EXPERIMENTAL STUDY ON UTILIZATION OF FLY ASH IN CEMENT BRICK

[1]Ankit B. Prajapati, [2]Dr. Jayeshkumar R. Pitroda, [3]Prof. Amitkumar D. Raval

[1]Final Year M. Tech Student, [2]Associate Professor, [3]Lecturer
[1]Construction Engineering and Management, Civil Engineering Department
[1]BVM Engineering College, Vallabh Vidyanagar, Gujarat, India

Abstract: In India different waste are generated form the different industrial, mining, and agricultural process. This waste causing major environment problem due to lager area required for their disposal. There are many scope to use such waste or by-product in many construction materials by using them as addition or replacement in different construction materials. Brick is the most important building material used in the construction. The use of the natural soil are increased as the brick is the important material in construction which increases the environmental degradation. Basically cement brick is the mixture of the cement, coarse aggregate, fine aggregate and water. The use of the cement brick increases the use of cement. So the uses of different industrial waste or a byproduct to reduces the use of cement and also reduce the environmental problem. It also help to reduce the cost of the materials and gives the ecofriendly material and sustainable materials. By using industrial waste in the cement brick enhance the physical and mechanical properties of the cement brick. This study is conducted to identify the different uses of industrial waste such as fly ash in cement brick. The cement are replace by fly ash at 0%, 10%, 20%, 30% and 40%. These fly ash cement brick tested in compression test and water absorption. Test gives high compressive strength and low water absorption at 30% replacement of cement by fly ash.

Keywords **- Cement brick, Fly ash, Industrial waste utilization, Eco-friendly, Economical**

I. INTRODUCTION

In India, population are increase rapidly. Due to increase in the population demand of building and building materials are constantly increased. Cement bricks are manmade material widely used in construction. Most of the ingredient in cement bricks are cement, fine aggregate, coarse aggregate and water. In India, different industrial waste are generated from the different industry, mining and agricultural industries. This waste require large area for the disposal this also causes the environment degradation. This waste can be used in cement bricks as a partially or fully replacement. Fly ash is also a one of the waste that are generated in large amount. There are many use of the fly ash in construction. Fly ash can also use in cement brick to make environment friendly and economical cement brick. Fly ash is nothing but it is a fine powder that is byproduct which is generated from the burning pulverized coal in the electric generation power plant. Large area are required for disposal of the industrial waste like fly ash. There are many use of the fly ash in construction industry. In cement brick cement are replace by fly ash in different proportion. Which help for proper disposal and proper use of the industrial waste like fly ash.

II. EXPERIMENTAL MATERIALS

The following materials are used for the preparation of the cement brick with fly ash.

2.1 Cement

A cement is the binder materials which can be used to bind the other materials in mortar, brick and concrete. Raw materials which are used for the manufacturing cement are lime, silica, alumina and iron oxide. Cement are available in the variety of the types and grade. The Portland cement is the most common type of cement which are used in construction industry. Cements are generally used for fill the voids between fine and course aggregate. Generally the cement has both adhesive and cohesive properties. The ordinary Portland cement of 53 grade are used which is as per the IS 12269: 1987 for making all cement brick mixture. For making cement brick cement are mixed with sand, aggregate, fly ash and water. Figure 1 shows the cement.

Figure 1 Cement

2.2 Fine Aggregate

Generally, the sand are used as a fine aggregate in cement brick. Sand are the naturally available materials which is composed of finely divided rocks and minerals particles. The aggregate which is pass through 4.75 mm IS sieve are known as fine aggregates. The natural river sand of well graded and passing through 4.75 mm sieve as per IS 383:1970 are used for cement brick. Figure 2 shows the fine aggregate.

Figure 2 Fine Aggregate

2.3 Coarse Aggregate

Coarse aggregates of sizes from 10mm are used as per the IS 383:1970. The compressive strength is also depends on the aggregate types and size which is used. Higher strengths is also achieved by using crushed stone aggregate. Figure 3 shows the coarse aggregate.

