QUALITY OF SANDCRETE HOLLOW BLOCKS PRODUCED IN KOGI STATE

BY

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OCTOBER, 1998

DECLARATION

I hereby declare that this thesis has been composed by myself and it is a record of my own research work.

It has not been accepted in any publication for a higher degree. All quotations are distinguished by quotation marks and the sources of information are specifically acknowledged by means of reference.

AMODU ISMAILA MOHAMMED.

CERTIFICATION

This thesis entitled "Quality of Sandcrete Hollow Blocks Produced in Kogi State" by Amodu Ismaila Mohammed, meets the regulations governing the award of degree of Master of Science (Structural Engineering) of Ahmadu Bello University, and is approved for its contribution to knowledge.

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DEDICATION

DEDICATED

to

My Father and Mother,

and

The entire members of my

Family.

ACKNOWLEDGMENT

I am greatly indebted to the various authors whose works I have made reference to in the course of this research work. My acknowledgment go to all of them for various quotations of their previous work.

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ABSTRACT

The quality of any building materials or structural unit cannot be over - emphasized as this is vital to the actual performance and durability of structures. This project is a study of the physical properties of sandcrete hollow blocks produced in Kogi State.

Site survey covering the entire state was first carried out. About seventy block industries all scattered within the state were visited. During the visit, many factors such as mix ratio, manner of mixing and curing, the condition survey of the current block industries were examined. Quality tests were carried out in the concrete laboratory of Dantata and Sawoe - a civil Engineering and building construction firm based in Abuja.

The various tests carried out on the block samples are: the wet development strength, dry development strength, wet and wetting expansion. These tests were done in accordance with the British standard 2028 (precast concrete blocks 1364: 1968 /2/ and the Nigerian Industrial standard.

Result from the tests conducted show that, the quality of sandcrete blocks produced in Kogi state do not meet the standard specification of the British standard 2028, 1364 (1968) /2/ and the Nigerian Industrial standard: II: 1974/3/. For example, the maximum 28 - day dry development strength is 1.40N/mm^2 while the N.I.S II /*3*/ specifies 3.45N/mm^2. The wet development strength shows low strength at 24 hours of immersion in water then increases gradually to a steady strength in subsequent days. The blocks take about a week to mature for use as evidenced in the dry development strength.

Condition survey showed that, there were about seventy block industries scattered all over the state and their methods of curing were not the best.

CHAPTER ONE

1.0 INTRODUCTION

1.1 PREAMBLE

Sandcrete hollow blocks can be defined as blocks made from a mixture of cement, Sand and water. The Cement serves as a binder which is the ordinary Portland Cement. The Portland Cement is usually the ordinary or rapid hardening types.

Sandcrete hollow blocks are walling Units, dimensionally larger than bricks and have one or more large cavities passing through them. The solid material is between 50 and 75 percent of the total volume of the block calculated from the overall dimension.

The specified nominal mixes of Sandcrete blocks are one part of cement to six or eight parts of sand (1:6 or 1:8) by volume; with water - cement ratio of 0.6 to 0.9.

Sandcrete blocks have three nominal sizes and are as follows: 230x230x460mm, 150x230x460mm, 100x230x460mm.

There are two main types of Sandcretes blocks, aggregate blocks and aerated blocks, and their respective methods of manufacturing are distinctly different.

Sandcrete hollow blocks are produced manually or by moulding machines. The manufacturing process involves compaction of the newly mixed constituent materials in a mould followed immediately by extrusion of the pressed block so that the mould can be repeatedly used. Blocks so produced are cured for a minimum of seven days and a maximum of twenty eight days.

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These blocks are extensively used as walling units such as external walls, internal walls or partitions. Because of their wide application, they are gradually replacing bricks and mud blocks as masonry units.

However, this project is intended to study the physical properties of sandcrete hollow blocks produced in Kogi State for the purpose of testing their quality, if they meet with required specified standard. Before the commencement of the physical tests to determine the quality of the blocks, initial site visits were made to the block industries to obtain general information on sizes, manner of curing and mode of production of sandcrete blocks.

1.2 OBJECTIVES

The objectives of the research are:

a) to find out the quality of the raw materials used for the production of sandcrete blocks

b) to ascertain the production procedures for the different block industries in the State.

c) to compare the quality of the finished products from different industries and

d) to compare the results with the existing international, and local standard as well as the results of technical reports.

1.3 SCOPE OF WORK

The following form the scope of work:

a) review of previous work on sandcrete hollow blocks

b) Sieve analysis to determine particle size distribution

c) Laboratory tests on the sandcrete hollow sample to determine the dry and wet development strengths, wet compressive strength, drying shrinkage, wetting expansion and density determination.

1.4 TEST RESULT

The test results show that the average value of dry development strength for the chosen five industries range from 0.60N/mm^2 -1.40N/mm^2. The wet development strength values range from 0.56N/mm^2 - 0.72N/mm^2.

The average wet development compression strength is between (0.40 - 0.75) N/mm^2. These values when compared to the specified value of 3.5N/mm^2 in the B.S 20028 are low.

2.0 CHAPTER TWO

2.1 LITERATURE REVIEW

2.1.1 Constitution Materials

The initial materials for making sandcrete blocks are, a hydraulic binder, water and aggregate and in the case of aerated concrete blocks only a reactive foaming agent to produce their characteristics cellular structure. Additives and /or admixtures are also used sometimes to extend the product age /7/.

These constituent materials are thus discussed below.

