacement of sand in concrete. Further the replaced concrete material is compared with the performance conventional concrete. In addition to that, this work helps in understanding the effectiveness of brick as in strength enhancement.

2. A REVIEW OF ALTERNATE SOURCES FOR REPLACEMENT OF FINE AGGREGATE

Civil Engineering construction activity is always associated with new development and projects. This can be a housing project, industrial infrastructure power plants, docks and harbour works etc., large quantities of traditional construction materials like earth, sand, stones, bricks, cement concrete, steel, aluminium, wood are used. The demand for these materials is increasing in geometric progression. Sustainable development means a commitment to finding and using resources that are renewable. With this philosophy in view, there is an urgent need for optimum reuse of building waste materials available after demolition and renewal of old structures. In the recent past, attention has been shifted in finding alternative sources and materials for the replacement of fine and coarse aggregates. Many researchers have tried different options from organic materials, herbs, glass materials, demolition wastes, wooden wastes, plastic wastes, and electronic wastes and so on. It is worthwhile for exploring the possibilities of application of these materials for further reuse.

Gamashta and Gumashta (2006) examined different properties in reused concrete and brick masonry waste materials and suggests suitable recommendations for further enhancing life of structures, thereby resulting in sufficient economy to the cost of buildings.

Muthulakshmi and Nivedhitha (2012) investigated through their experiments to gauge the effect of partial replacement of natural coarse aggregates (NCA) and natural fine aggregates (NFA) by recycled coarse aggregates (RCA) and recycled fine aggregates (RFA) on compressive strength, tensile strength and flexural strength of recycled concrete. 10%, 20%, 30% of NCA and NFA were replaced with RCA and RFA respectively. The results obtained from compressive strength test, split tensile test and flexural test were compared with the conventional concrete. From the experimental study, it was observed that compressive strength & tensile strength of concrete with recycled aggregates increased up to 20%

replacement of natural aggregates with recycled aggregates whereas the flexural strength of recycled concrete was found to decrease with increase in percentage of RCA & RFA. Jayakumar et al 2016 aimed finding the optimum concrete mixture encompassing of cement mortar and brick bat debris as a substitute for fine aggregate. The basic properties of cement mortar debris and brick bat debris as fine aggregate was studied and it is compared with the traditional fine aggregate. It was tried in different proportions on strength and was recorded at the curing age of 7, 14 and 28 days. The results concluded that particular proportions of cement mortar debris and brickbat debris displayed enhancing effect on the compressive strength.

Nili et al 2012 worked on the concrete potential as a friendly environmental construction material to use different type of waste materials as a partial replacement for aggregates and even cement. Six type of waste materials include: recycled concrete aggregate (RCA), waste glass of all kinds mostly (container glass, thin film transistor liquid crystal display [TFT-LCD], crushed clay brick aggregate, various plastic types such as polyethylene (PET), scraped PVC pipes and rubbers , recycled ceramic materials from sanitary installation and recycling ornamental stones (Granite and Marble). For all six categories of recycled materials, mechanical and durability properties are discussed. Also reuse of these materials in concrete were evaluated from the viewpoints of environmental aspect and cost efficiency. It is concluded that by introducing of some outstanding features of these materials, a new perspectives to concrete technology and efficiently may be expected.

Sriharsha and Murthy (2014) utilized demolition debris from old structures of construction industries and the blast furnace slag which is easily available from iron ore industries for manufacturing the test samples in various batch mix proportions with 53 grade cement; providing a stage for further research in this aspect, using the feasible results from experimental studies, in order to manufacture test blocks or bricks as practicable. Laboratory tests are carried out to assess the physical properties like compression strength and water absorption on these test samples. The strength characteristics of all the above samples with standard mixes and modified proportions are studied. The compressive strength and water absorption are calculated for each sample and are compared with each mix and conclusions are drawn.

Kumar and Siva (2015) carried out laboratory experiments to scrutinize a concrete made of partial replacement of coarse aggregate with construction and demolition waste materials like ceramic tiles waste, plastic debris, crushed bricks. The resultant concrete thus produced was tested on the following parameters like compressive strength, workability, flexural strength. The results thus obtained are compared with a plain cement concrete. By using low weight materials like plastic debris they got a light weight concrete. The workability of concrete produced with construction waste when compared with plain cement concrete is not reliable but it produced a considerable increase in the compressive strength.

