International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Experimental Investigation on use of alternative materials in bricks

P.S. Kulkarni1, P.Shewale2, N.Dhume3, P.Shevale4, S.Tanpure5.

1Asst. Prof., Civil Engg., Vishwakarma Institute of Information Technology, Pune, deshpandeneela@yahoo.com

2B.E Student, Vishwakarma Institute of Information Technology, Pune, pashevale20@gmail.com

3B.E Student, Vishwakarma Institute of Information Technology, Pune, rajshevale@gmail.com

4B.E Student, Vishwakarma Institute of Information Technology, Pune,nachiketdhume@gmail.com

5B.E Student, Vishwakarma Institute of Information Technology, Pune tanpuress@gmail.com

Abstract— A substantial growth is seen in the consumption of plastic and glass in recent years which leads to growth in their wastes and creates huge environmental threat. On the other hand conventional fine aggregate used in bricks are depleting at an increasing rate. Thus to curb the problem of environmental threat and depleting natural resource, plastic bottle waste and glass bottle waste can be used in fly ash bricks as partial replacement to conventional artificial fine aggregate. The current paper focuses on experimental studies done on fly ash bricks made using plastic bottle waste, termed as waste plastic aggregates (WPA) and glass bottle waste, termed as glass aggregates (GA). Artificial sand used in bricks is replaced by WPA and GA in appropriate percentages and the properties of compressive strength, flexural strength, water absorption and density were tested with water binder ratio of 0.1 and 0.15. The results show that the compressive strength and water absorption increases with increase in percentage of WPA and GA. Reduction in flexural strength and density is seen with increase in percentage of WPA and GA in bricks. However at appropriate water to binder ratio the bricks can comply with the specifications of class A bricks.

Keywords- Bricks, waste plastic aggregates, glass aggregates, water binder ratio.

1.INTRODUCTION

Use of industrial wastes and by-products as aggregate is of great practical significance for developing building material components as substitutes for the traditional materials. Annually, Asia alone generates 4.4 billion tones of solid wastes of which about 48 (6%) MT is generated in India [1]. In India, 0.7% of total urban waste generated comprises of glass. It is estimated that approximately 10 thousand tons per day of plastic waste is generated. Among the various types of plastics, the largest component of the plastic waste is low density polyethylene/linear low density polyethylene (23%), 17.3% of high density polyethylene and other types [2]. Thus waste generation in India is huge and their disposal is creating a environmental threat. On the other hand bricks are widely used material of building and its manufacturing consumes natural aggregates. Thus use of glass and plastic waste in bricks as replacement to fine aggregates can be an alternative to curb the environmental threat created due to glass and plastic waste and depletion of natural resources. compressive and tensile strength as compared with reference mixes [6]. Compressive strength of the concrete increases with partial replacement of sand by finely crushed waste glass at the later ages indicating the contribution of pozzolanic reaction. Water absorption decreased with increase waste glass aggregate ratio and with 20% of glass aggregate replacement a reduction of 14.68% at 28-day age compared to control can be seen [7]. Concrete with glass mixtures exhibit a faster setting, larger elastic modulus, greater abrasion resistance, lower chloride ion penetrability, lower water absorption, and lower drying shrinkage [8]. Use of waste plastic in concrete can improve its toughness behavior, can absorb high amounts of energy and lowers the various strength properties of concrete and mortar specimens [9]. For a 20% replacement, the slump has decreased to 25% of the original slump value with 0% plastic particle content and the compressive strength shows a sharp reduction up to 72% of the original strength. With 5% replacement the compressive strength shows a 23% reduction [6]. As plastic waste aggregates are incorporated into the concrete its compressive strength, splitting tensile strength and modulus of elasticity decrease, regardless of the type and curing time or the plastic Type and the decrease grows with the w/c ratio of the mixes [10]. In a study done, 10% of plastic in concrete reduces strength and is 10.5% to 13.5% for pulverized blow and injection molded plastic and PET bottles, whereas in the case of polythene bags the reduction in strength is 3.5% and restricts the replacement of sand not more than 10% for RCC works [11]. In the current study, experimental investigation was done to understand the properties of bricks like compressive strength, water absorption; density and flexural strength of bricks made using glass aggregates (GA) and waste plastic aggregates (WPA). Details about materials and their properties comprise the next part of the paper followed by results and discussion on experimental investigations on bricks made using GA and WPA.