2.1.2 Cement

The hydraulic binder referred to above is the Portland cement. The Portland cement is usually of ordinary or rapid hardening type /7/. Cement is a material with adhesive and cohesive properties which is capable of binding mineral fragments into a compact whole. Cement in addition with water leads to chemical reaction thus causing it to set and harden. The essential requirement is that, the cement should be able to produce strong, dense durable sandcrete blocks with definite setting and hardening characteristics.

The manufacturing process of cement involves intimately grinding and mixing of the raw constituent which are limestone and clay in certain proportions, burning this mixture at a very high temperature to produce clinker and then grinding to form powder with 1 to 5 percents of gypsum added. Gypsum is added to control the setting of the cement, which will otherwise set most quickly for general use /7/. Different types of Portland cement are obtained by varying the proportion of raw materials, the temperature of burning and the fineness of

grinding and in some cases by intergrinding the linker with other recognised materials such as pulverized fuel ash:

Portland cement is composed of four main oxides compounds. These are:

Tricalcium Silicate----------C_3S

Dicalcium Silicate----------C_2S

Tricalcium Aluminate----------C_3A

Tricalcium Aluminofenite----------C_4F

The two silicate, C_3S and C_2S which are most stable of these compounds together form 70 to 80 percent of the constituent in the cement and contribute most to the physical properties of sandcrete blocks when cement comes in contact with water. C_3S begins to hydrate rapidly, generating a considerable amount of heat and making a significant contribution to the development of the early strength, particularly during the first 14 days. In contracts. C_2S which hydrates slowly and is mainly responsible for development in strength after about 7 days, may be active for a considerable period of time/7/. It is generally believed that cements rich in C_2S results in a greater resistance to chemical attack and a small drying shrinkage than other Portland cements of the four principal compounds, Tricalcium aluminate, C_3A is the least stable as its hydration is extremely exothermic and takes place very quickly. Cements containing more than 10 percent of this compound produce concrete products which are particularly susceptible attack. C_4AF is of less important than the other three compounds when considering the properties of hardened cement products /7/

2.1.3 Sand

Sand is much cheaper than cement and maximum economy is obtained by using as much aggregate as possible in the production of sandcrete hallow blocks. Its use also considerably improves both the volume stability and the durability of the resulting sandcrete blocks.

Sand used should be as clean as possible and should produce the desired properties in hardened sandcrete blocks. The properties of aggregate known to have a significant effect on sandcrete blocks are its strength, durability, hardeners, voids, and density./8/

The characteristics which determine the value of sand in a mix is its grading. The density of a batch of sand depends on the variety of sizes of grains in a batch. A batch of sand containing grains of even approximately the same size would have undesirable air spaces between the grains which would seriously lower the sandcrete block strength and density. In sand containing a wide range of grain sizes, the small grains fill the spaces between the larger grains to make a satisfactory dense material./8/

According to NIS: 1974 /14/, the sand to be used for producing sandcrete blocks shall be approved clean, sharp, fresh water or pit sand free from clay loam, dirt, organic or chemical matter of any description and shall mainly pass through 4.70mm or fall within zones 1 and 2 of British standard test sieves.

STRENGTH

Sand does not fracture under the action of increase force unlike a compact material. Therefore, an aggregate subject to a force would reduce in volume

accompanied by crushing of the particles to produce a larger proportion of fine particles. Thus, a value of failing stress cannot be obtained.

HARDNESS

This is the resistance of an aggregate to wear. Aggregate used in the production of sandcrete blocks should be able to resist wear so that durable sandcrete are produced.

VOIDS

Two district voids could be associated with sand:

(a) External Voids - This occur between the sand particles.

(b) Internal Voids - This occur within each particle.

The internal voids in particles could again be subdivided into permeable voids which are accessible from the exterior and impermeable voids which are totally enclosed.

If no moisture is present in sand, it is said to be oven dry. Where water has filled the internal permeable voids, it is said to be saturated and dry. With further addition of more water, it accumulates in the external voids, and when these are full, the sand is said to be just - saturated. The addition of water to an oven dry sample without compaction to produce an increase in volume is known as bulking. Finer sands have been known to show a greater degree of bulking as against coarse sand. A knowledge of bulking of sand is essential if its volume is used as a measure of its quality./8/

DENSITY

The density of sand could be considered in two separate ways:

Bulk Density: This refers to the material in bulk including all the voids.

Relative Density: Is the ratio of its unit weight to that of water. The amount of water present in the voids would affect the density, so ,reference should always be made to moisture condition of the aggregate when bulk or relative density is measured.

Particle Size

Distribution: For void content to be reduced, there must be suitable proportion of smaller particles to occupy the spaces between the larger ones. So, particle size distribution is one of the factors which affect the proportion of external voids in aggregate.\8\

2.1.4 Water

Water used in the production of sandcrete blocks, in addition to reaction with cement and thus causing it to set and harden, also facilitated mixing, placing and compacting of sandcrete mixture /7/. It is also used for curing purpose. In general, water fit for drinking, such as tap water is acceptable for mixing. The impurities that are likely to have an adversely effect when present in appreciable quantities include silt, clay, acids, alkalis, and other salts. The use of sea water does appear to have adverse effect on the strength and durability of Portland

cement concrete as it is known to cause surface dampness, efflorescence and staining and should be avoided where concrete with good appearance is required. /7/

2.2 MIX PROPORTIONS

According to NIS: 1974/14/, the mix used for sandcrete blocks shall not be less than one part of cement to six parts (1.6) up to a mix of one part cement and eight part of sand.(1:8).

