International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-4, March 2013

Feasibility Study of Partial Replacement of Cement and Sand in Mortar by Brick Waste Material

Hemraj R. Kumavat, Yogesh N. Sonawane

***Abstract*— Brick waste is investigated for its use as a replacement of cement and sand in cement mortar as it behaves as a pozzoloana. It may make an important contribution towards decreasing the adverse effect of the production, disposal and the dumping of brick waste on the environment. The results show that richer mixes gives lower value of bulk density and higher values of compressive strength for sand replacement with brick waste up to 40%. The paper presents useful data for the brick manufacturing industry, builders and mortar manufacturing companies in terms of minimizing the impact of brick waste and using eco-efficient materials.**

***Index Terms*—Bulk dry density of fresh and hardened mortar, cement replacement, compressive strength, sand replacement.**

I. INTRODUCTION

For manufacturing of cement a major source is lime-stone which evolves CO_2 has significant contribution in the greenhouse gases. Each tone of the cement produced release about 0.9 tone of CO_2 into the environment which is dangerous to environment.[8]

The main objective of the use of very fine red clay ceramic waste in rendering mortars is the reduction in the primary binder (cement) content made possible by the potential pozzolanic effect of this recycled material, with very clear environmental benefits in the reduction of overly-high energy consuming cement and economic benefits in the potential reduction of the cost of mortars. [2]

Currently in the industry there are various by-products, minerals are used in the replacement of the cement and sand for the production of the mortar, such as Fly ash, Silica fume, Blast furnace slag, Marble powder, GGBS etc.

Brick waste may be used as alternative material for partial replacement of cement and sand in mortar. The major content and chemical, physical properties of brick waste material is similar to cement and sand, hence we may used this material as one of the construction material in the construction industry to fulfill the current industry demand and to ensure sustainable construction. The Brick waste product use for experimental work is collected from different brick plant sites in Jalgaon and Dhule district and collecting sample of brick waste with different proportion of fly ash and clay used for brick manufacturing.

Manuscript published on 30 March 2013.
***Correspondence Author(s)**

Prof. Hemraj Ramdas Kumavat, Civil Engineering Department, North Maharashtra University/ R. C. Patel Institute of Technology, Shirpur, Dist.Dhule, Maharashtra, India.

Prof. Yogesh Narayan Sonawane, Civil Engineering Department, North Maharashtra University/ R. C. Patel Institute of Technology, Shirpur, Dist.Dhule, Maharashtra, India.

Photo 1 –Brick waste from brick manufacturing plant

II. LITERATURE REVIEW

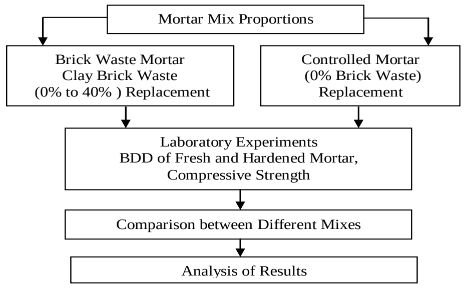
Amorim and Ferreira [1] studied the use of residential construction waste and residues from red ceramic industry for production of rendering mortars. Silva et al. [2] conclude from their research on the use of burnt clay fines, whose characteristics are similar to those of ceramics, its manufacturing depending on the temperature they are subjected to in the transformation, are also a frequent object of study for this type of application in mortars.. From observation results carried out the replacement of cement and sand with fine aggregates in mortars, fine ceramics are among the ones on which greater emphasis has been laid essentially due to its potential pozzolanic properties. Moriconi et al. [9], Toledo et al. [5] and Silva [6] are some typical examples of studies where very interesting results are obtained.

Studies on the incorporation of fines that were considered potentially pozzolanic make up most of the research on the replacement of cement in mortars, such as those of Moriconi et al. [9], who used fly ash mortar. Other fine materials have equally been studied through its addition to mortars components and the simultaneous reduction of the cement content. Nehdi and summer [4] studied the production of cements incorporating high volume replacement of ordinary Portland cement (OPC) by recycled industrial byproducts. On the other hand, Angelim et al. [10] studied the influence of the addition of clay and siliceous fines on the properties of rendering mortars.