Dinesh Kumar et al 2016 focused on the usage of coal bottom ash in replacing the fine aggregate. Bottom ash forms up to 25% of the total ash while the fly ash forms the remaining 75%. Their research experimented the behaviour of concrete using coal bottom ash at different replacement level of sand. The study evaluated the potential of coal bottom ash as a partial replacement of sand in concrete by 0% , 10% , 20% , 30%, 40%, and 50% . In order to study the mechanical properties of concrete, M25 grade was fixed. At the point when the bottom ash is utilized as a part of the concrete, the workability of existing is diminished because of the water request. At last, the utilization of coal bottom ash in concrete is prescribed as a different option for fine aggregates in concrete but limited to 20% by weight of fine aggregate.

Sai Samanth and Prakhar (2016) dealt with the analysis of properties of concrete replaced by recycled construction and demolition debris as aggregates in concrete mix. Determining the replacement ratio of this debris as fine and coarse aggregate is presented in this paper with experimental results. This effective utilization of the debris as aggregates without altering the properties of conventional concrete contributes in solid waste management and also helps in finding partial replacement for sand and quarry.

Based on the literature review, the present research work focusses on the demolished bricks as an alternate source. As bricks are wasted during the demolition of some construction site in some sites it is being used as a replacement of coarse aggregate. In India about 30% of construction is being done on the demolition site where most of the waste construction is wasted. Such waste construction material can be used as replacement in making concrete blocks.

3. MATERIALS AND METHODS

Concrete is prepared by mixing various constituents like cement, aggregates, water etc. which are economically available. Ordinary Portland cement of 53 grade was used throughout the work. The fine aggregate used in this investigation was clean river sand, whose maximum size is 4.75 mm, conforming to grading zone II. The properties of the materials are presented in Table 1.

Table 1 Properties of the constituent materials

No.	Parameter	OPC used	Brick Debris	Fine Aggregate	Coarse Aggregate
1.	Normal Consistency	29%	--	--	--
2.	Initial Setting Time (minutes)	45	--	--	--
3.	Final Setting Time(minutes)	240	--	--	--
4.	Specific Gravity	3.15	2.00	2.45	--
5.	Bulk density	--	975	1135	1169
6.	Fineness modulus	--	3.76	4.62	--
7.	Water Absorption	--	5.26%	2.04%	--
8.	Apparent specific gravity	--	2.23	2.57	--
9.	% of Voids	--	112.99%	55.02%	154.65%

Bricks crushed in coarse powder form were used as a fine aggregate for making concrete. The waste bricks as obtained from garbage of a broken building were collected and pulverized to get the particle passing 4.75 mm sieve and retained on 0.075 mm sieve to get the grading of fine aggregate. 5, 10, 15, and 20% brick powder is used as replacement of fine aggregate in the experiments.

The aim of the experiment was to assess the properties of concrete made with crushed brick and to study important aspects such as compressive strength of concrete prepared by using brick debris with different percentage of replacements with Fine Aggregate. The concrete mix design was proposed using Indian Standard for control concrete (IS 10262:1982). The grade was M20. The Proportion of materials shown in Table 2. The replacement levels of sand by brick powder were used in terms of 5%, 10%, 15%, and 20% in concrete.

Table 2 Mix proportion

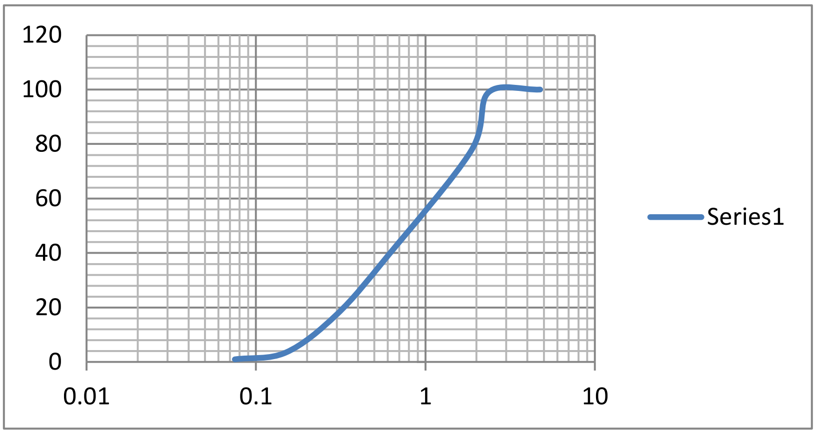
No.	Ingredients	Kg/m^3	Proportion
1.	Ordinary Portland Cement	383	1:1.5:3 W/C = 0.5
2.	Fine Aggregate	546	
3.	Coarse Aggregate	1187	