2.3 MANUFACTURING

The materials for the manufacture of sandcrete blocks (basically cement, sand and water) must be thoroughly mixed together to produce a homogenous material in which each particle of sand is entirely covered with cement paste and then gradually adding the water while mixing continues. The newly mixed constituent is fed into a mould followed immediately by compaction and extrusion of the pressed block so that the mould can be used respectively ./7/. The need for good compaction cannot be overemphasized as inadequately compacted sandcrete blocks would have air voids. These voids in excess of those due to water which is not needed for hydration will lower the strength of the blocks. Therefore, sandcrete mix placed in moulds must be well compacted so as to reduce the void content to a minimum. Since the finished blocks are required to be self supporting and able to withstand any movement and vibration from the moment they are extruded, very much drier, higher fine aggregate content and lesser mixes are used than normal concrete work /7/.

As the sandcrete blocks are extruded, they must be protected from extreme weather condition of wind and temperature. They must be kept under cover as well as promote the hydration of cement so that maximum possible strength of the block is attained. The process of ensuring that the block is kept in contact with moisture is termed curing. The aim of curing is to keep the block saturated until the original water filled space in fresh cement paste has been filled by products of hydration. The chemical process of hardening continues at a diminishing rate for an indefinite period as long as moisture is present and temperature is favourable. This increases the compressive strength of the blocks as well s the durability, impermeability, abrasion resistance and stability. The curing process should be for a minimum of 7 days and the blocks must be placed under shed for the first 24 hours.

2.4 FORM AND SIZE

There are three basic forms of sandcrete blocks, solid, cellular and hollow./13/. A solid block has no formed holes or cavities other than those inherent in the material. While cellular and hollow blocks have one or more formed holes or cavitties which pass right through them /13/.

British standard B.S. 6073 /13/ defines a block as mansory unit of a large size in all dimension than specified for bricks but no dimension should exceed either its length or six times its thickness. In the British standard 2028 /12/, concrete blocks are divided into three types.

TYPE A Dense aggregate concrete blocks.

TYPE B Lightweight aggregate concrete blocks.

TYPE C Lightweight aggregate concrete blocks for non load bearing walls.

TYPES A and B are both suitable for load bearing walls and can be used for rendering external walls, internal walls and partitions, and paneling in framed buildings.

TYPE C blocks are used for internal wall only, for partition and paneling to framed building.

Concrete blocks are available in wide range if sizes. Jackson and Dhir /7/ give the following work sizes as shown in Table 1.

TABLE 1

Face Length (mm)	Height(mm)	Thickness(mm)
390	190	
440	140	
440	190	60,75, 100,140
440	215	
440	290	150, 190, 200, 215
590	140	
590	190	
590	215	

To obtain coordinating sizes, add 10mm for mortar joints to the length and height dimensions but not to the thickness./7/.

Also the British standard 2028 /12/ gives the dimension of blocks as shown in table 2.

TABLE 2: DIMENSION OF HOLLOW SANDCRETE BLOCK BS2028

1	2	3	4
BLOCK TYPE	Length x Height		Thickness (work size) (mm)
TYPE A	Coordinating Size (mm)	Work Size (mm)	
	400 x 100	390 x 90	75, 90, 100
	400 x 200	390 x 100	140, 190 & 190
	450 x 225	440 x 215	75, 90, 100
			140,190 & 215
TYPE B	400 x 100	390 x 90	75, 90, 100,
	400 x 200	390 x 100	140, 190, & 190
	450 x 200	440 x 190	75, 90, 100
	450 x 225	440 x 215	140,190 & 215
	450 x 300	440 x 290	
	600 x 200	590 x 190	
	600 x 225	590 x 215	
TYPE C	440 x 200	390 x 190	60 and 75
	450 x 200	440 x 215	
	450 x 200	440 x 290	
	450 x 300	590 x 190	
	600 x 200	590 x 190	
	600 x 225	590 x 215	

2.5 PROPERTIES

The properties of sandcrete blocks depend on a varying degree on the type and proportions of the constituent materials, and the mode and duration of curing method employed as well as on the form and size of the block itself /7/.

2.5.1 Strength

Amongst the properties of sandcrete hollow blocks, its strength is of prime importance. The compressive strength of a sancrete block is dependent mainly on the mix composition (in particular binder content), degree of compaction, fine aggregate,water, the curing condition, age of cement and the type of weather /8/.

Ola and Owoleye /10/ who both conducted test on stabilised compressed blocks for civil engineering works came out with the following results.

a) The compressive strength of soil-cement blocks increases appreciably with the increase in cement content.

b) The compressive strength of soil-cement increases appreciably with increase in compactive effort up to a compactive effort of about 8MM/m^2 when the subsequent increase is no longer appreciable.

c) The tensile sttrength of soil - cement blocks increases with increase in cement content.

d) The tensile strength of soil-cement blocks increases with compactive effort up to a compactive effort of 6-8MN/m^2.

e) Tensile strength of soil- cement blocks appear to be independent of the sizes of blocks. On the other hand, larger blocks appear to have smaller compressive strengths.

In the seminar on the use of clay bricks and blocks for the provision of cheaper and durable housing in October 1985 at Zaria, Floreck and Ejeh /5/ jointly presented a paper on soilcrete hollow block as a building unit. The soilcrete blocks were produced by occidental construction company, Zaria. They jointly concluded that the development of dry compressive strength is 3MN/m2 after 28 days of hardening.

