Development of the Bricks from Red Mud by Industrial Waste (Red Mud)

Manoj Bhaskar, Salim Akhtar, Geeta Batham

Abstract: ***Red mud emerges as the major waste material during production of alumina from bauxite by the Bayer's process. It comprises of oxides of iron, titanium, aluminum and silica along with some other minor constituents. In the present investigation experimental study was conducted for development of brick using red mud. Red mud brick of different trial mix were produced in the lab and test were conducted to find the properties of red mud brick properties found from tests were compared with the properties of ordinary bricks. It is found from the study that a red mud brick shows better performance than ordinary brick. As red mud bricks are eco-friendly & economical they protect the environmental also. Compressive strength of red mud bricks are more as compound to ordinary bricks. Water absorption is also more but within limit, change is size and weight losses of red mud brick are negligible in case of red mud bricks.***

Keywords – Red mud material, Fly Ash, Coal Dust, Clay Guard Etc.

I. INTRODUCTION

Red Mud or Bauxite Residue is a waste/by-product produced from the alumina industry. The worldwide annual production is 70 million tones. Its disposal remains an issue of great importance with environmental implications. "Red Mud" is called a by-product/waste that derives from the alumina producing industries. It is called "Red" because usually has a red colour "Mud" because it is slurry. It is often also named "Bauxite Residue" whereas proprietary names of processed Red Mud can be found, such "Cajunite" (Kaiser Aluminum), "Bauxaline" (Aluminum Pechiney), "Ferro alumina" (Aluminum de Greece) etc. Red mud, an industrial waste resulting from extraction of alumina from Bayer process, is a mineral waste, containing iron in the form of hematite (Fe2O3), left-over aluminum oxide (Al2O3), silica (SiO2), some titanium dioxide (TiO2), and other residual minerals. Because Bayer process uses dissolution of alumina in caustic soda for extraction of the same, the waste also contains approximately 3wt. % sodium hydroxide that makes the mud highly alkaline (pH in the range of 12 to 13). At high pH, solubility of alumina and silica is much higher than at neutral Ph. Thus, one can take advantage of the dissolved minerals of these oxides and bind red mud particles to form complexes of the dissolved substances. We evaluated the resulting products approximately 30 years back in an extensive study on Jamican red mud [1]. The products are now known as "Geo polymers [2]". The work was conducted mainly in University of the West Indies and Jamaica Bauxite Institute in collaboration with McGill University in Montreal. Canadian International Development and Research Centre (IDRC) funded this project. Manufacture of bricks is mostly a village industry.

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Bricks have been produced since the dawn of civilization in the sun dried form. The Great Wall of China was made of both burnt and sun dried bricks. Bricks have been used all over the world in every class and kind of building. In places where plenty of clay is available, brickwork is cheaper. The cost of construction work is less with bricks. Bricks resist fire and, hence, they do not easily disintegrate. The atmospheric effects are resisted by bricks of good quality.

II. EXPERIMENTAL PROCEDURE GENERAL

The main aim of this experimentation is to find out the effect of addition of red mud, fly ash, and coal dust with clay guard which is a waste product from the aluminum industries, on the properties of brick from red mud containing three admixtures. There are several investigations on red mud, focused on the characteristics of red mud in both fresh and hardened. Majority of these studies are found commonly used red mud brick like making construction blocks, in making floor and all tiles, Red mud polymer door etc. There is no dedicated study on red mud. There for, in this project an attempt have been made to focus the characteristic & performance.

MATERIALS USED

Red mud's of Chhattisgarh are localized in occurrence and are found mostly in the BALCO. These soils occur in catenary sequence along with laterites and are found mainly as deposits by colluviation in foothills and small hillocks. The rapid permeability of the surface mud also has been responsible for the characteristic development of these red mud's, which are very deep and homogeneous without much expression of horizons. The mud's have red colour, which has been attributed to the presence of Fe2O3 or Al2O3, SiO2 etc.

