Effects of Chemical Additives on the Production of Structural Brick for Construction Works

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ABSTRACT

Effects of chemical additives in the production of structural bricks was investigated. It aimed at discovering improved method of brick production at reduced rate in order to increase its usage/patronage in construction works. Clay, the major material is one of the natural resources available in the country in large quantities and the oldest building material with unique qualities was sourced locally. One industrial chemical additive known as KS770 and another local one known as soda ash (named eyin aro in Yoruba language) were used for production of samples of sun-dried (unfired) and oven burnt (fired) structural bricks in addition to a set of non chemical samples for comparison. The results obtained show that KS770 being concrete chemical plasticizer adversely increase clay moisture content, hence can only be used at reduced quantity of water to yield higher compressive strength compared to non chemical one. Samples with soda ash prove to be a good plasticizer and water reducing agent with highest strength at lowest density.

Keywords: *Clay, Water, Structural Bricks and Chemical Additives*

INTRODUCTION

Shelter is one of the three principal needs of man irrespective of class or race. Every normal human being is entitled to a house, the cost of which had made it difficult for many to construct even the minimum category of such. Construction of a simplest house consists of three major components, namely; substructure (foundation), superstructure (walling) and covering (roof). Out of the three components, wall construction could be the most expensive, depending on the nature of site (ground) on which structure is proposed to be constructed and the choice of materials used. In addition to ventilation advantage among others, affordable housing scheme, recommends the use of bricks for wall construction. Other higher categories of building make use of bricks for a lot of aesthetic and structural construction works.

This investigation therefore aims at improving quality of structural bricks and reduce the cost of its production, making construction of building affordable to average and below average income earners and thus alleviating the problem of housing among the populace. Brick remains the oldest in the history of building construction materials, made from either clay, calcium silicate or fly ash. Brick was widely used in the 1700, 1800 and 1900s due to the fact that it is much more retardant of flame than wood and other materials from plants and is fairly cheaper to produce *(www.en.wikipedia.org/wiki/bricks).*

The oldest shaped brick found dated back to 7,500 B.C. They have been found in Cayonu, in the upper Tigris region and in South East Anatolia close to Diyarbakir. Other more recent findings, dated between 7,000 and 6,395 B.C come from Jericho and Catal Huyuk. From archeological evidence, the invention of the fired brick is believed to have arisen in about the third millennium B.C in the Middle East. Bricks enabled the construction of permanent building in regions where the harder climate preludes the use of mud bricks, owing to its resistance to cold and moist weather conditions *(www.en.wikipedia.org/wiki/bricks).*

Unfired Bricks: By the fourth millennium B.C., the people of Mesopotamia were building palace and temples of stores and sun-dried brick (Adobe or Unfired Brick). In the third millennium, the Egyptians erected the first of their stones temples and pyramids. In the last centuries prior to the birth of Christ, the Greeks perfected their temples of limestone and marble. Control of the western world then passed to the Romans, who made the first large-scale use brick masonry arches and roof vaults in their temples, basilicas, baths palaces and aqueducts. Medieval Civilization in both Europe and the Islamic world brought brick masonry vaulting to a high level of development. The Islamic craftsmen built magnificent palaces, markets and mosques of bricks and often faced them with brightly clay tiles. The Europeans directed their efforts towards fortresses and cathedrals of stone, culminating in the pointed vaults and flying buttresses of the great Gothic churches (Edward and Joseph, 2004).

Fired Bricks: The Ancient Egyptians and the Indus valley civilization also used mud brick extensively. This can be seen in the ruins of Buhen, Mahenjodaro and Harappa. One of the largest brick structures in the world is that of ancient Jetavanaramaya stupa in Anurad Hapura, Sri-lanka. The world's highest brick tower of St. Matin's church, Lands hut, completed in 1500. The Romans made use of fired bricks, and the Roman legions, which operated mobile kiln, introduced bricks to many parts of empire. Romans bricks are often stamped with the mark of the legion that supervised its production. In Pre-modern China, brick making was the job of lowly and unskilled artisans, but a kiln master was respected as a step above the latter. The kiln master had to make sure that the temperature inside the kiln stayed at a level that caused the clay to shimmer with the colour of molten gold or silver, *(www.en.wikipedia.org/wiki/bricks).*