In addition, the minimum wet to dry compressive strength ratio is 0.4 and the average ratio for the blocks is about 0.65.

Adepegba /1/ in his studies observed that the compressive strength as well as the tensile strength of latercrete are higher.

He /1/ also observed that the most economic range of use of these stablised soil lies between 0-10 percent cement content, latercrete doubles that of sandcrete.

The quality of sandcrete hollow blocks were tested in Bauchi, Kaduna, Mubi, Saminaka and Zaria all in the Northen Nigeria between 1976 and 1984 by Floreck /2/ in his studies, he discovered that the quality of these products were below expectation as the value did not meet the standard specifications. Below is the average strength for the various size of blocks.

TABLE 3: AVERAGE COMPRESSIVE STRENGTH FOR VARIOUS SIZE OF BLOCKS

SIZE OF BLOCKS (mm)	AVERAGE STRENGTH N/mm2	STANDARD DEVIATION(N/mm^2)	EFFICIENT OF VARIATION(%)
100 x 230 x 460	1.64	0.399	24.3
150 x 230460	3.88	2.471	49.3
230 x 230 x 460	2.43	1.872	77.1

He /7/ therefore recommended that the relevant standard taking into account Nigeria materials and equipment should be elaborated as soon as possible and quality tests of blocks are obligatory for all manufacturers. The tests should be carried out by authorised building materials testing laboratories.

Ejeh /4/ made studies on the compressive strength of soilcrete hollow blocks. some of his /4/ findings are stated bellow.

a. The soilcrete hollow blocks will fully develop its dry compressive strength after curing by spraying with water and covering with cellophane materials for about a week.

b. The soilcrete hollow blocks have a ration of average constant wet compressive strength to dry strength of 0.65.

c. The soilcrete hollow blocks have a minimum wet compressive strength to dry compressive strength ration of 0.42.

d. Block samples should be immersed in water for a period of 24 hours in the laboratory before testing for the wet compressive strength.

e. Soilcrete blocks should be tested between soft boards this is because, it gave higher compressive strength than the rest packing materials.

- According to /7/, the compressive strength is calculated as the crashing load divided by the gross area.

Com. strength = Crushing load/gross area.

(soil, cellular, or hollow) will not affect its loads carrying capacity.

The British standard 2028: 1364/12/gives the average compressive strength of type C blocks as 3.5N/mm2 and the lowest individual blocks as 2.8N/mm2, while the Nigeria industrial standard /14/ gives the average value of type a blocks as 3.45/Nmm2 and type Bas 2.76N/mm2.

However, the Federal Ministry of works decided to lower the requirements for precast concrete blocks produced in Nigeria during the annual conference in Kano (1979) /3/ due to the fact the blocks will not be subjected to severe climatic conditions. Indeed the conference recommended that the average compressive strength of three should not be less than 2.1 N/mm2 while the lowest compressive blocks of individual blocks should not be less than 1.7N/mm2.

The compressive strength of concrete block testes in accordance with B.S 6073: part I is specifies as a minimum average value of ten blocks of which no single value should fall bellow 80% of the permitted average value. The range of strength values specified in B.S 6073: part 2/13/ is 2.8N/mm2 to 3.5N/mm2.

According to author Rock, Chauhuri and Aggarwal /3/ who jointly carries out a detailed study on mix composition. strength and the cost of sandcrete blocks for buildings, they discovered that,

a. The weight as well as the compressive strength of a sandcrete block increase with increase in cement content ans also with the addition of coarse aggregate is highest with addition of 45 percent of coarse aggregate.

b. The compressive strength in wet state is about 80 percent of the strength in dry state.

FACTOR INFLUENCING COMPRESSIVE STRENGTH OF SANDCRETE BLOCKS

According to Iloghalu /6/, the variables that can affect a cement product are many, namely water/cement ratio, cement/sand/gravel ratio, locality and

temperature of curing, quality of cement use, method of compaction, block geometry and type of additives.

2.5.1.1 EFFECT OF COMPACTION

If the block is not adequately compacted, air voids would remains in the hardened block. These voids are in excess of those due to water which is not needed for hydration, will lower the strength of blocks /8/.

2.5.1.2 EFFECT OF WATER CONTENT ON STRENGTH

Initial water added to the mixture of cement and sand fills the internal permeable voids in the sand which are not already filled with water. Hydration process of cement commences when further water is required. It is this water that eventually evaporates leaving voids in the block. /8/

Thus, there is, for any particular sandcrete block, a certain optimum water content at which the block will achieve its maximum strength. As the water content decreases from this level, the strength decreases because compaction becomes more difficult, resulting in more voids, and the degree of hydration decreases.

As the water content increase from this level, the strength decreases because of the increase in void content.

2.5.1.3 EFFECT OF WEATHER ON STRENGTH

Sandcrete block making in hot weather is affected by high losses of of mixing and curing water, early stiffening, because, the hydration process is

accelerated. Surface shrinkage and possibly cracking of the sandcrete block might occur.

There is an increase in the rate of gain of early strength, this occurs if and only of there is no loss of water due evaporation, that is, the blocks are properly cured. By making blocks under less ambient conditions, avoiding delays and placement in the mid-day, providing proper shade and protection and curing as soon as possible would minimise the effects of hot weather on sandcrete blocks./8/

2.5.2 DENSITY

The density of sandcrete blocks is determined by The materials used and the void content. The objective of compaction of sandcrete blocks is to minimise air hole and to achieve maximum density. In order to obtain maximum density, it is necessary to use a mix which has adequate workability to enable the operator to place it in position without difficulty with the equipment he has available.