Table-1 Chemical analysis of the red mud sample

Compounds & Elements	Quantity (%)
Fe2O3	35.04
Al2O3	20.2
SiO2	13.5
Na2O	9.4
TiO2	4
CaO	5.3
K2O	0.39
Mgo	0.33
CO2	3.19
S	0.06
Mn	0.02
A.Z.	8.44

The red mud used in the experimentation was obtained from HINDALCO, Belgaum. The fineness of red mud was found to be 35 m^2/gm with particle size of 75 microns and its density is found to be 3gm/cc. The chemical analysis of red mud is shown in TABLE- 1

Table 2: Particle size, compaction parameters & specific gravity of mix composition

Mix Composition (Mud + Ash)	Grain Size Analysis			Proctor Density		Specific Gravity
	Sand	Silt	Clay	OMC %	Dry Density (gm/cc)	
	%	%	%			
50%+50%	65	28	7	28	1.49	2.74
70%+30%	50	40	10	28	1.56	2.91
30%+70%	70	28	2	29	1.41	2.44
60%+40%	58	35	7	27	1.54	2.64
40%+60%	63	32	5	28	1.52	2.68

Test for water absorption for test results:

Table 3 - Observations & Calculation

Sn	Oven dry wt.of specimen	Wet wt. of specimen	Water absorption in %	Average Water absorption in %
	w_1(kg)	w_2(kg)	$(w_2-w_1)/w1x100$	
1	993	1098	10.57	13.56%
2	1021	1123	9.99	
3	1068	1245	16.57	
4	956	1125	17.67	
5	899	1106	23.02	
6	906	1022	12.8	12.58%
7	936	1082	15.59	
8	948	1100	16.03	
9	929	1078	16.03	
10	1461	1725	18.06	
11	1775	2048	15.38	14.63%
12	981	1160	18.24	
13	964	1136	17.84	
14	892	1026	15.02	
15	926	1157	24.94	
16	852	1073	25.93	16.69%
17	964	1136	17.84	
18	926	1157	24.94	
19	948	1100	16.03	
20	1068	1245	16.57	

Test for compressive strength

Table 4 - Observation & calculations

Sn.	Max. Load at Failure (N)	Size of Bricks	Area of Bricks (Sq. mm)	Compressive Strength (N/Sq.mm)	Average Compressive Strength (N/Sq. mm)
1	90000	190 x 90 x 90	17100	5.26	5.15
2	95000	190 x 90 x 90	17100	5.56	
3	85000	190 x 90 x 90	17100	4.97	
4	90000	190 x 90 x 90	17100	5.26	
5	80000	190 x 90 x 90	17100	4.68	
6	90000	190 x 90 x 90	17100	5.26	5.03
7	100000	190 x 90 x 90	17100	5.85	
8	85000	190 x 90 x 90	17100	4.97	
9	85000	190 x 90 x 90	17100	4.97	
10	70000	190 x 90 x 90	17100	4.09	
11	80000	190 x 90 x 90	17100	4.68	5.26
12	90000	190 x 90 x 90	17100	5.26	
13	100000	190 x 90 x 90	17100	5.85	
14	85000	190 x 90 x 90	17100	4.97	
15	95000	190 x 90 x 90	17100	5.56	
16	95000	190 x 90 x 90	17100	5.56	5.03
17	75000	190 x 90 x 90	17100	4.39	
18	85000	190 x 90 x 90	17100	4.97	
19	95000	190 x 90 x 90	17100	5.56	
20	80000	190 x 90 x 90	17100	4.68	