Cement used for the study was tested for the parameters specific gravity, fineness, consistency test, setting time. Fine aggregate were tested for Fineness modulus, specific gravity, Water absorption, Bulk density, Void ratio. Concrete blocks were tested for compressive strength under four different mixes. In CC mix, the conventionally Cement, Coarse aggregate, Fine Aggregate were mixed with Water and analysed for strength parameters. In R-1 mix only 5% Fine Aggregate is replaced with brick debris and other ingredients were as same in CC mix. In R-2 mix only 10% Fine Aggregate is replaced with brick debris and other ingredients were as same in CC mix. In R-3 mix only 15% Fine Aggregate is replaced with brick debris and other ingredients as same in CC mix. In R-4 only 20% Fine Aggregate is replaced with brick debris and other ingredients were as same in CC mix.

In order to study the effect of replacement of sand in various ratio of brick debris 12 numbers of cube of 150mm x150mm x 150mm size were cast and used as test specimens to determine the compressive strength at the age of 7,14 and 28 days. All specimens were tested every time at the required days and mean value was taken. Sieve analysis (IS 2386-PART I) was carried out on the river sand, cement mortar debris and brick bat debris as shown in Table 3 and Table 4.

Table 3 Gradation analysis of the fine aggregate

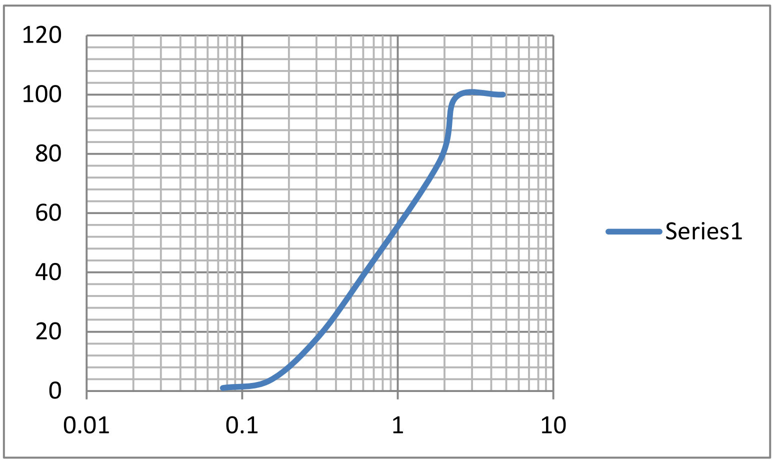
No.	Sieve size	Weight of Aggregate retained	Weight retained (%)	Cumulative % weight retained	Percentage passing (%)
1.	4.75	0	0	0	100
2.	2.36	10	10	1	99.0
3.	1.18	215	225	22.5	77.5
4.	500µ	385	610	61.0	39.0
5.	300µ	215	825	82.5	17.5
6.	150µ	140	965	96.5	3.5
7.	75µ	25	990	99.0	1
8.	pan	10	1000	100.0	--



Graph 1 Sieve analysis graph for fine aggregate

Table 4 Gradation analysis of the brick debris

No.	Sieve size	Weight of Aggregate retained	Weight retained (%)	Cumulative % weight retained	Percentage passing (%)
1.	4.75	0	0	0	100
2.	2.36	40	40	4.0	96.0
3.	1.18	125	165	16.5	83.5
4.	500μ	175	340	34.0	66.0
5.	300μ	155	495	49.5	50.5
6.	150μ	290	785	78.5	21.5
7.	75μ	155	940	94.0	6
8.	Pan	10	1000	100.0	--



Graph 2 Sieve analysis graph for brick debris

4. EXPERIMENTAL OBSERVATIONS

The casted cubes were tested for compressive strength at 7, 4 and 28 days of curing. The compressive strength values of 7, 14 and 28 days were obtained and are listed in the following Table 6, Table 7 and Table 8 respectively.