III. EXPERIMENTAL DETAILS

A. *Sequence of Testing*

The experimental analysis is given in the following chart:



B. *Materials and Methods*

The proportion of cement to sand ratio in the mortar is 1:4. The brick waste was blended with cement at replacement with cement and sand, ratios of 100:0, 90:10, 80:20, 70:30 and 60:40. The data from the brick waste mortar is compared with data from a "control" mortar without brick waste. Normally a mason uses his experience in varying the water content to obtain a mortar with suitable workability for his desired application. The water cement ratio for this experiment is taken from 0.8 to 1.0. Test which were conducted in general accordance with the applicable procedures outlined by the European Norm EN 1015-10 (1999) [2], ASTM C 270 [3]. This research work carried out in two states; in fresh state dry bulk density of fresh mortar determined, in hardened state dry bulk density, compressive strength of hardened mortar is determined and compare the result of controlled mortar with replaced mortar.

IV. RESULTS AND DISCUSSION

A. *Bulk density of fresh mortar*

This test was performed by weighing a known volume of fresh mortar according to European norm EN-1015 [2], using a sample of approximately 200 ml of fresh mortar for each composition. They show that fresh mortar bulk density substantially decreases, almost linearly as the fine aggregate was replaced with brick waste powder as shown in figure-1. The bulk density of brick waste mortar is generally lower than that of controlled mortar they are presented in table-I, II. There is approximately linear relationship between the replacement ratio and bulk density of fresh mortar.

Table I: Bulk Density of fresh Mortar – Cement replacement

Replace level	M_2-M_1	V_v	Bulk density = (M_2-M_1) /Vv	Bulk density (Kg/m^3)
BW-0	403.5	π/4 x $(0.05)^2$ x 0.088 =0.00017 27	2336.42	22.92
BW-5	402.57		2331.03	22.86
BW-10	401.64		2325.65	22.81
BW-15	399.22		2311.66	22.67
BW-20	396.81		2297.68	22.54
BW-25	393.67		2279.5	22.36
BW-30	390.53		2261.32	22.18
BW-35	390.94		2263.69	22.2
BW-40	391.35		2266.06	22.23

Table II: Bulk Density of fresh Mortar – sand replacement (1:4)

Replace level	M_2-M_1	V_v	Bulk density = (M_2-M_1) /Vv	Bulk density Kg/m^3
BW-0	403.5	π/4 x $(0.05)^2$ x 0.088 =0.0001 727	2336.42	22.92
BW-5	403.14		2334.12	22.89
BW-10	402.78		2332.25	22.87
BW-15	397.4		2301.11	22.56
BW-20	392.02		2269.95	22.26
BW-25	390.07		2258.79	22.15
BW-30	388.13		2247.64	22.04
BW-35	386.39		2237.45	21.94
BW-40	384.65		2227.27	21.84

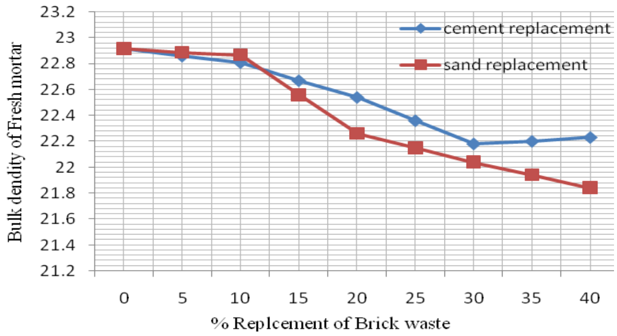


Figure 1: Bulk density of fresh mortar with replacement ratios

B. *Dry Bulk density of hardened mortar*

This test was performed in accordance with European Norm EN-1015 [2]. It consisted of measuring the mass of mortar prisms 40 x 40 x 160 and dividing it by their volume. A sample of three specimen previously subjected to curing period of 28 days was used for each mortar.

The dry bulk density of hardened mortar decreases as sand was replaced with brick waste. As for fresh mortar, due to lower density of brick waste powder compared with that of sand. However, lower compactness is also responsible for a decrease of dry density of mortar with sand replacement than cement replacement; the results are presented in table-III, IV. Dry bulk density suddenly decreases in cement replacement and linearly decreases in sand replacement as shown in figure-2, 3.