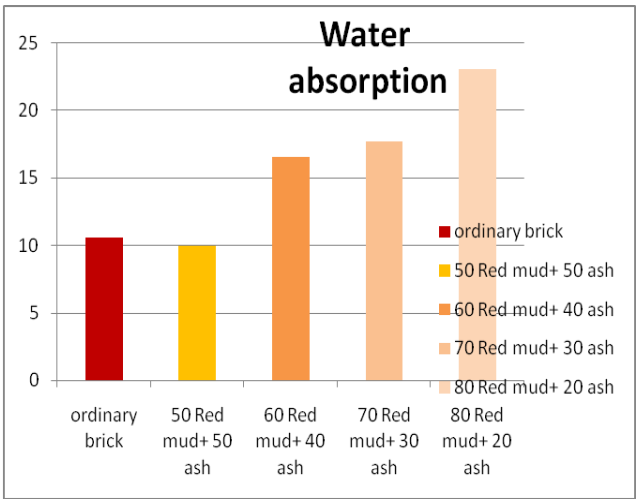

Figure- 1 Water absorption

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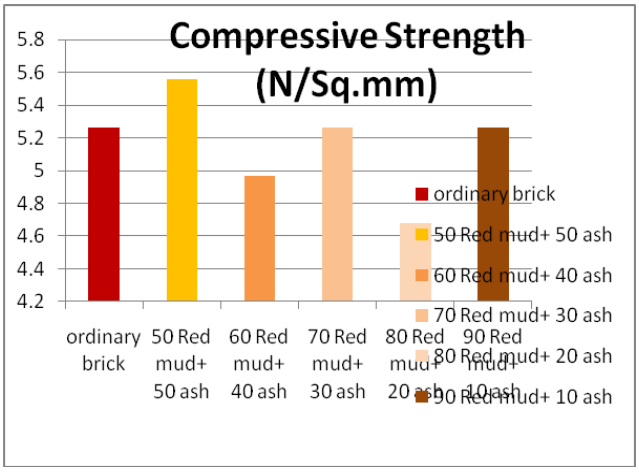

Figure- 2 Compressive Strength

III. EXPERIMENTAL PROCEDURE

These are the different mixing of bricks ready for use after manufacturing the red mud bricks some test are done before using its. There are various tests those may be carried out do determine the quality of the bricks:-

Field tests-

Uniformity in shape and size.
Colours test
Hardness test
Soundness test
Strength

The following laboratory test may be conducted on the bricks to find suitability:-

A) Test for water absorption
B) Test for compressive strength

Brick Type	Displacement in mm
ordinary brick	0.069297
50 Red mud+ 50 ash	0.041835
60 Red mud+ 40 ash	0.052307
70 Red mud+ 30 ash	0.069751
80 Red mud+ 20 ash	0.104631
90 Red mud+ 10 ash	0.209216

IV. FINITE ELEMENT METHOD

The finite element method (FEM) (its practical application often known as finite element analysis (FEA)) is a numerical technique for finding approximate solution of partial differential equation (PDE) as well as integral equation. The solution approach is based either on eliminating the differential equation completely (steady state problem), or rendering the PDE into an approximation system of ordinary differential equation, which are then numerically integrated using standard technique such as Euler's method , Runge-kutta, etc. In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied , but is numerically stable , meaning that errorin the input and intermediate calculation do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, all with advantages and disadvantage. The finite element method is a good choice for solving partial differential equation over complicated domain (like cars and oil pipelines), when domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, when the solution lacks smoothness.

Table 5- Material Property of brick:

Brick Type	Young's modulus E In Mpa	Poisson's ratio
ordinary brick	7000	0.15
50 Red mud+ 50 ash	11501	0.345
60 Red mud+ 40 ash	9201.1	0.344
70 Red mud+ 30 ash	6901.2	0.343
80 Red mud+ 20 ash	4601.4	0.342
90 Red mud+ 10 ash	2301.6	0.341

Boundary condition and Loading:

Boundary condition- Fixed at bottom of brick
LOAD: Pressure of 5.263 N/sq mm equivalents to force of 90,000 N applied at top surface

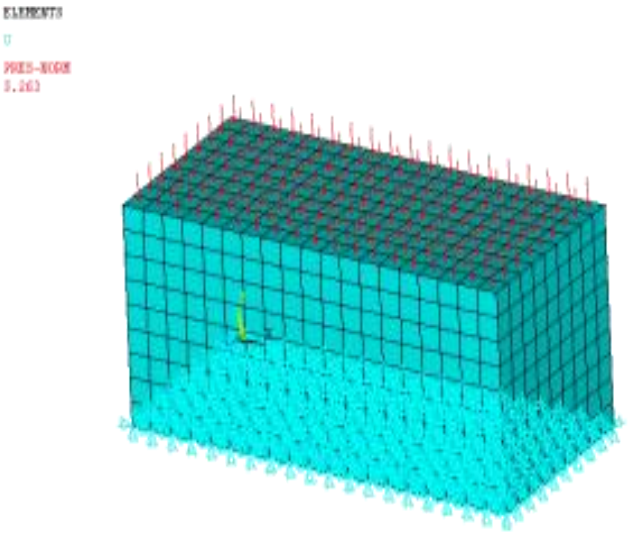

Figure- 3

Solution: Perform the analysis using Ansys. Post Processing: Interpretation of result and comparison.
Displacement:

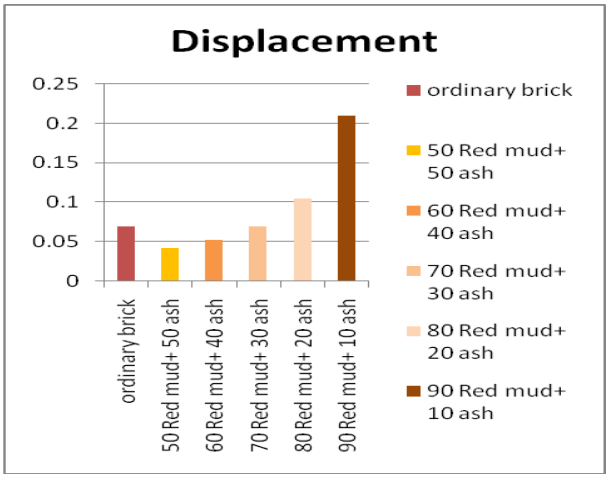

Figure- 4 Dispalacement

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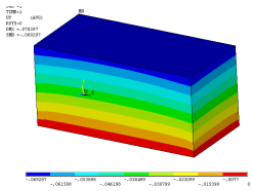
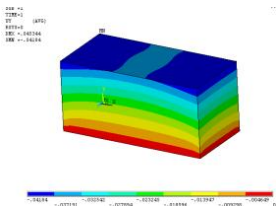
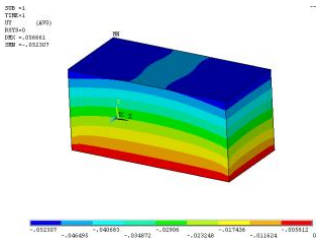


Figure- 5 Ordinary brick –Displacement



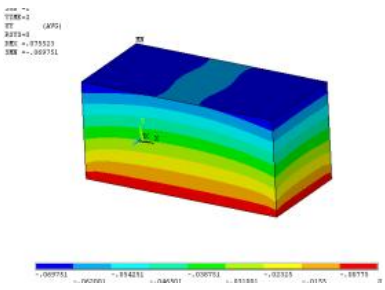
50 Red mud+ 50 ash

Figure- 6



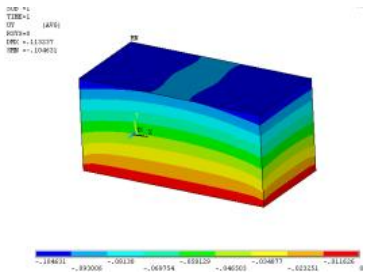
60 Red mud+ 40 ash

Figure- 7



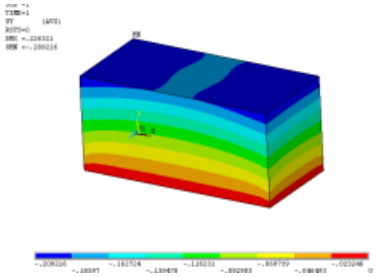
70 Red mud+ 30 ash

Figure- 8



80 Red mud+ 20 ash

Figure- 9



90 Red mud+ 10 ash

Figure- 10

Table 6-Compressive Stress:

Brick Type	Compressive Stress in Mpa
ordinary brick	5.185
50 Red mud+ 50 ash	5.026
60 Red mud+ 40 ash	5.028
70 Red mud+ 30 ash	5.03
80 Red mud+ 20 ash	5.031
90 Red mud+ 10 ash	5.033