2. OBJECTIVES OF THE PROJECT

The objectives of the current project are:

1. To study the basic physical and mechanical properties of WPA and GA.

2. By using IS 2185 –Part I to IV and other related codes, design mix for masonry unit – concrete blocks with an aim of maximum utilization (in percentages) of WPA and GA.

3. Study the properties like density, compressive strength, flexural strength, density and water absorption of bricks mad using WPA and GA.

3. MATERIALS USED IN THE PROJECT

The materials used in the project are plastic waste derived from crushing and shredding plastic bottles or container wastes to a fraction 10mm and below (Refer fig.1) and is referred as waste plastic aggregates(WPA). Polyethylene terephthalate (PET) bottles mainly most common thermoplastic polymer resin of the polyester family and consists of polymerized units of the monomer ethylene terephthalate, with repeating $C_{10}H_8O_4$ units.

Figure. 1 Waste plastic aggregates

Figure. 2 Glass aggregates

The next material used is glass cullet made from crushing of glass bottles to a size of 4.75mm and below (Refer fig.2) and referred as glass aggregates (GA). Container glass is formed from a specific type called soda-lime glass, composed of approximately 75% silicon dioxide (SiO_2), sodium oxide (Na_2O) from sodium carbonate (Na_2CO_3), calcium oxide (CaO), and several minor additives. The other materials used are 53 grade cement, coarse aggregates-20mm and artificial fine aggregate (AS).

4. METHODOLOGY ADOPTED FOR THE PROJECT

In the initial phase conventional brick with cement, fly ash, artificial sand (AS) and water was made which acts as a control specimen. WPA and GA were used as replacement to AS in two phases i.e. phase I and phase II. In phase I, design of mix for brick was made using IS 2185 –Part I to IV and other related codes with WPA and water binder ratio (w/b) of 0.1 and 0.15 with volume batching, as mentioned below: Cement, Fly Ash, AS, water and WPA (0.5% to 1.5 % replacement to AS). In Phase II, design of mix for brick was made using IS 2185 –Part I to IV and other related codes with GA and water binder ratio (w/b) of 0.1 and 0.15 with weight batching, as mentioned below:

Cement, Fly Ash, AS, water and GCA (1% to 5% replacement to AS). The percentage replacement of WPA and GA in mix depends upon the consistency of mortar and the binding properties of WPA and GA with other materials. The proportion of materials selected for the mix was arrived at by two methods i.e. trial and error method employed in lab studied and visits to brick making plants to know the proportion used commercially. The size of the brick manufactured was 230x150x75mm.

5.RESULTS AND DISCUSSION

In the initial phase of mix designing of brick, it is important to understand the properties of materials used for the project. The characteristics of brick tested experimentally are compressive strength, flexural strength, water absorption and density.

5.1 Properties of materials used

The table 1 shows that, the specific gravity of WPA is less due to the thin shape and structure than AS. Larger fineness modulus of WPA is attributed towards the larger size of WPA which can lead to masonry with higher pores and water absorption and affect the strength characteristics of brick.

Specific gravity of GA is slightly lower than AS and WPA. The higher fineness modulus of GA could lead to presence of pores and increased water absorption.

Table 1: Properties of AS, WPA and GA

Property of Aggregate	AS	WPA	GA
Specific Gravity	2.89	1.61	2.4
Fineness Modulus	3.05	3.38	3.16
Moisture Content	2.83	-	-
Loose Bulk Density	1.35kg/lit	1.58kg/lit	1.45kg/lit
Water Absorption	3.86%	-	-
Material finer than 75µ	2.85%	-	-

5.2 Compressive strength

Table 2 show the compressive strength, water absorption, density and flexural strength of bricks made using WPA. Table 3 show the compressive strength, water absorption, density and flexural strength of bricks made using GA. Table 2 and 3 also shows the properties of conventional fly ash brick.