For sandcrete blocks, density is largely a function of the aggregate density, size and grading , degree of compaction or aeration, and the block form /7/. The typical range for dry density is 50 to 2100kg/m3 with aerated and solid dense aggregate concrete blocks being on the lighter and heavier end of the scale respectively and lightweight and dense aggregate concrete blocks of cellular and hollow form falling in the middle of the range. The British standard specification /12/ states that, the block density of type A shall not be less than 1500kg/m3 while type B and C shall be less than 1500kg/m3.

Therefore, the distinction between types A and B blocks is based on the block density.

2.5.3 DRYING SHRINKAGE AND MOISTURE MOVEMENT

Drying blocks will undergo some dimensional changes owing to variations in the ambient moisture and temperature condition. The magnitude of such movements, to a varying degree is largely influenced by the constituent materials (mainly the aggregate), mix proportion and the process of block manufacturing adopted. Drying shrinkage is considered to be most important /7/.

The dying shrinkage is the reduction in length obtained when a saturated sample is dried under certain conditions and the moisture movement is the increase in length of the sample when again saturated.

The drying shrinkage and moisture movement depend on the cement and in particular its fineness, the richness of mix, the water/ cement ratio, the kind of curing and in particular at early age. The rate at which movement or shrinkage takes place also depends on the permeability of the concrete.

The British standard specification/2/ specifies that the average value of the dying shrinkage shall not exceed the value given below in table 4.

TABLE 4: DRYING SHRINKAGE

BLOCK TYPE	DRYING SHRINKAGE (%)
A	0.04
B	0.06
C	0.08

Floreck and Ejeh /5/ conducted drying shrinkage and moisture movement tests on soilcrete.The result of their tests are presented below in tables 5 and 6.

TABLE 5: DRYING SHRINKAGE

Sample No	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	C4
Drying Length (mm)	100.74	100.93	100.80	100.74	100.72	100.44	100.82	100.88	100.61	100.83	100.88
Wet Length (mm)	100.83	101.01	100.88	100.80	100.79	100.52	100.89	100.99	100.69	100.90	100.94
Drying shrinkage (%)	0.09	0.08	0.08	0.06	0.07	0.08	0.07	0.11	0.08	0.07	0.08

Average drying shrinkage is 0.08%

TABLE 6: MOISTURE MOVEMENT

Sample No.	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	C4
Drying Length (mm)	100.74	100.93	100.80	100.74	100.72	100.44	100.82	100.88	100.61	100.83	100.84
Wet Length (mm)	100.81	101.01	100.89	100.81	100.79	100.54	100.90	100.95	100.70	100.89	100.96
Drying Shrink Age (%)	0.069	0.079	0.089	0.069	0.069	0.10	0.079	0.069	0.089	0.069	0.079

Average drying shrinkage is 0.08%

Average moisture movement = 0.08%

The high drying shrinkage percentage was due to laterite. To reduce drying shrinkage and moisture movement, sandcrete blocks should be well made, cured and adequately dried by the manufacturer. Also they should be

protected from moisture as much as possible from the time they leave the factory until the completion of the building. This implies that when necessary, they must be covered during transit, while stacked on the dry process of the building itself.

The difference between the dry weight and final weight expressed as a percentage of the dry weight is known as water absorption or moisture movement.

The Nigerian Industrial standard 74:1976 specifies that the average water absorption of common building bricks shall not be more than 25 percent by weight after immersion in water for 24 hours /14/.

Iloghalu /6/ in his works compared the properties of fired bricks viewed against that of sandcretes. He /6/ observed that in a production factory, the determination of water absorption is used for quality control, because it is much simpler and less time consuming than the measurement of porosity is approximately twice the figure obtained for water absorption.

Table 7 below shows the relationship between water absorption and apparent porosity while Table 8 shows the different results of absorption tests conducted.

TABLE 7: SAMPLE RESULTS OF APPARENT POROSITY, WATER ABSORPTION AND BULK DENSITY FROM PRODA DENSE REFRACTORY TEST SAMPLES

Samples No.	Apparent Water Porosity (%)		Bulk Density (%) Absorption (%)
1	35.37	20.26	2.70
2	36.36	21.09	2.71
3	36.04	20.95	2.70
4	34.08	19.34	2.68
5	34.45	19.55	2.69

TABLE 8: 24 - HOURS SOAKING TEST AND 5 - HOURS BOILING TEST RESULTS FOR WATER ABSORPTION FROM THE TEST SAMPLE

Sample Code	1	2	3	4	5	6	7	8	9	10
% Water Absorption 24 hrs Soaking test	17.99	17.39	17.44	17.39	17.34	17.13	17.18	17.44	16.86	16.99
% water absorption - 5 hrs boiling test	21.44	19.71	20.02	19.60	20.03	19.67	19.72	19.93	19.07	19.02

The absorption test immediately gives the idea of how porous and more importantly, how permeable a brick is.

2.5.4 THERMAL CONDUCTIVITY

The thermal conductivity of a concrete block is largely dependent on its block density. It has been found that aerated concrete and lightweight concrete blocks have relatively low thermal conduciveness. Similarly their low density have lower thermal conduciveness than their solid counterparts.

2.5.5 FIRE RESISTANCE

The general, concrete blocks have good fire resistance properties. However, their actual fire endurance is controlled by numerous factors such as grading of aggregate, the cement content I the mix, the form, weight, thickness of the block and its moisture content. As a general rule, most concrete blocks of 100mm thickness can provide an adequate resistance to fire up to 2 hours if load bearing or up to 4 hours if non-load bearing /7/.