Figure 3 Coarse Aggregate

2.4 Fly Ash

Generally, Fly ash is the fine particulate waste material. It is produced by pulverized coal-based thermal power station. Fly ash is generated from the combustion of the coal in thermal power plant. It is an environmental pollutant. It is nowadays used in cement, concrete and other cement based applications in India. Figure 4 shows the fly ash.

Figure 4 Fly Ash

Table 1 shows the physical properties of the fly ash.

Table 1 Physical properties of Fly Ash

Parameter	Result
Specific gravity	2.20
Bulk density	1540 Kg/m^3
Porosity	20.88%
Water absorption	7.65%

(Source: Modi Laboratory, Ahmedabad, Gujarat)

Table 2 shows the physical properties of the fly ash.

Table 2 Chemical Properties of Fly Ash and Cement

Chemical composition	Fly ash (%)	Cement (%)
SiO2	2.54	22.90
Al2O3	1.76	4.29
Fe2O3	0.40	2.80
CaO	50.10	63.20
MgO	1.25	1.92
Na2O	0.11	0.70
K2O	2.32	0.50
SO3	0.65 mg/ 100 gm	0.35
LOI	41.42	1.70

(Source: Modi Laboratory, Ahmedabad, Gujarat)

2.5 Water

Water is the most important ingredient of cement brick. Water is least expensive. If water are not properly use then it lead to poor quality of cement brick. The water which is used is must free from the oils, acids, and alkalis. The water which contain sewage, mine water or waste from industrial plants is not use for cement brick, unless tests indicate that it is suitable for making cement brick. Water from such sources should be avoided. Fresh portable water must be used for preparing the cement brick. It helps for chemical reaction with cement. Mixing and curing is done by using fresh portable water which is locally available.

III. MIX DESIGN

Cement brick mixes with replacement of cement by fly ash is done. As shown in table 3 fly ash is replace with cement in different proportions. Fly ash is replace with cement at 0%, 10%, 20%, 30% and 40%.

Table 3 Material requirement for $1m^3$

Brick Mixes	Design Mix for Cement Brick (By Weight)					
	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Fly Ash (kg)	W/C Ratio	% Replacement Cement by Fly Ash
A1	204.85	459.15	915.44	0.00	0.60	0%
B1	184.37	459.15	915.44	20.49	0.60	10%
B2	163.88	459.15	915.44	40.97	0.60	20%
B3	143.40	459.15	915.44	61.46	0.60	30%
B4	122.91	459.15	915.44	81.94	0.60	40%

IV. EXPERIMENTAL METHODOLOGY

Cement, fine aggregate, coarse aggregate, fly ash and water are manually fed into a mixture machine in required proportion. The materials are mixed in mixture machine. Mixture are then place in the mould. The vibration is then applied to mould. After removing cement brick from mould curing is done. The compressive strength test on cement brick after 7 days, 14 days and 28 days is carried out. The water absorption test on cement brick after 7 days and 28 days is carried out.

3.1 Compressive Strength Test (IS 3495: 1992 Part I)

Compressive strength tests were performed on compression testing machine using brick samples. Five samples per batch were tested. Average of five value gives the compressive strength of cement brick. For carried out compressive strength specimen is place with flat horizontal face between two plywood sheets and center carefully horizontally between plats of testing machine. Load is applied axially at a uniform rate 14 N/mm^2 per minute till failure occurs and the maximum load at failure is noted. Figure 5 shows the setup for compressive strength testing machine.

Figure 5 Setup of compressive strength testing of cement brick
(At BVM Engineering College Testing Laboratory, Vallabh Vidhyanagar, Gujarat)

Table 4 shows the test results of compressive strength of fly ash cement brick.

Table 4 Compressive strength test results for cement brick with fly ash

Compressive strength test brick (N/mm^2)			
Size of brick 230mm X 110mm X 75mm			
Brick mixes	**7 days**	**14 days**	**28 days**
A1 (0%)	16.05	20.08	23.08
B1 (10%)	15.42	21.58	23.16
B2 (20%)	16.05	22.06	23.72
B3 (30%)	16.36	23.72	26.01
B4 (40%)	12.57	15.89	19.76

Table 5 shows the change in the compressive strength of the cement brick with fly ash in different proportion.