Table 6 Compressive strength values for 7 days

No.	Mix % of brick debris	Days	Area mm^2	Weight kg	Load kN	Compressive strength N/mm^2
1	Normal	7	150x150	8.100	520	23.11
2	5%	7	150x150	8.025	615	27.33
3	10%	7	150x150	8.086	596	26.49
4	15%	7	150x150	7.910	535	23.78
5	20%	7	150x150	7.865	484	21.51

Table 7 Compressive strength values for 14 days

No.	Mix % of brick debris	Days	Area mm^2	Weight kg	Max Load kN	Compressive strength N/mm^2
1	Normal	14	150x150	8.250	627	27.87
2	5%	14	150x150	7.930	807	35.87
3	10%	14	150x150	7.810	878	39.02
4	15%	14	150x150	8.210	664	29.51
5	20%	14	150x150	7.950	680	30.22

Table 8 Compressive strength values for 28 days

No.	Mix % of brick debris	Days	Area mm^2	Weight kg	Load kN	Compressive strength N/mm^2
1	Normal	28	150x150	7.925	508	22.57
2	5%	28	150x150	7.345	561	24.93
3	10%	28	150x150	8.355	564	25.06
4	15%	28	150x150	8.060	448	19.91
5	20%	28	150x150	7.405	474	21.06

5. RESULTS AND DISCUSSIONS

The experimental investigations carried out in the laboratory to determine the strength properties of the concrete with the additional mixture of crushed brick and test results are discussed. As per design obtained in accordance to code IS-10262, mix proportion of various materials (viz. Cement, Coarse Aggregate, Fine Aggregate and Water) is calculated for M-20 grade of concrete. The cubes were casted and tested in the laboratory. The results of compressive strength of cubes for 7, 14 and 28 days for various mixes are compared and presented in Figure 1. The compressive strength for 5% 10%, 15% and 20% replacement of Fine Aggregate by brick debris were compared with conventional/Natural concrete.

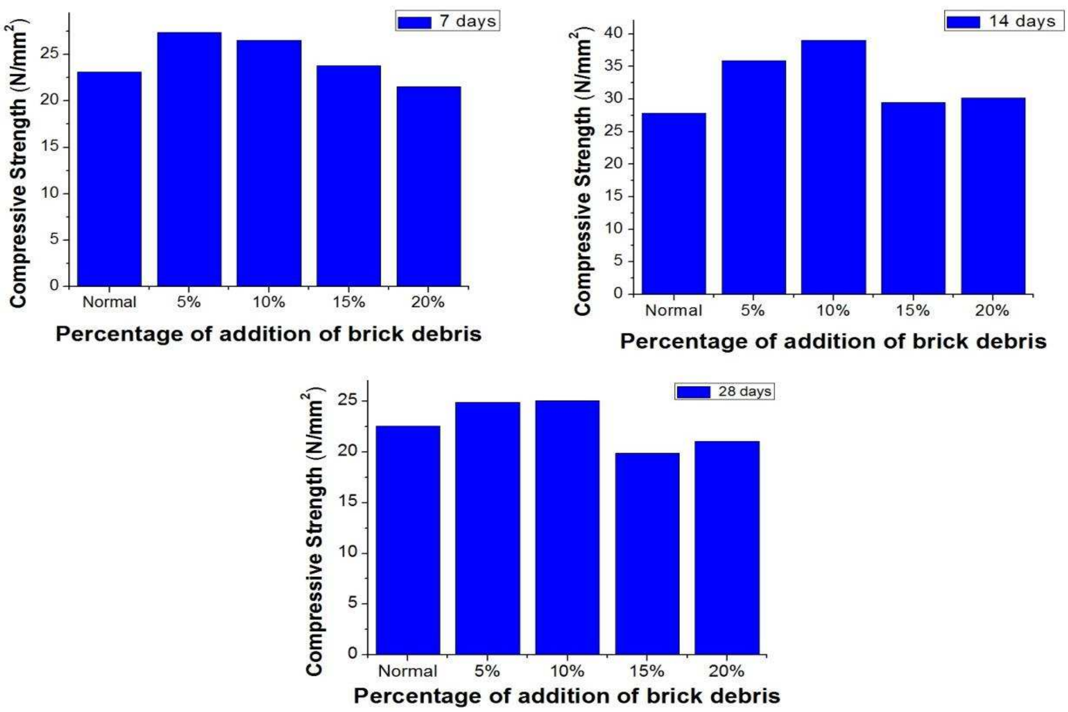


Figure 1 Comparison of Compressive strength for various proportions of brick debris @ 7, 14 and 28 days

Out of all tests conducted on concrete, compressive strength of concrete has utmost importance and which gives all the important characteristics of a concrete. We have casted a total of 12 concrete blocks with different proportions including OPC. Size of the concrete block 150mm×150mm×150mm cube moulds are used for the tests. The concrete is poured in to mould and are tampered to avoid voids. After hours of duration test moulds are removed and the specimens are kept in water for curing. These specimens are tested under compressive testing machine after 7 days, 14 days and 28 days after casting.