Table 2: Properties of bricks made with WPA as aggregates

Sr. No	Mix ratio C:F:S:W:PA	% replacement of WPA	w/b ratio	28 days compressive strength (N/mm^2)	Flexural strength (N/mm^2)	Water absorption %	Density (Kg/m^3)
1	1:4.72:16.26:0.57:0	0	0.1	8.85	1.23	4.2	2276.92
2	1:4.72:16.23:0.57:0.05	0.5	0.1	13.5	1.91	4	2220.51
3	1:4.72:16.17:0.57:0.1	1	0.1	10.32	1.53	0.96	2282.05
4	1:4.72:16.13:0.57:0.15	1.5	0.1	12.38	1.37	1.68	2165.38
5	1:4.72:16.26:0.57:0	0	0.15	11.70	1.61	2	2289.21
6	1:4.72:16.23:0.83:0.05	0.5	0.15	11.57	1.31	4.31	2187.18
7	1:4.72:16.17:0.83:0.1	1	0.15	12.18	1.37	2.20	2208.97
8	1:4.72:16.13:0.83:0.15	1.5	0.15	14.04	1.39	3.08	2193.59

Table 3: Properties of bricks made with GA as aggregates

Sr. No	Mix ratio C:F:S:W:GA	% replacement of WPA	w/b ratio	28 days compressive strength N/mm^2	Flexural strength N/mm^2	Water absorption %	Density Kg/m^3
1	1:4.72:16.26:0.57:0	0	0.1	8.85	1.23	4.2	2276.92
2	1:4.72:15.95:0.62:0.32	2	0.1	8.10	1.24	2.8	2362.82
3	1:4.72:15.79:0.57:0.49	3	0.1	10.50	1.27	3.1	2189.74

4	1:4.72:15.46:1.03:0.81	5	0.1	11.30	1.49	1.96	2180.77
5	1:4.72:16.26:0.57:0	0	0.15	11.70	1.61	2	2289.21
6	1:4.72:15.95:0.87:0.32	2	0.15	12.4	1.59	2.4	2321.79
7	1:4.72:15.79:0.83:0.49	3	0.15	13.8	1.62	4.8	2173.08
8	1:4.72:15.46:1.13:0.81	5	0.15	15.9	1.34	4.1	2226.92

Fig. 3 and fig. 4 show the influence of partial replacement of WPA and GA for artificial fine aggregate on compressive strength of bricks.