Table 5 Change in Compressive strength of cement brick with fly ash

Change in Compressive strength of brick (%)			
Size of brick 230mm X 110mm X 75mm			
Brick mixes	**7 days**	**14 days**	**28 days**
A1 (0%)	0	0	0
B1 (10%)	(-) 4.08	(+) 6.95	(+) 0.34
B2 (20%)	0	(+) 8.97	(+) 2.69
B3 (30%)	(+) 1.89	(+) 15.34	(+) 11.26
B4 (40%)	(-) 27.68	(-) 26.36	(-) 16.80

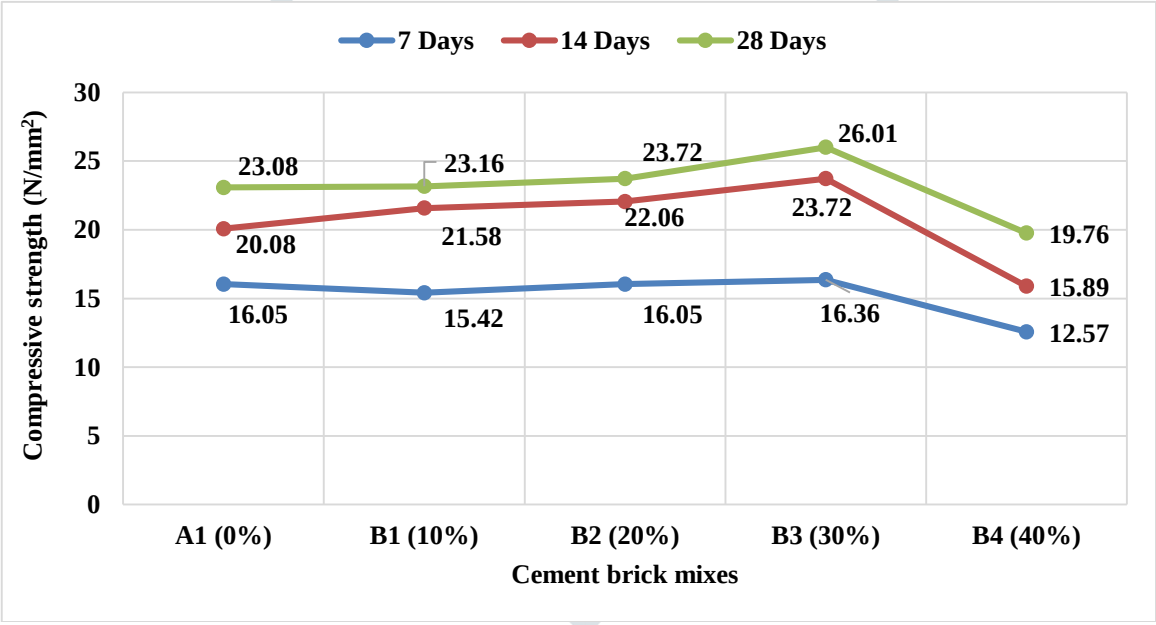

Figure 6 Compressive strength of cement brick using fly ash

Figure 6 gives the compressive strength of cement brick using fly ash. From the figure 6 the compressive strength of the cement brick is increased day by day. Compressive strength of the cement brick is increases with the increases in fly ash in cement brick. The compressive strength of the cement brick with 10%, 20%, and 30% fly ash replacement with cement gives higher compressive strength. Compressive strength for the replacement of 40% cement by fly ash gives lower compressive strength. At 30% replacement B3 mix shows 26.01 N/mm2 maximum compressive strength after 28 days.

3.3 Water Absorption (IS 3495: 1992 Part II)

Dry specimen are place in ventilated oven at a temperature of 105 to 115°C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (Dry Weight W1). Dry specimen are completely immerse in clean water at a temperature of 27 ± 2 °C for 24 hours. Remove the specimen from the water and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing 3 minutes after the specimen has been removed from water (wet weight W2). Water absorption, percent by mass, after 24-hour immersion in cold water is given by formula:

Water absorption in % by weight = (W2 – W1/W1) x 100 (3.1)

Table 6 shows the water absorption of cement brick using fly ash.