6. CONCLUSIONS

Based on the experimental study of investigating the use of brick debris in concrete, the following conclusions which are limited to the materials used in the study.

- This is an eco-friendly concrete as it subsides the stagnation of demolished brick waste by consuming it.
- As much as of the total cost of cement in conventional method can be saved by this procedure. Cost saving percentage increases with increase in richness of mix design.
- Concrete gains early strength and hence shuttering can be removed early thereby reducing the secondary overhead copy.
- The test results of compressive strength shows that the optimum replacement of fine aggregate is achieved at 10% replacement of fine aggregate by crushed brick debris compared to the respective conventional concrete strength.
- The possibility exists for the partial replacement of fine aggregate with brick debris which is produced during demolition of construction site.

Also other industrial and agro-waste materials can be appropriately utilized in civil construction works. Therefore, the economic viability of such applications along with the durability of these materials needs further examination. An important obvious advantage is that with recycling of stone, aggregate, bricks etc. quarrying and mining for stones, and will be reduced. Thus the earth surface can be further saved and ecological disturbances on account of this activity will be reduced. For example, raw material for bricks manufacturing is totally earth based. Reuse of bricks means lesser possibilities of removing fertile earth, soil grass cover and forestation. This will minimize environmental destruction in over all terms. With large volume of building works, and to meet its demand, it is observed that there can be large uncontrolled growth of brick kilns, contributing to environmental decay.

REFERENCES

[1] Animesh, K. Tiwari, J. Soni, K. A Review of Partial Replacement of Fine Aggregate & Coarse Aggregate by Waste Glass Powder & Coconut Shell. International Research Journal of Engineering and Technology. 4(10), 2017, pp 187-190.

[2] Sharifi, Y. Houshiar, M. Aghebati, B. Recycled Glass Replacement as Fine Aggregate in Self-compacting Concrete. Frontiers of Structural and Civil Engineering. 7(4), 2013, pp 419-428.

[3] Muthu Lakshmi, S. Nivedhitha, R.R. Efffect of Partial Replacement of Aggregates by Recycled Concrete Debris on Strength of Concrete. Malaysian Journal of Civil Engineering. 27(2), 2015, pp 250-259.

[4] Dinesh Kumar, G. Mohiuddin, M.Y. Haleem, M.A. An Experimental Study on Partial Replacement Fine Aggregate with Coal Bottom Ash in Concrete. International Journal of Research Sciences and Advanced Engineering. 2(15), 2016, pp 39-49.

[5] Nili, M. Biglarijoo, N. Mirbagheri, S.A. A Review on the Use of Various Kinds of Debris and Demolitions in Concrete and Mortar Mixes. 10th International Congress on Advances in Civil Engineering. 17-19 October 2012 Middle East Technical University, Ankara, Turkey.

[6] Sai Samanth, A, Prakhar. Study of Strength Properties of Concrete with Construction Debris as Aggregates. International Journal of Engineering Research in Mechanical and Civil Engineering. 1(5), 2016, pp 42-45.

[7] Gamashta, L. Gumashta, S. Reuse of Concrete and Masonry Waste Materials in Construction to Minimize Environmental Damages due to Quarrying. Journal of Environmental Researh and Development. 1(1), 2006, pp 65-67.

[8] Kumar, N.S.T. Siva, C. Use of Construction Renovation and Demolition Waste in Partial Replacement of Coarse Aggregate in M20 Concrete. International Journal of Research in Engineering and Technology. 4(10), 2015, pp 375-378.

[9] Shriharsha, Murthy S.N. Alternative building materials using fine ground granulated blast furnace slag and fine demolition debris. International Journal of Renewable Energy and Environmental Engineering. 2(2), 2014, pp 86-88.