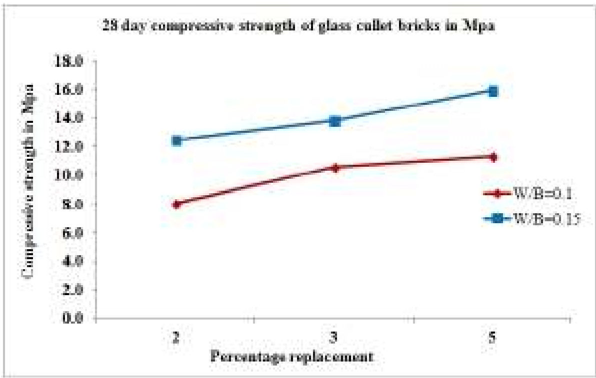


Figure 3. Compressive strength of bricks with WPA

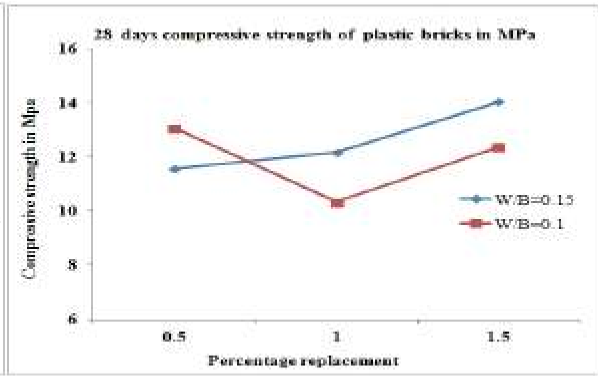


Figure 4. Compressive strength of bricks with GA

IS: 2185 part I, IS 13757:1993 and IS 1077:1997, states that the CS should not be less than 5 N/mm2 for masonry bricks [12, 13, 14]. Figure 3 clearly shows that at w/b ratio of 0.1 and 0.15 and as the percentage replacement of WPA and GA increases in brick the compressive strength also increases. A water binder ratio of 0.15 proves to be appropriate i.e workable with increase in strength characteristics than w/b ratio of 0.1. A slight decrease in strength can be seen when 1% of WPA was replaced in the mix. The increase in strength with plastic waste is due to the elastic property of WPA. The cracks prorogated in bricks during testing which are arrested by the plastic waste and thus the strength characteristics show a improved trend. WPA are characterized by comparatively smooth surface which leads to lower low bond strength between the surface of the plastic waste and the cement paste and thus the bricks with WPA could not be bonded beyond 1.5% replacement. Lower w/b ratio contributes towards increase in strength for 1.5% replacement of WPA.

GA added bricks show an increase in strength with increase in its percentage replacement. The smooth surface of GA contributes towards better workability for a w/b ratio of 0.15. Smaller cullets of glass act as a filler material and seals the pores which increase the strength characteristics of mix.

The GA in the current project consists of particle size 4.75mm and below which also leads to higher compressive strength. Increase in the strength can also be attributed to the pozzolanic reaction with addition of GA. The appropriate percentage of replacement of GA is seen to be 5% with compressive strength of 15.9 N/mm2 and can be treated as class A bricks. For w/b ratio of 0.1 the strength at 5% GA is 11.30 N/mm2 which is lower than strength of brick with w/b ratio of 0.15, however higher than the control mix.

5.3 Flexural strength

Figure 5 and 6 show the trend of attainment of flexural strength of bricks made using WPA and GA.

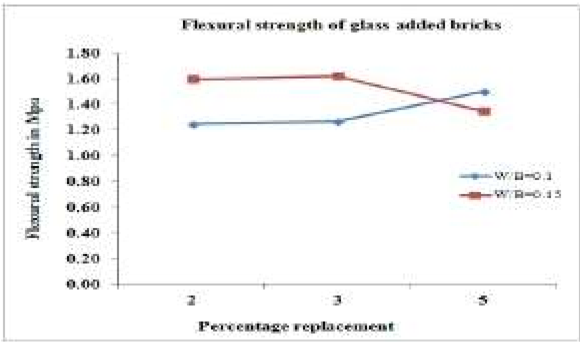


Figure 5. Flexural strength of WPA added bricks

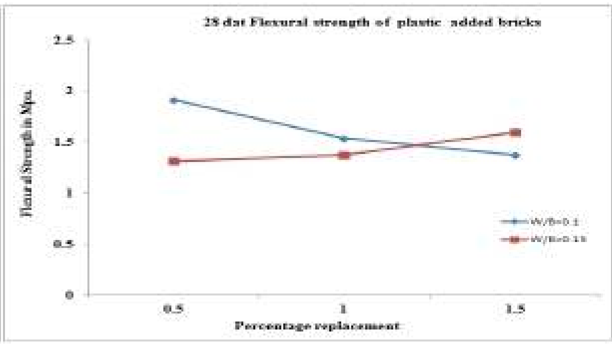
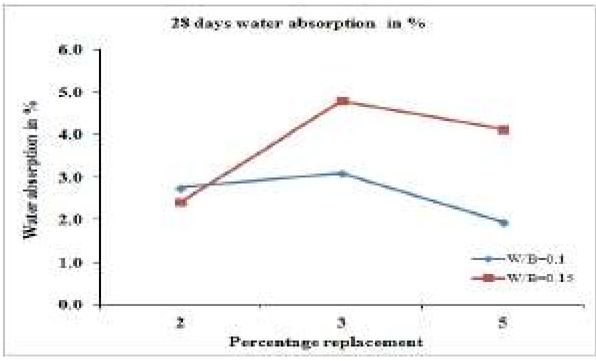