Table 6 Water absorption results for cement brick with fly ash

Water absorption (%)		
Size of brick 230mm X 110mm X 75mm		
Brick mixes	**7 days**	**28 days**
A1 (0%)	4.49	4.88
B1 (10%)	3.60	4.27
B2 (20%)	3.44	3.72
B3 (30%)	3.07	3.23
B4 (40%)	5.03	5.17

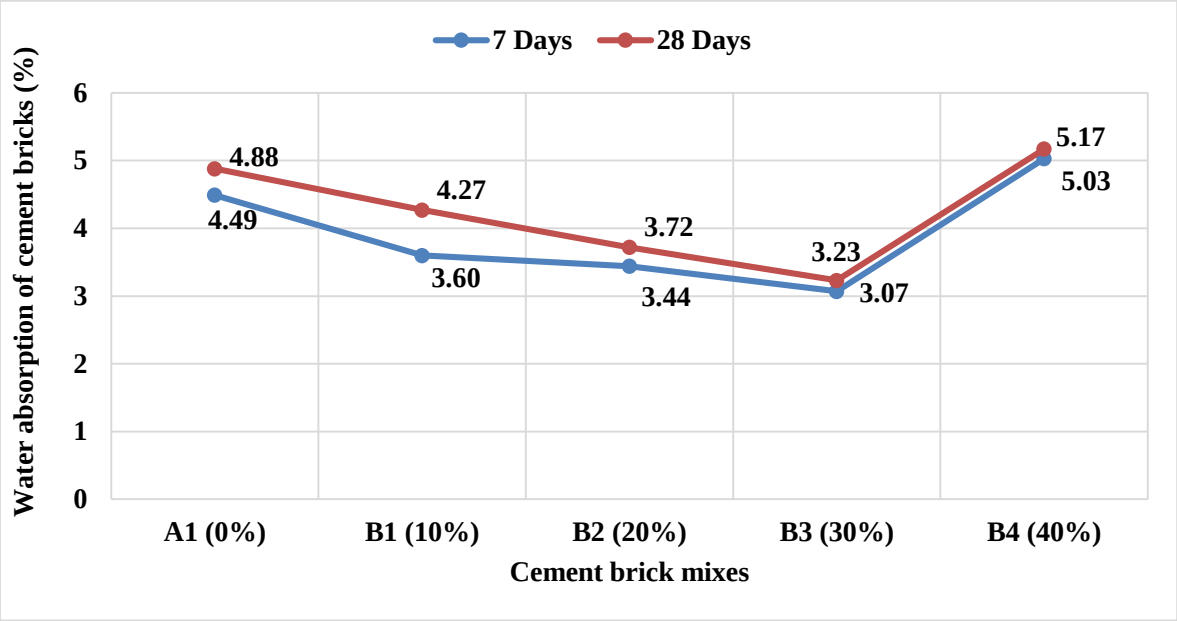

Figure 7: Water absorption of cement brick using fly ash

V. ECONOMIC FEASIBILITY

The following table 7 shows the cost of the different materials. The Table 8 shows the cost of different cement brick mixes. Figure 8 shows the cost of the cement bricks with fly ash in different proportion.

Table 7 Cost of materials

Materials	Rupees per kg
Cement	6.00
Fine aggregate	0.67
Coarse aggregate	0.80
Fly ash	0.50