In the twelfth century, bricks from northern Italy were re-introduced to northern Germany where an independent tradition is evolved. It is culminated in the so called Gothic, a reduced style of gothic architecture that flourished in northern Europe, especially in the region around the Baltic Sea, which are without natural rock resources (Edward and Joseph, 2004). Aesthetically, bricks made of calcium silicate have the advantage of being made in variety of colours. While fly ash bricks made of fly ash, a by-product of coal powder has the advantage of solidifying under pressure rather heat, saving energy, reducing mercury pollution, alleviating the need for landfill disposal, self cementing and above all its total cost of production is 20% less than that of traditional clay brick. However, clay brick is the most widely used due to the fact of being locally sourced and is the most common material. Structural clay brick, being the most popular of all bricks, can be unfired or fired. The fired structural brick is much more preferred in wet climate regions. It can be formed through any of the three processes; soft mud, dry pressed or extruded, after which they are fired manually by stacking in spaced array called clamps or fired in kiln which is the modern method of firing. Unfired bricks, otherwise called adobe brick or unburnt brick has the advantage of being relatively cheaper and used in regions with dry climate. According to McGraw (1987) Encyclopedia of Science and Technology, unfired bricks had been in use since ancient times and still widely employed in dry climate. It was also noted by Sohrab and Ali (2003) that clay bricks have a heavy weight that account for the great mass of construction and thus, causes more vulnerability against earthquake forces. The addition of chemical additive helps in reducing the weight of brick structures thus Lessing its vulnerability against earthquake forces. It also acts as pore-forming material as well as improves its thermal insulation properties. These chemical additives are substances introduced into a batch of clay or concrete to alter or improve the properties of a particular finished product (Shetty, 2004). Additives are added to the mixture of clay during its preparation for production of structural brick, thus modifying a specific process or end use properties. They generally include: air entraining agent, accelerator and plasticizers, hardening or setting retarders, polystyrene foam and KS 770. All these are the popular ones before the discovery of a local chemical additive known as soda ash. Clay as raw material has a very indefinite chemical mineralogical and physical significance. It consist of great variety of minerals with a very complex composition (Ray, 1971). The purpose of this study is to examine effects of chemical additives in the production of structural bricks with the aim of discovering improved method of brick production at reduced rate in order to increase its usage/patronage in construction works.

MATERIALS AND METHOD

The sampled Clay used for this study was collected from nearby borrow-pit and observed accordingly. The same was made to possess required properties and characteristics for production of modern bricks. Plasticity property was gotten to allow shapes/mould of interest after mixing with water and to ensure sufficient wet and air-dried tensile strength in order to maintain proper shape formation as clay particles fused together when subjected to rising temperatures. The water used was free of impurities to enhance the setting time and strength of clay minerals. Water is required to produce a workable plastic mix, so as to enhance and keep its shape after formation. It is also known that strength of any structural bricks depends upon many factors among which water plays an important role. The chemicals were used as additive in the experiment are (i) KS-770: and (ii) Local Soda Ash. KS-770 is a brownish liquid industrial chemical, chloride free, water reducing and superior plasticizing. It was originally designed to aid high strength in concrete and sandcrete works. It is packaged in 5, 20, 25 and 50 litres of plastic jars. Also available is the bulk packaging of 200 litres metal drum. Characteristically, experience reveals remarkable effectiveness on concrete and sandcrete works to extent of over 10% reduction in water-cement ratio. Local Soda Ash is popularly known as 'Eyin Aro' by the Yoruba speaking people of Nigeria. It is a brownish liquid and a by-product of the locally filtered ash of the burnt cocoa pad in the making of the black soap. Effect of the two were physically observed, results collected, collated and analyse for discussion. The experimental method involves materials sampling, physical observation, specimen preparation, firing, and laboratory determination of stresses. Results were collected, collated, analysed and effects discussed accordingly.