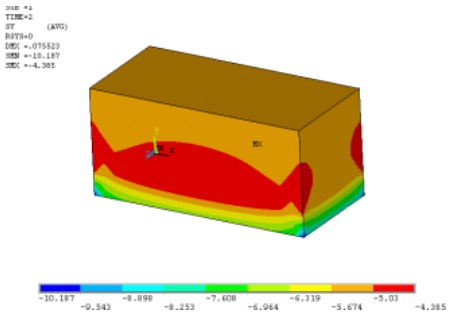


Figure- 11

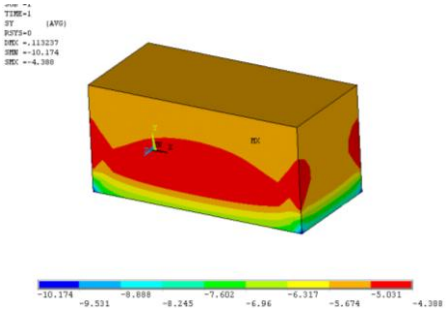


Figure- 12

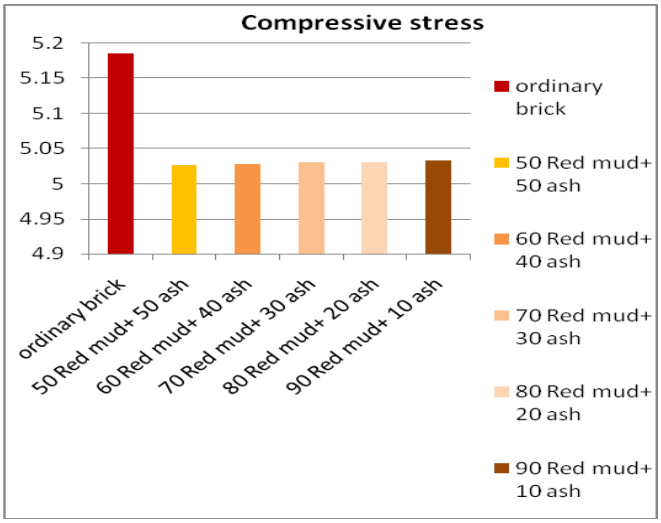
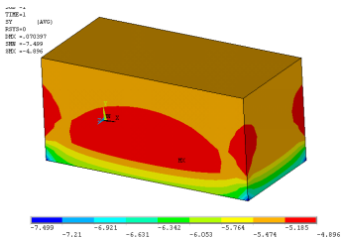
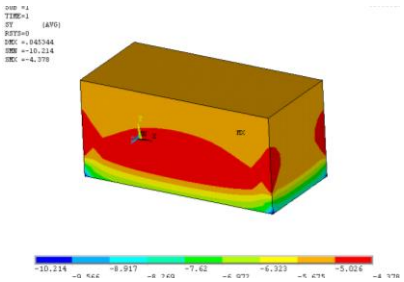