Table III: Dry Bulk Density of hardened Mortar - Cement Replacement (1:4)

Replace %	M_{dry}	M_{sat}	M_{ime}	M_{sat}-M_{ime}	Volume = M_{sat}-M_{ime} /1000	BDD M_{dry}/V_s
	(Kg)	(Kg)	(Kg)	(Kg)	(m^3)	(Kg/m^3)
BW-0	0.768	0.786	0.456	0.33	0.00033	2327.27
BW-10	0.752	0.770	0.432	0.338	0.000328	2224.85

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

BW-20	0.750	0.768	0.430	0.338	0.000338	2218.93
BW-30	0.720	0.738	0.410	0.328	0.000328	2195.12
BW-40	0.724	0.744	0.412	0.332	0.000332	2180.72

Table IV: Dry Bulk Density of hardened Mortar - sand Replacement (1:4)

Replace %	M_{dry}	M_{sat}	M_{ime}	M_{sat}-M_{ime}	Volume= M_{sat}-M_{ime} /1000	BDD M_{dry}/V_s
	(Kg)	(Kg)	(Kg)	(Kg)	(m^3)	(Kg/m^3)
BW-0	0.768	0.786	0.456	0.33	0.00033	2327.27
BW-10	0.770	0.770	0.424	0.346	0.000346	2225.43
BW-20	0.732	0.734	0.392	0.342	0.000342	2140.35
BW-30	0.718	0.720	0.380	0.340	0.000340	2111.76
BW-40	0.696	0.700	0.354	0.346	0.000346	2011.56

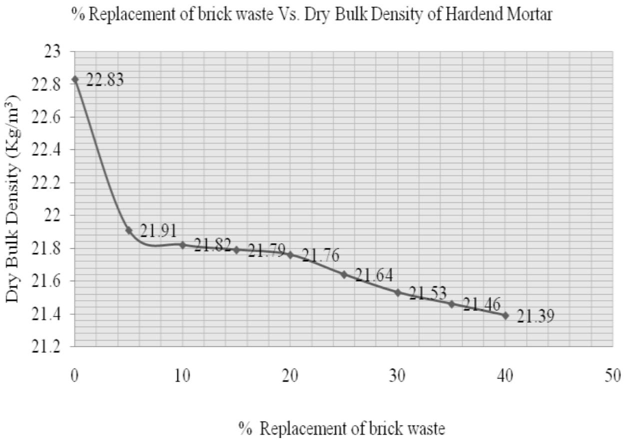


Figure 2: Dry bulk density of hardened mortar Cement Replacement (1:4)

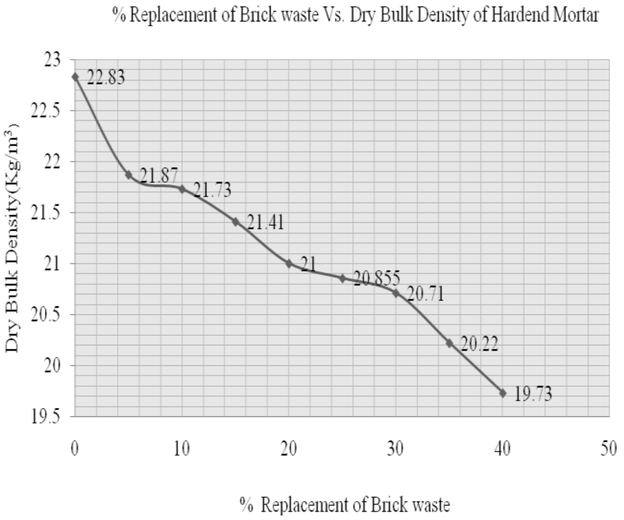


Figure 3: Dry bulk density of hardened mortar sand Replacement (1:4)

C. Compressive strength of hardened mortar

The result show that compressive strength increased for replacement ratio of sand with brick waste up to around 40% are shown in figure-5. For higher replacement ratio, values increased. This is the combination of some degree of pozzalnic effect of these brick waste with filler effect.