Lateritic clay obtained from borrow-pit was brought to laboratory, prepared and sieved using sieve number 24 so as to allow substantial quantity of coarse particles in the grading. The material was divided into two portions for the two additives. Each of the portions were again subdivided into three portions and mixed with varying quantities of water (with and without additives). Mould prepared was dipped into water, mixed materials filled into the mould and tamped properly for 24times using tamping rod before dressing the surface for removal. The samples were allowed to dry completely under sun for days. Each group was further divided into two and a portion of each taken to oven for firing. The whole samples were then taken to the laboratory for test. Results collected and collated for analysis before discussion.

RESULTS AND DISCUSSION

Fired and unfired specimens were tested in the laboratory to determine compressive strength of the materials. Change in volume and weight were also noted to calculate density accordingly. Details of the results are presented on the tables. Iranian Polymer Journal, Vol. 12, No. 4 (2003) reported a test carried out by Sohrab and Ali (2003) in which polystyrene foam was used as additive in the production of structural bricks. This test showed that by increasing the additive, the compressive strength and the density of the bricks decrease although water absorption increases. It was also reported that addition of 2% of recycled polystyrene foam maintained the compressive strength of the resulted bricks as suitable for load bearing bricks.

In the direction of the same focus, industrial and local additives were investigated. Considering the results of the fired samples on Table 1, specimen serial No 1.4 with equal quantity (0.36lit.) of soda ash local additive (FSA) produced minimum average weight of 1333.5g, minimum average density of 0.95g/cm^3 and maximum average compressive strength of 2.33N/mm^2, FSA Fig. 1. The same quantity (0.36) of KS770, an industrial additive (specimen Serial No 3.4, Table 1) yielded minimum average weight of 1656g, minimum average density of 1.18g/cm^3 and Maximum average compressive strength of 2.13N/mm^2. While the normal (control) sample without additives, Serial No 2.1 reads average weight 1750g, minimum average density 1.20g/cm^3 and maximum average compressive strength 1.97N/mm^2. In the case of the unfired sample, Table 2, Serial No 1.2 of samples without additives (UNA), record shows minimum average weight 1793.5g, minimum average density 1.28g/cm^3 and maximum average compressive strength 1.94N/mm^2. Next is that of soda ash additive, Serial No 2.1 (US) with maximum average weight 1533g, minimum average density 1.42g/cm^3 and maximum average compressive strength 1.69N/mm^2. While that of KS770 ranks the least average weight value of 1763g, minimum average density 1.16g/cm^3 and minimum average compressive strength.