2.5.6 ACOUSTIC PROPERTIES

Unrendered lightweight concrete blocks are often used for internal walls because they are believed to have good sound absorbing qualities. Lightweight concrete blocks do not however reduce sound transmission and in general, the heavier the blocks, the greater is its ability to reduce the transmission of sound /7/.

There are two important acoustic properties viz: sound transmission and sound absorption. These properties are dependent on the density and void content of the sandcrete blocks. Increased density reduces sound transmission while increased voids increases sound absorption.

2.5.7 EFFLORESCENCE

Efflorescence is the deposition of salt by evaporation on the surface of sandcrete block brought by water, while efflorescence may be disfiguring, it is often not harmful and disappear after a few seasons. Such efflorescence that occur in concrete blocks normally consist of sodium, potassium and calcium carbonates formed as a result of reaction between the corresponding free hydroxides brought to the surface and atmospheric carbon dioxide.

Its occupance can further be reduced by autoclaving, using a puzzolana in the mix. This will increase durability as it retards the rate of setting and hardening.

2.6 CUTTING, NAILING AND RENDERING

All lightweight concrete blocks can easily be out with normal bricklayers' tools chisels for pipes runs etc can also easily be formed and they will accept and hold nails quite readily. All lightweight concrete provide a very good key for rendering and plastering /10/.

2.7 SAMPLING

To have a good representative of the entire blocks, proper sampling must be done before tests are carried out. The sampling could be classified as stratified sampling or random sampling. The British standard 2028 /12/ gives the number of blocks necessary for each test in the table below:

TABLE 9: NUMBER OF BLOCKS NECESSARY FOR EACH TEST

	Purpose of Which Requires	Purpose of Which Requires	
	TYPES OF TEST	TYPE A/B	TYPE C
a	Checking and measurement of dimension	10	10
b	Determination of density	3	3
c	Determination of strength	10	5
d	Determination of drying shrinkage and/or moisture	4	4
e	Spares	3	3
f	Total require for fall	20	15

2.8 SITE SURVEY

Several visits were made to various block moulding industries in Kogi State. There are many block industries scattered in the States. These visits were conducted so as to collect all necessary information on the mix and mixing process of the industries, production capacities, curing, type of materials, they used - including the machine types, and the cost of the blocks as per each industry.

The survey covered about 70 blocks making industries within the states. Most of the industries are using obsolete moulding machines. They do not cure their blocks very well. They only spray water once a day for one or two days and maximum of three days. The demand for blocks is generally low except in Lokoja, where the demand is high because it is a growing state capital. The price for one block ranges between twenty - five naira to thirty naira only depending on the industry. The process of mixing and mixing ratio vary from one industry to another. A mix ratio of cement to sand used is between 1 part of cement to 10 or 12 parts of sand (1:10 or 1:12).

2.9 COLLECTION OF SAMPLES

Five prominent block industries that are fairly spread all over the state were chosen for sample collection. In each of the industries, about fifty (50) block samples were randomly selected for various strength tests. That means that about two hundred and fifty (250) blocks samples were collected from all the five industries.

These five industries apart from being well spread with the state, have high production capacity as they use block moulding machines. They make use of the abundant sand in the state, cement from other states as there is no cement industry in the state.

The five seated industries are located as follows with reference to the state capital.

i. Industry A Idah - which is situated in the South Eastern part of the state headquarter (Lokoja) which is about one hundred and fifty kilometers (150KM) from Lokoja.