Table 8 Cost of the cement brick for different mixes

Brick Mixes	Rupees per brick
A1	4.30
B1	4.09
B2	3.88
B3	3.67
B4	3.45

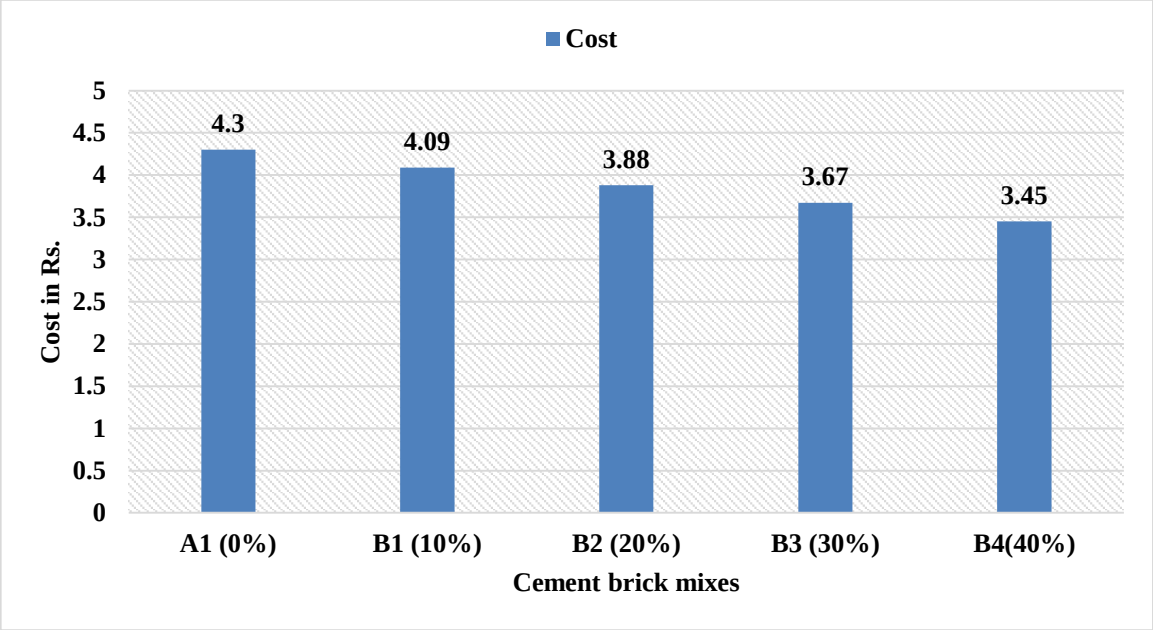

Figure 8 Cost of the different cement brick mixes

Table 9 shows the comparison between clay brick, cement brick and fly ash cement brick.

Table 9 Comparison between Clay brick, Cement brick and Fly ash cement brick

Sr. No.	Description	Clay Brick	Cement brick	Fly Ash Cement Brick
1	**Size (mm)**	230 X 110 X 75	230 X 110 X 75	230 X 110 X 75
2	**Volume (cm^3)**	1897.50	1897.50	1897.50
3	**Density (kg/m^3)**	1600	2241	2236
4	**Range of Compressive Strength (N/mm^2)**	3.5 to 7.5	15 to 23	19 to 26
5	**Cost (Rupees / No.)**	4.50	4.30	3.67
6	**Range of Water Absorption (%)**	0 to 20	4 to 5	4 to 6

VI. CONCLUSION

Based on the experimental investigation on fly ash cement brick the following conclusion are made:

1. Compressive strength is increases with increase in fly ash in cement brick.
2. Water absorption is decreases with increase in fly ash in cement brick
3. By using fly ash in cement brick help to use the industrials waste in proper manner, also reduce the environmental degradation.
4. It help to produce the eco-friendly cement brick.
5. It is found that the 30% replacement gives higher compressive strength 26.01 N/mm^2 and water absorption 3.23%.
6. The cost of the cement brick is also reduces with increase in fly ash in cement brick.

Acknowledgment:

I thankful to Prof. (Dr.) I. N. Patel, Principal, BVM Engineering College Vallabh Vidyanagar, Gujarat, Dr. Jayeshkumar R. Pitroda, Associate Professor, PG Coordinator Construction Engineering and Management, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat, Prof. Amitkumar D. Raval, Lecturer, Civil Engineering Department, B & B Institute of Technology, Vallabh Vidyanagar, Gujarat for their motivation and support for the research work.