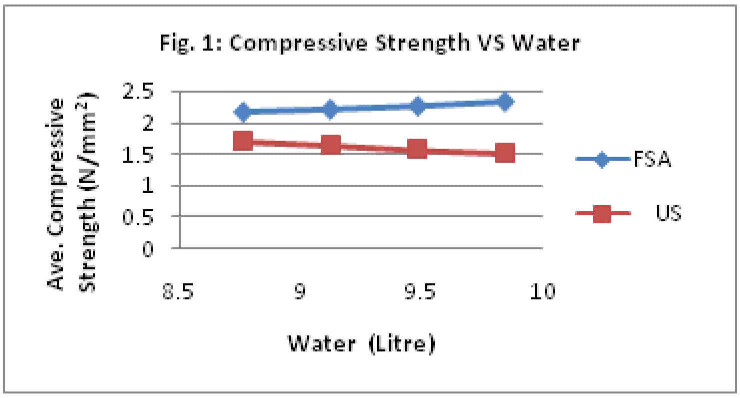
Table 1: Result of Fired Brick Samples

S/No	Soil Type	Specimen	Weight (g)	Additive (lit)	Water (lit)	Volume (cm^3)	Density (g/cm^3)	Average Density (g/cm^3)	Specimen Area (mm^2)	Load (N)	Compressive Strength (N/ mm^2)	Average (N/mm^2)	Remarks
1.1	Lateritic	FSA 1^A	1840	0.36	8.76	1403.52	1.31	1.30	21.93	48.00	2.19	2.17	Highest
		FSA 1^B	1805	0.36	8.76	1403.52	1.29		21.93	47.00	2.14		strength of
1.2	Lateritic	FSA 2^B	1704	0.36	9.12	1403.52	1.21	1.20	21.93	48.00	2.19	2.21	2.33N/mm^2
		FSA 2^B	1655	0.36	9.12	1403.52	1.18		21.93	49.00	2.23		obtained with
1.3	Lateritic	FSA 3^B	1684	0.36	9.49	1403.52	1.20	1.10	21.93	48.90	2.23	2.26	lowest density
		FSA 3^B	1404	0.36	9.48	1403.52	1.00		21.93	50.22	2.29		of 0.95g/cm^2
1.4	Lateritic	FSA 4^B	1404	0.36	9.84	1403.52	1.00	0.95	21.93	50.44	2.30	2.33	
		FSA 4^B	1263	0.36	9.84	1403.52	0.90		21.93	51.76	2.36		
2.1	Lateritic	FNA 1^A	1740	0.36	9.12	1403.52	1.21	1.20	21.93	41.00	1.99	1.97	Average
		FNA 1^B	1670	0.36	9.12	1403.52	1.19		21.93	39.69	1.94		density
2.2	Lateritic	FNA 2^A	1633	0.36	9.12	1403.52	1.16	1.15	21.93	38.00	1.85	1.81	obtained
		FNA 2^B	1600	0.36	9.12	1403.52	1.14		21.93	36.18	1.77		
3.1	Lateritic	FK7 1^A	1780	0.54	9.12	1403.52	1.27	1.26	21.93	37.72	1.72	1.73	Average
		FK7 1^B	1740	0.54	9.12	1403.52	1.24		21.93	38.16	1.74		strength
3.2	Lateritic	FK7 2^A	1805	0.36	8.76	1403.52	1.29	1.28	21.93	44.74	2.04	2.05	obtained
		FK7 2^B	1768	0.36	8.76	1403.52	1.26		21.93	45.18	2.06		
3.3	Lateritic	FK7 3^A	1712	0.36	8.40	1403.52	1.22	1.21	21.93	45.40	2.02	2.08	
		FK7 3^B	1684	0.36	8.40	1403.52	1.20		21.93	45.83	2.09		
3.4	Lateritic	FK7 4^A	1670	0.36	8.04	1403.52	1.19	1.18	21.93	46.27	2.11	2.13	
		FK7 4^B	1642	0.36	8.04	1403.52	1.17		21.93	47.15	2.15		

Table 2: Result of Unfired Brick Samples

1.1	Lateritic	UNA 1^A	1910	0.36	9.12	1403.52	1.36	1.34	21.93	37.00	1.77	1.79	Highest
		UNA 1^B	1853	0.36	9.12	1403.52	1.32		21.93	38.82	1.82		density of
1.2	Lateritic	UNA 2^A	1819	0.36	9.12	1403.52	1.30	1.28	21.93	40.00	1.90	1.94	1.34g/cm^2
		UNA 2^B	1768	0.36	9.12	1403.52	1.26		21.93	41.67	1.98		obtained
2.1	Lateritic	US 1^A	1960	0.36	8.76	1403.52	1.40	1.42	21.93	36.00	1.64	1.69	Average
		US 1^B	2015	0.36	8.76	1403.52	1.44		21.93	38.00	1.73		density
2.2	Lateritic	US 2^A	18 75	0.36	9.12	1403.52	1.34	1.33	21.93	35.09	1.60	1.63	obtained
		US 2^B	1853	0.36	9.12	1403.52	1.32		21.93	36.40	1.66		
2.3	Lateritic	US 3^A	1768	0.36	9.48	1403.52	1.26	1.25	21.93	34.87	1.59	1.56	
		US 3^B	1740	0.36	9.48	1403.52	1.24		21.93	33.55	1.53		
2.4	Lateritic	US 4^A	1670	0.36	9.84	1403.52	1.19	1.16	21.93	32.68	1.49	1.51	
		US 4^B	1856	0.36	9.84	403.52	1.13		21.93	33.55	1.53		
3.1	Lateritic	UK 71^A	1979	0.54	9.12	1403.52	1.28	1.29	21.93	31.60	1.44	1.46	Lowest
		UK 71^B	1825	0.54	9.12	1403.52	1.30		21.93	32.46	1.48		strength of
3.2	Lateritic	UK 72^A	1782	0.36	8.76	1403.52	1.27	1.28	21.93	29.82	1.36	1.38	1.31N/mm^2
		UK 72^B	1810	0.36	8.76	1403.52	1.29		21.93	30.70	1.40		obtained
3.3	Lateritic	UK 73^A	1726	0.36	8.40	1403.52	1.23	1.25	21.93	29.17	1.33	1.34	
		UK 73^B	1782	0.36	8.40	1403.52	1.27		21.93	29.61	1.35		
3.4	Lateritic	UK 74^A	1712	0.36	8.04	1403.52	1.22	1.23	21.93	28.51	1.30	1.31	
		UK 74^B	1740	0.36	8.04	1403.52	1.24		21.93	28.95	1.32		