Figure 6. Flexural strength of GA added bricks

A decrease in the flexural strength can be seen in bricks with WPA with increase in percentage replacement of WPA from 0.5% to 1.5%. However the flexural strength attained at 1.5% WPA at w/b ratio of 0.1 shows an increase of 0.14 N/mm2 and a decrease of 0.22 N/mm2 at w/b ratio of 0.15 than control mix. The flexural strength however at 0.5% to 1.5% does not show drastic change. Plastic waste due to its alignment in the mix affects the flexural strength of brick. For GA added bricks the flexural strength is similar as control mix. However at 5% a decrease can be seen with flexural strength of 1.34 N/mm2 at w/b ratio of 0.15. The irregular geometry of GA and its alignment in the mix contributes towards better flexural strength of bricks. The irregular geometry of GA contributes towards good bond between GA and mortar paste and increases the flexural strength up to 3% of replacement of GA. Also when the lime in the cement reacts with the silica in the crushed waste glass in the presence of moisture, calcium hydroxide and tobermorite gel which are the hydration products of two compounds, namely, tricalcium silicate and dicalcium silicate are the result. The tobermorite particles are responsible for the cementing properties as well as otherengineering properties such as strength and shrinkage. In both the types of bricks increase in w/b ratio reduces the flexural strength of bricks.

5.4 Water absorption and density

Figure 7 and 8 below show the water absorption for WPA added brick and GA added bricks for w/b ratio of 0.1 and 0.15.



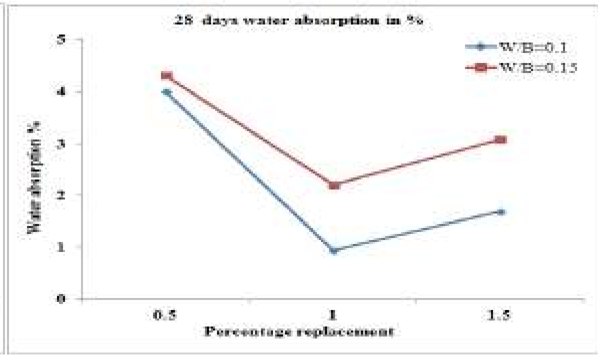


Figure 7. 28 day water absorption of WPA added bricks in % Figure 8. 28 day water absorption of GA added bricks

A slight decrease in water absorption can be seen in WPA added bricks at 1% and 1.08% increase at 1.5% of WPA in bricks. The irregular shape of WPA and GA add towards better bond between WPA and GA and remaining mortar and thus the number of voids reduces and thus reduces the water absorption with increase in percentage of WPA ad GA in mix. The presence of less free water is in the mix with w/b ratio of 0.1 and thus the reduction in water absorption is more evident in the mix than in the mix with w/b ratio of 0.15. The presence of WPA and GA in brick reduces the density of brick with increase in percentage replacement of WPA and GA. 2165.38 kg/m3 is the density recorded for brick with 1.5% WPA at w/b ratio of 0.1 and 2193.59 kg/m3 at w/b ratio of 0.15. Lower density of WPA in the bricks reduces the density of bricks. 2180.77 kg/m3 is the density recorded for 5% GA added bricks at w/b of 0.1 and 2226.92 kg/m3 for w/b ratio of 0.15. The lower decrease in the density of GA added bricks is due to the continuing process of hydration of cement which leads to the formation of hydration products that might fill some of existing voids and hence the density increased of paste. Small increase in density with time and increase in amount of waste content indicates that there may be less further hydration occurred and the positive effect of waste glass on the micro voids of cement paste.

Thus the current project focuses on the fact that WPA and GA can be used in bricks as partial replacement to artificial fine aggregate. Experimental investigation on compressive strength, flexural strength, water absorption and density on bricks show that 1.5% replacement of WPA in bricks with w/b ratio of 0.1 and 0.15 show a compressive strength between 12.28 N/mm2 and 14.4 N/mm2 and can be treated as a class A brick which has a minimum requirement of 5 N/mm2 as compressive strength [12]. The water absorption for the same WPA percentage is seen to be 1.69% and 3.08% and is higher than the control brick, but satisfies the guidelines of maximum 10% of absorption as per guidelines laid by IS 2185:Part I and II. 5% replacement of GA in bricks with w/b ratio of 0.1 and 0.15 show a compressive strength of 11.30 N/mm2 and 15.9 N/mm2 and 1.49 N/mm2 and 1.34 N/mm2 of flexural strength and can be treated as class A bricks. The water absorption is lower at 0.1 as w/b ratio than that at 0.15 w/b ratio for 5% replacement of GA, but is in the range of 10% guided by IS 2185[12].