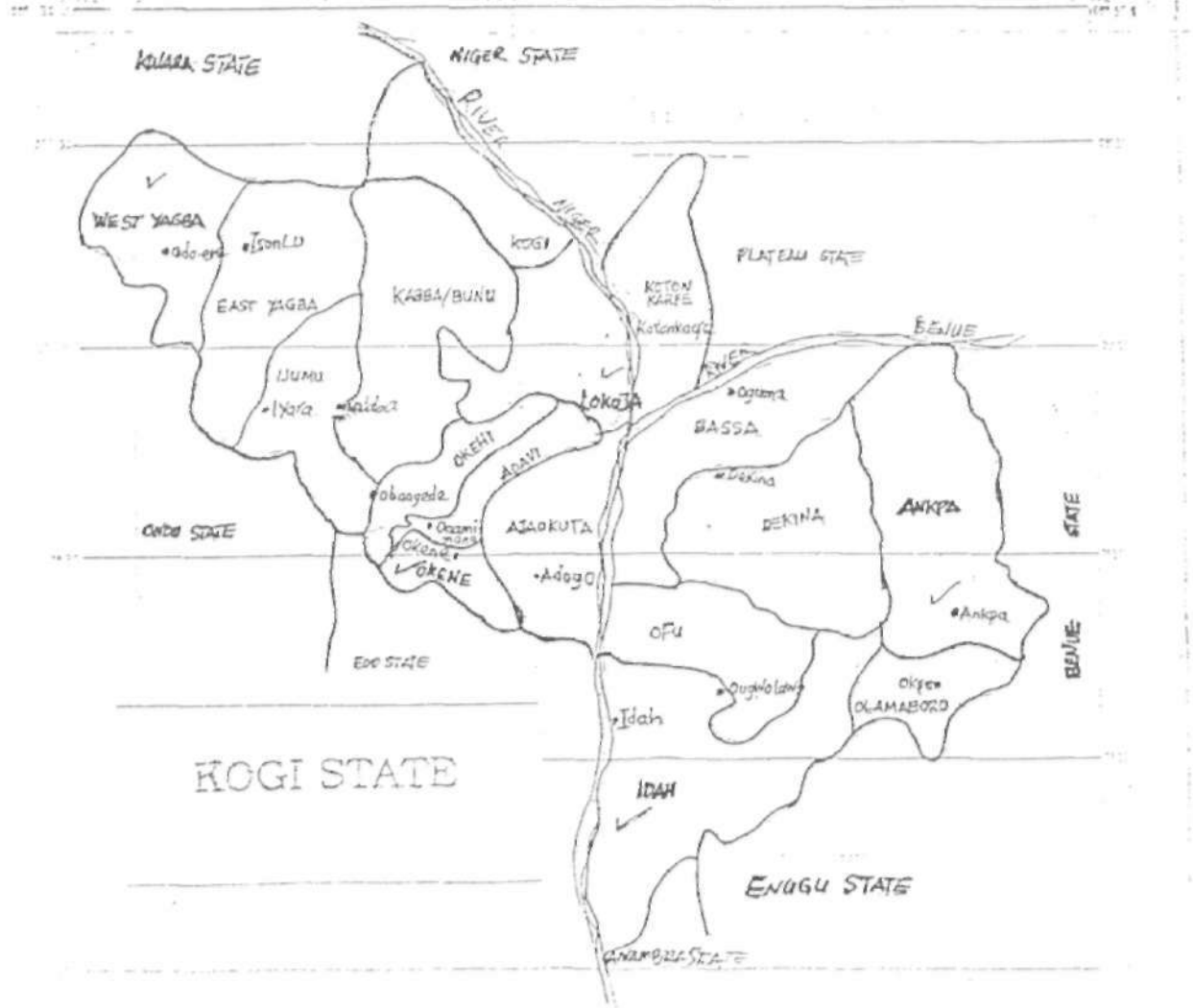
ii. Industry B Okene - which is situated in the Southern part of Lokoja. It is about seventy kilometer (70KM) from Lokoja.

iii. Industry C Lokoja - the capital of Kogi State which is about one hundred and eighty kilometer (180KM) from Abuja, where the various tests were conducted. This industry has the highest number of blocks in the state and more patronised.

iv. Industry D West Yagba - Located inthe Western part of Lokoja. It is about two hundred and fifty kilometer from Lokoja.

v. Industry E Ankpa - situated in the North Eastern part of Lokoja. About one hundred and sixty kilometers from Lokoja.

For identification purposes, the industries are labeled A, B, C, D, E, F. The alphabets have nothing to do with the quality of block.



MAP OF KOGI STATE SHOWING VARIOUS INDUSTRIES

2.10 INDUSTRY A

The sand used for the production of blocks in this industry was got from the River Idah, which is a branch of River Niger. The cement here comes from various places but predominantly, the Benue cent company, Gboko.

In this industry, a mix of one part of the cement to ten or twelve parts of sand (1:10 or 1:12) by volume was used. About five hundred to eight hundred blocks (500 to 800) were produced daily. They used mostly Lister type of moulding machines. The blocks sold for twenty five naira each for (230 x 230 x 450mm) nine inches and eighteen to twenty naira each for (150 x 230 x 540mm) six inches. The cost of transporting the blocks to Dantata and Sawoe Company site in Abuja where the tests were conducted was done by my company but least is about ₦15 per block.

This industry cured their blocks by spraying water once in a day for maximum of three days. Between three to seven days, the blocks will be stacked on each other. About five blocks high to create space for productions.

2.11 INDUSTRY B

This industry obtained its cement from Edo Cement Okpella. It also used from other states like Ashaka Cement and Benue Cement. The sand is got from erosion left overs and pits within the town. The sand is very silty. It was observed that, a mix ratio of about one part of cement to twelve parts of sand by volume was used (1:12). Water used for mixing and curing was tap water.

The production capacity of this industry was about seven hundred to one thousand blocks daily. The blocks were stacked after three days for space. The curing process was very poor as the blocks are cured by spraying water once a

day for a maximum of two days. The owner (Director) of the industry and his men (workers) were not Engineers. They are only working with experience.

Blocks produced are of two types: 230 x 230 x 450mm /6"/ ad 150 x 230 x 450mm and the cost per block for 9 inches is twenty naira and eighteen naira for 6". Although, transportation of blocks was done by the company, it cost ten naira a block. On employment of the company are about 8 workers comprising two operators, two mixers and five unskilled workers.

2.12 INDUSTRY C

The sand used here is got from the Conflux Rivers (Benue/Niger) and sometimes from the left over of erosions. Being a growing state capital, almost all the cement from all the industries in Nigeria were represented. The Ashaka Cement and Benue Cement were the ones that are mostly patronised.

A mix of one part of cement to ten parts of sand by volume were seen to be used (1:10). The demand for blocks is very high here and the industry capitalized on that to sell the blocks very exorbitantly. Two type of blocks are produced: 230 x 230 x 450mm and 150 x 230 x 450mm. The cost for one block was between thirty naira to thirty - two naira and twenty two to twenty five naira for nine and six inches respectively.

The blocks were fairly cured as the industry sprayed water once a day for three days. The industry hardly met the demand so that, their was no need to stack them as whatever was produced was used after their maximum cure.