FNA: *Fired Brick Sample Without Additive* ***FSA:*** *Fired Brick Sample With Local Additive (Soda Ash Liquid)*
FK7: *Fired Brick With Industrial Additive (KS 770)* ***UNA:*** *Unfired Brick Sample Without Additive*
US: *Unfired Brick With Local Additive (Soda Ash Liquid)* ***UK7:****Unfired Brick Sample With Industrial Additive(KS 770)t*



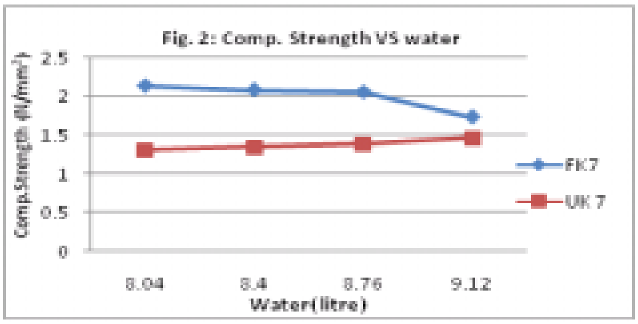


Fig. 2: Comp. Strength VS water

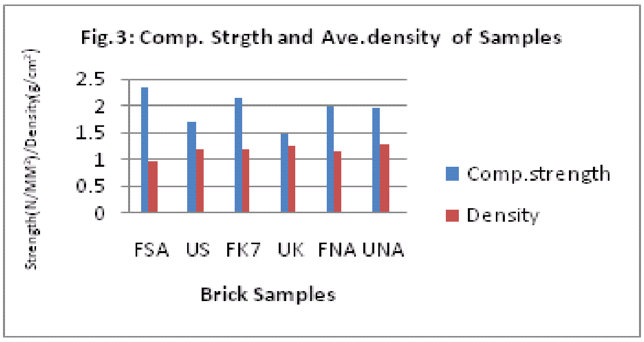


Fig.3: Comp. Strgth and Ave.density of Samples

CONCLUSION

Studies on results of the experiment carried out to investigate effect of the two chemical additives in the production of structural blicks reveals positive impact. Soda ash (local) additive has a better quality out-put in terms of strength, weight and density. The findings confirm that soda ash additive is also a good plasticizer and water reducing agent. It yields highest compressive strength at reduced weight and minimum density when fired or unfired. KS770 is also not without its own quality compared with normal brick production. The results reveal that using this additive requires more carefulness as the same measure of water increases moisture content of the prepared clay batch. Thus better result is obtainable at 10% reduction in the water when softening the clay batch. It is however fascinating to declare that the two additives yielded more numbers of bricks at same quantity of water dosage for producing normal structural bricks. Hence the use of these additives showed cost effectiveness at better output advantage. Survey also confirms that all the materials needed for commercial production are readily available and the required skill can be acquired within a short time.

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