5. CONCLUSION

The current project is an attempt to understand the suitability of using WPA and GA as replacement to artificial aggregate in bricks. The experimental investigation leads towards the following conclusion:

1. 1.5% replacement of WPA with a w/b ratio of 0.1 and 0.15 in bricks show compressive strength of 12. 38 N/mm2 and 14.4 N/mm2, water absorption of 1.68% and 3.08% and flexural strength of 1.37 N/mm2 and 1.39 N/mm2 respectively and can be treated as a class A bricks.

2. Increase in percentage replacement of WPA in bricks increases the strength of bricks however the appropriate percentage is seen to 1.5% of WPA and later increase in WPA could not be done due to weak bonding properties of bricks.

3. 5% replacement of GA in bricks with w/b ratio of 0.1 and 0.15 show compressive strength of 11.30-15.9, water absorption of 1.96% and 4.1%, flexural strength of 1.49 N/mm2-1.34 N/mm2 respectively. The brick can be treated as class A brick with minimum requirement of 5 N/mm2.

REFERENCES

[1] P. Asokan, "Solid wastes generation in India and their recycling potential in building materials," Building and Environment, vol. 42(6), pp. 2311-2320, June 2007.

[2] M. Malik, M. Bashir, S. Ahmad, T. Tariq, U. Chowdhary ," Study of Concrete Involving Use of WasteGlass as Partial Replacement of Fine Aggregates", IOSR Journal of Engineering, vol. 3(7), pp. 08-13, July. 2013.

[3] S. Gautam, V. Srivastava and V. Agarwal, "Use of glass wastes as fine aggregate in Concrete", J. Acad. Indus, Res. vol. 1(6), pp. 320-322, Nov. 2012.

[4] S. Abdallah, M. Fan, "Characteristics of concrete with waste glass as fine aggregate replacement", International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, vol. 2(6), pp. 11- 17, Jun. 2014.

[5] Corinaldesi, V., Gnappi, G., Moriconi, G. and Montenero, A. "Reuse of ground waste glass as aggregate for mortars." Waste Manage, vol. 25(2), pp. 197–201, 2005.

[6] M. Batayneh, I. Marie, I. Asi, "Use of selected waste materials in concrete mixes", Waste Management, vol. 27, pp. 1870–1876 , 2007.

[7] Sadoon, A., Mizi, F., "Characteristics of concrete with waste glass as fine aggregate replacement". International Journal of Engineering and Technical Research, vol. 2(6), pp. 11-17, 2014.

[8]Jared, R.W., Chris, C., Dan, F., and Farshad, R., "Fresh and Hardened Properties of Concrete

Incorporating Recycled Glass as 100% Sand Replacement", Journal of Materials in Civil Engineering, vol. 26, pp. 1-11, 2014.

[9]N. Saikia, J. Brito, "Use of plastic waste as aggregate in cement mortar and concrete preparation: A review", Construction and Building Materials, vol. 34, pp. 385–401, 2012.

[10] L. Ferreira, J. Brito, N. Saikia, "Influence of curing conditions on the mechanical performance of concrete containing recycled plastic aggregate", Construction and Building Materials vol. 36, pp. 196–204, 2012.

[11] L. Bandodkar, A. Gaonkar, N. Gaonkar, & Y. Gauns, "Pulverised PET Bottles as Partial Replacement for Sand", International Journal of Earth Sciences and Engineering vol. 04(6), pp. 1009-1012, Oct. 2011.

[12] Bureau of Indian Standards. (1990). Specification for Concrete Masonry units. IS: 2185 Part I.

[13] Bureau of Indian Standards. (1990). Burnt clay fly ash building bricks- Specifications. IS 13757:1993.

[14] Bureau of Indian Standards (2002).Common burnt clay building bricks- specification. IS 1077:1997.