Figure- 13 Compressive Stress



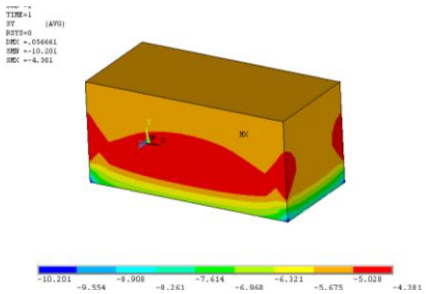
Ordinary brick

Figure- 14



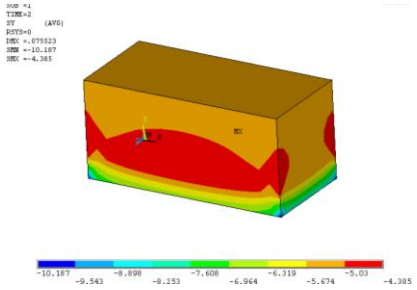
50 Red mud+ 50 ash

Figure- 15



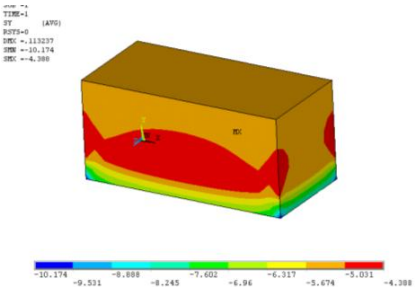
60 Red mud+ 40 ash

Figure- 16



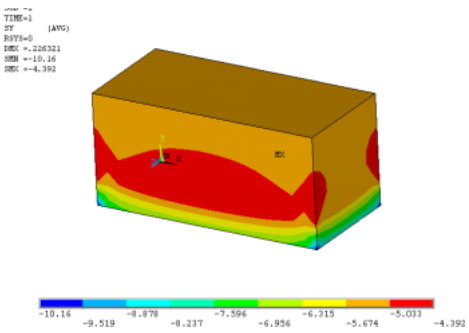
70 Red mud+ 30 ash

Figure- 17



80 Red mud+ 20 ash

Figure- 18



90 Red mud+ 10 ash

Figure- 19

V. FINALY COMPAIRE RESULTS AND ANALYSIS WITH FEM

Generally water absorption of ordinary brick of size 190x90x90(mm) range from 10% to 12%. It's hence in the trail I to IV water absorption average 14.11% and hence to max water absorption 11%. If the red mud quantity are more mixing of block than the found water absorption are increase v/s ordinary bricks.Generally compressive strength of ordinary brick of size 190x90x90(mm) range from 5mpa. It's hence in the trail I to IV compressive strength average 5.11mpa and hence to max compressive strength 4mpa. If the red mud quantity are more mixing of block than the found compressive strength are increase v/s ordinary bricks.

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ANYSIS RESULTS FOR BRICK GEOMETRY:

With the help of ANSYS result obtained for case brick geometry, we can observe that Poisson ratio and young modulus in Normal bricks Length of Brick =190 mm Width of Brick = 90 mm Height of Brick= 90 mm Hole Dia. = 25 mm In normal bricks, composition value with Poisson ratio 0.15 and young modulus 70000 MPa the applied the load 90,000 N then displacement of bricks 0.069297mm and compressive stress 5.185MPa. Poisson ratio and young modulus in 50% red mud and 50% ash in Normal bricks:
In normal bricks, composition value of red mud 50% and ash50% with Poisson ratio 0.345 and young modulus 11501 MPa the applied the load 90,000 N then displacement of bricks 0.041835mm and compressive stress 5.026 MPa. Poisson ratio and young modulus in 60% red mud and 40% ash in Normal bricks: In normal bricks, composition value of red mud 60% and ash 40% with Poisson ratio 0.344 and young modulus 9201.1 the applied the load 90,000 N then displacement of bricks 0.052307mm compressive stress 5.028MPa. Poisson ratio and young modulus in 70% red mud and 30% ash in with Poisson ratio 0.344 and young modulus 9201.1 the applied the load 90,000 N then displacement of bricks 0.052307 mm compressive stress 5.028MPa. Poisson ratio and young modulus in 70% red mud and 30% ash in Normal bricks: In normal bricks, composition value of red mud 70% and ash 30% with Poisson ratio 0.343 and young modulus 5.03 the applied the load 90,000 N then displacement of bricks 0.069751mm and compressive stress 5.03MPa.

VI. CONCLUSIONS

In the present thesis work of experimental study was done on manufacturing and testing of bricks using red mud. Hence as per test and results of the study following points can we recommend on the properties of red mud bricks.

1. Red mud +fly ash brick is having the lowest water absorption and highest compressive strength.
2. Red +fly ash brick is having the water absorption of 12%.
3. Fly ash +clay bricks are having the highest water absorption.
4. Among the curing condition studied water cured bricks have shown higher compressive strength.
5. Among the various systems studied red mud based bricks have shown higher compressive strength.
6. Among the curing periods studies 28 days curing period had shown the highest compressive strength.
7. Saving of 50% of clay, which are very important materials.
8. Cly materials are the agriculture used.
9. Environmental saving.
10. Recycling of waste material, total disposal for water soil.
11. Potential problem solve, 0.5 mm saving of clay.
12. Jute / sisal fibre reinforced red mud/fly ash/ marble slurry dust
13. polyester composite (R-wood) shows :
14. Good mechanical properties as compared to
15. other wood substitutes
16. Good fire retardency
17. Eco friendliness
18. Cost effectiveness
19. Good abrasive wear resistance
20. Reinforcement of industrial wastes exhibits good abrasive
21. wear resistance and opens new avenue for flooring tiles
22. To facilitate the commercialization, a R-wood technology enabling
23. centre is designed and setup at RRL, Bhopal

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LIST OF IMPORTANT IS CODES RELATED TO BRICKS

IS: 3495-1976 Method of test for burnt clay building bricks (Part I to IV).
IS: 1077-1976 Specification for common burnt clay building bricks.

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