Abbreviation: - *M_1= Weight of empty cylinder, M_2= Weight of cylinder + mortar, M_2-M_1= Weight of mortar up to 200 ml level, Vv = volume of voids, M dry = Dry weight, M sat = Saturated weight, Mime = Immersed weight, V_s = Saturated volume, B.D.D = Bulk dry density*

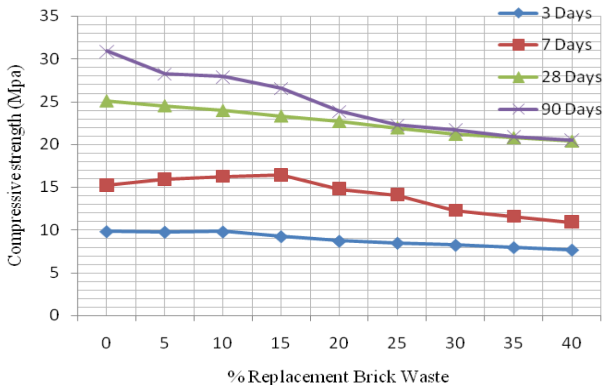


Figure 4: Compressive strength - Cement Replacement (1:4)

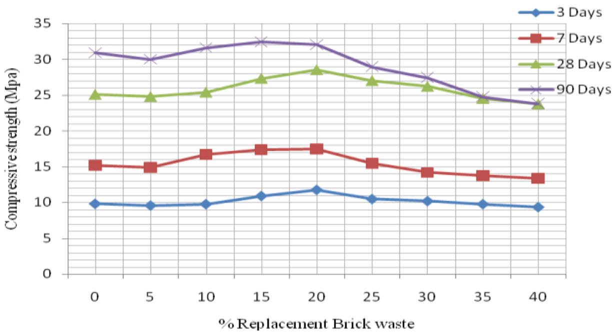


Figure 5: Compressive strength - sand Replacement (1:4)

IV. CONCLUSION

After studying the experimental results we conclude that:

[1] The bulk density of fresh mortar reduces 80% to 90% of controlled mortar in sand replacement. The sudden decrease in bulk dry density of mortar in 5% to 10% of replacement of BW in cement replacement.

[2] Decreases compressive strength of brick waste mortar than controlled mortar in cement replacement and increase compressive strength of brick waste mortar than controlled mortar up to 30% in sand replacement

[3] From observed results of compressive strength of cement replacement reduces the comprssive strength of mortar with increase in percentage of replcement of BW, and in replacement of 5% to 10%, compressive strength is same as controlled mortar.

[4] From observed results of compressive strength of sand replacement, strength increases from replacement of 10% to 25% compared with controlled mortar.

[5] The result of compressive strength of sand replacement of 3,7,28 days curing period is more than compressive strength of 90 days curing period with compared to controlled mortar. So this type of mortar gives early strength, as acclerartor.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

[6] Results of dry bulk density shows that, this type of mortar is useful for high rise building structure due to lesser weight of mortar in dry condition.

Standards used in the experimental work

A. European Standards

[1] European Standard (1998-a) "Methods of test for mortar for masonry, Part 6: Determination of bulk density of fresh mortar." EN 1015-6, European Committee for Standardization CEN, Brussels, October.
[2] European Standard (1999-b) "Methods of test for mortar for masonry, Part 10: Determination of dry bulk density of hardened mortar." EN 1015-10, European Committee for Standardization CEN, Brussels, August.
[3] European Standard (1999-c) "Methods of test for mortar for masonry Part 11: Determination of flexural and compressive strength of hardened mortar." EN 1015-11, English European Committee for Standardization CEN, Brussels, August.