References:

1. Apurva Kulkarni, Samruddha Raje, Mamta Rajgor, "Bagasse Ash As An Effective Replacement In Fly Ash Bricks", International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 10 - Oct 2013, PP: 4484-4489.
2. C.S. Poon, S.C. Kou, L. Lam, 2002 "Use of recycled aggregates in molded concrete bricks and blocks", Construction and Building Materials 16 Elsevier, PP: 281–289
3. Dina M. Sadek, 2012 "Physico-mechanical properties of solid cement bricks containing recycled aggregates", Journal of Advanced Research, PP: 253-260.
4. Fakher J. Aukour,2009," Incorporation of Marble Sludge in Industrial Building Eco-blocks or Cement Bricks Formulation", Jordan Journal of Civil Engineering, Volume 3, No. 1, PP: 58-65.
5. IS: 3495 (Part 1 and 2)-1992, Methods of tests of Burnt Clay Building Bricks—Specification, Bureau of Indian Standards, New Delhi.
6. Lokeshwari M, K.S Jagadish 2016, "Eco-Friendly use of Granite Fines Waste in Building Blocks", International Conference on Solid Waste Management 5IconSWM Procedia Environmental Sciences 35, PP: 618 – 623.
7. M. Angeline Swarna, R. Venkatakrishnaiah, 2014 "Manufacturing of Bricks Using Tannery Effluent sludge", International Journal of Recent Development in Engineering and Technology, ISSN 2347-6435(Online) Volume 3, Issue 4, PP:33-36.
8. Paki Turgut a, Bulent Yesilata, 2008 "Physico-mechanical and thermal performances of newly developed rubber-added bricks", Energy and Buildings 40, Elsevier, PP: 679–688.
9. Sumathi A, Sarvana K 2014 Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust. International Journal of Chem Tech Research 7(1) 28-36.
10. S.P. Raut, R.V. Ralegaonkar, S.A. Mandavgane, 2011 "Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks", Construction and Building Materials 25 Elsevier, PP: 4037–4042.

Authors Biography:

Ankit Bharatkumar Prajapati received Bachelor of engineering degree (Civil Engineering) from A. D. Patel Institute of Technology Technology, Gujarat Technological University in 2017. At present, he is final year student of Master of Technology in Construction Engineering & Management from Birla Vishwakarma Mahavidhyalaya, Guajarat Technological University.

Dr. Jayeshkumar R. Pitroda received his Bachelor of Engineering Degree in Civil Engineering from Birla Vishvakarma Mahavidyalaya Engineering College, Sardar Patel University (Vallabh Vidyanagar, Gujarat-India) in 2000. In 2009 he received his master's degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya Sardar Patel University (Vallabh Vidyanagar, Gujarat-India). In 2015 he received his Doctor of Philosophy (Ph.D.) Degree in Civil Engineering from Sardar Patel University (Vallabh Vidyanagar, Gujarat-India). He has joined Birla Vishvakarma Mahavidyalaya Engineering College as a faculty in 2009, where he is lecturer of Civil Engineering Department and at present working as Associate Professor since February 2018 having total experience of 19 years in the field of Research, Designing and Education. In present holding charge of PG Coordinator Construction Engineering and Management. He is guiding M.E. / M. Tech (Construction Engineering and Management/ Construction Project Management/ Environmental Engineering) thesis work in the field of Civil / Construction Engineering/ Environmental Engineering. He is also guiding Ph.D. Students (Civil Engineering). He has published many papers in National / International Conferences and Journals. He has published nine Research Books in the field of Civil Engineering, Rural Road Construction, National Highways Construction, Utilization of Industrial Waste, Fly Ash Brick, Construction Engineering and Management, Eco-friendly Construction.

Prof. Amitkumar D. Raval was born in 1990 in Anand. He received his Bachelor of Engineering degree in Civil Engineering from the Birla Vishvakarma Mahavidyalaya, Vallabh Vidyanagar, Sardar Patel University in 2011. In 2013 he received his Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Gujarat Technological University. He joined Bhailalbhai & Bhikhabhai Institute of Technology, Vallabh Vidyanagar as a faculty where he is Lecturer of Civil Engineering Department (GIA) with a total experience of 8 years in the field of Research, Designing and education. He is guiding M.E. (Construction Engineering & Management and Infrastructure Engineering and Technology). Currently he is pursuing Ph.D. in the field of Civil Engineering. He has published papers in National Conferences and National/International Journals.