B. Annual Book of ASTM Standards

[1] ASTM C 150-86, *Standard Specification for Portland Cement, Annual Book of ASTM Standards*, 1988, (Vol. 4.01-Cements, Lime, Gypsum), Easton, USA.
[2] ASTM C 109-87, *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars*, Annual Book of ASTM Standards, 1988, (Vol. 4.01-Cements, Lime, Gypsum), Easton, USA.
[3] ASTM C-270 *Standard Specification for Mortar for Unit Masonry*.
[4] ASTM C 109 / C 109M - 11b *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).*

C. BIS Codes

[1] BIS Codes No. IS 2250:1981 (reaffirmed 2005) - Code of Practice for Preparation and Use of Masonry Mortars (First Revision), IS 1905: 1987 (Reaffirmed 2007).
[2] BIS 8112 (2005) Specification for 53 grade Ordinary Portland Cement. Manak Bhavan New Delhi.
[3] BIS 2116 (1980) Specification for Sand for masonry mortars (1st revision), Manak Bhavan New Delhi, India.
[4] BIS-3812 (Part-1): 2003 Pulverized fuel ash-specification for use as pozzolana in cement, cement mortar and concrete, Bureau of Indian Standards, New Delhi, India.

REFERENCES

1. Amorim L. V., Lira H. L. and Ferreira H. C. (2003) "Use of residential construction waste and residues from red ceramic industry in alternative mortars." *J. Environ. Eng.*, 129-10, pp- 916–920.
2. J Silva, J de Brito and R Veiga (2008) " Fine ceramics replacing cement in mortars partial replacement of cement with fine ceramics in rendering mortars" *Materials and structures* (2008) 41, pp-1333-1344
3. Miranda L. , Selmo S. (1999). "Evaluation of the effect of recycled waste on the properties of hardened mortars, by rational proportioning procedures." *Proc., III Brazilian Symp. of Mortars Technology (SBTA)*, IPT, Vitoria, Brazil, 583–594
4. Nehdi M. and Khan A. (2004) Protective system for buried infrastructure using recycled tire rubber-filled cement mortars *Rep. No. SP- 219, American Concrete Institute (ACI)*, Detroit, pp- 99–114.
5. R. D. Toleda Filho, J.P. Goncalves, B. B. Americano and E. M. R. Fairbairn "Potential for use of crushed waste calcined clay brick as a supplementary cementitious material in brazil" *Cement and concrete research* 37-2007, pp-1357-1365
6. Silva J. (2006) "Incorporation of red-brick waste in cement mortars." ME dissertation, IST Technical Univ. of Lisbon, Lisbon, Portugal.
7. Toledo Filho R., Americano B., Fairbairn E., Rolim J., and Filho J.(2001) "Potential of crushed waste burnt clay brick as a partial replacement for Portland cement." *Rep. No. SP-202, American Concrete Institute (ACI)*, Detroit, PP-147–160.
8. A B. Tardale, S S Patil, N. J. Pathak, (2011), "Feasibility Study of Replacement of Cement and Sand in Concrete and Mortar by ECOSPHERE Material", *International Journal of Earth Sciences and Engineering* , Volume 04, No 06 SPL, October 2011, pp- 920-923
9. Moriconi G, Corinaldesi V, Antonucci R (2003) "Environmentally-friendly mortars: a way to improve bond between mortar and brick", *Material and Structure*, 36(10), pp-702–708
10. Angelim RR, Angelim SCM, Carasek H (2003) "Influence of the addition of limestone, siliceous and clay fines in the properties of mortars and renderings", Paper presented at the V *Brazilian Symposium on Mortars Technology* (SBTA), Paulo, Brazil, 11–13 June 2003

AUTHOR PROFILE

Hemraj Ramdas Kumavat, Completed B.E. in Civil Engineering in 2003 and M.E. in Building Science and Technology in 2009 from North Maharashtra University, Jalgaon (MS). Presented and published 04 research papers in international conference, 01 paper in national conference and published 02 papers in international journal. Along with the publication author had attended 04 workshops sponsored by ISTE. Also he has associate member of IEI. Have 2.5 year industrial experience of construction of various civil engineering projects like Building, Roads and Canals. From last 7.5 years he is working as Assistant Professor in Civil Engineering Department in R.C.Patel Institute of Technology, Shirpur, Dist. Dhule (MS)

Yogesh Narayan Sonawane, Completed B.E. in Civil Engineering in 2008 and M. TECH. STRUCTURE in 2010 from SVNIT, Surat. Presented and published 02 research papers in international conference, and published 02 paper in international journal. Along with the publication author had attended 04 workshops. From last 03 years he is working as Assistant Professor in Civil Engineering Department in R.C. Patel Institute of Technology, Shirpur, and Dist. Dhule (MS)

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)