The owner of the industry and his workers were ignorance of the strength requirements as they were not engineers. The production capacity was very high, between one thousand to one thousand two hundred. The industry

employs about 9 workers to carry out the production of the sandcrete blocks and these are two operators, two mixers and six unskilled formers.

2.13 INDUSTRY D

This is the farthest industry to the state capital. The sand used in producing blocks in this industry was got from pit outside the town. Most times, the industry went in search of sand. The cement used by this industry was mainly the Edo Cement Okpella. Two sizes of sandcrete blocks are produced: 230 x 230 x 450mm and 150 x 230 x 450mm. The cost per block here was very low, as nine inches block sold for twenty naira while the six inches block was for fifteen naira only. The mix ratio was one part of cement to two parts of sand by volume (1:10).

The production capacity was about three hundred to five hundred blocks daily. The curing process was very poor. it was done by spraying water once a day for two days. About six workers are employed by the company to carry out the production of sandcrete blocks. These are one operator, two mixers and three unskilled workers.

The owner of the industry and his workers were not aware of any strength regulations. They were not engineers but only trying with experience.

2.14 INDUSTRY E

The cement here was from Gboko (Benue Cement). The sand was from Umabolo river and some from the pits outside of the town.

The mix was one part of cement to ten or twelve parts of sand by volume (1:10 or 1:12).

The production capacity of this industry is between eight hundred to one thousand sandcrete blocks daily. The blocks were cured by spraying water twice a day for two or three days.

The blocks were sold for twenty five naira for nine inches and eighteen naira only for six inches respectively.

The cost of transporting the blocks to Abuja was free. The owner of the industry and his worker worked under a builder who had an OND in building since 1990 from the Institute of Management Technology in Enugu. However, he was not aware of any code for strength requirements. The influence of that OND man could be seen in their activities as they knew why they were doing something though not according to the strength requirements.

3.0 CHAPTER THREE

3.1 EXPERIMENTATION AND TEST RESULT

In the previous chapter, it was stated that two hundred and fifty (250) block samples were obtained from the chosen industries in Kogi State. Attempts were also made to collect information in respect of materials, cost and mode of production used by the various manufacturers in the state.

3.2 DRY DEVELOPMENT STRENGTH

The block samples were tested for dry development strength. They were stacked inside the laboratory. The block samples prior to testing were marked for easy identification and were then crushed between celotex board at different ages of curing using the STRASSEN TEST machine. The strength indicated against each age is average strength of three blocks for each industry. The ages considered were 1st, 3rd, 7th, 14th, 21st, and 28th days. The average result for industries A, B, C, D and E are shown in tables 10 and 14. All raw data are shown in the Appendix A_1 to A_5.

TABLE 10: DRY DEVELOPMENT STRENGTH OF INDUSTRY A

DATE OF CASTING: 6 - 2 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm2
1	1	7-1-97	459	216	230	15	0.15
2	3	9-1-97	460	215	231	32	0.32
3	7	13-1-97	459	215	231	45	0.46
4	14	20-1-97	459	215	231	62	0.63
5	21	27-1-97	459	215	231	72	0.73
6	28	3-2-97	459	215	231	81	0.82

TABLE 11: DRY DEVELOPMENT STRENGTH OF INDUSTRY B

DATE OF CASTING: 3 - 6 - 96

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm2
1	1	7-1-97	459	216	230	10.7	0.10
2	3	9-1-97	459	215	230	27.7	0.27
3	7	13-1-97	459	215	230	35.7	0.35
4	14	20-1-97	459	215	230	52.0	0.50
5	21	27-1-97	459	215	230	55.0	0.53
6	28	3-2-97	459	215	230	62.0	0.60

TABLE 12: DRY DEVELOPMENT STRENGTH OF INDUSTRY C

DATE OF CASTING: 6 - 1 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm2
1	1	7-1-97	460	222	233	167	0.17
2	3	9-1-97	460	222	233	45	0.44
3	7	13-1-97	460	222	233	103	1.01
4	14	20-1-97	460	222	233	112	1.10
5	21	27-1-97	460	222	233	125	1.22
6	28	3-2-97	460	222	233	143	1.40

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TABLE 13: DRY DEVELOPMENT STRENGTH OF INDUSTRY D

DATE OF CASTING: 3 - 3 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm2
1	1	4-3-97	459	215	231	16.7	0.17
2	3	6-3-97	459	215	230	29.1	0.30
3	7	10-3-97	460	216	231	42	0.43
4	14	17-3-97	459	216	231	58	0.59
5	21	24-3-97	459	215	231	70	0.71
6	28	31-3-97	460	216	231	80	0.81

TABLE 14: DRY DEVELOPMENT STRENGTH OF INDUSTRY E

DATE OF CASTING: 3 - 3 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm2
1	1	4-3-97	459	215	231	12	0.12
2	3	6-3-97	459	215	231	29	0.29
3	7	10-3-97	459	215	231	38	0.38
4	14	17-3-97	459	215	231	61	0.62
5	21	24-3-97	459	215	231	69	0.70
6	28	31-3-97	459	215	231	74	0.75

3.3 WET COMPRESSIVE STRENGTH

The test was carried out after 28 days of age of block samples. The blocks were randomly selected from the various block industries and soaked for crushing. Ten blocks from each industry were crushed. Prior to crushing, the measured block samples were bedded on both faces with mortar using a mix of one part by weight of cement to one part by weight of sand (1:1)

Mortar cubes were also made out of the mortar mix used for bedding and were also immersed in water. When the mortar had attained the required strength, the compressive strength of each block samples was determined. The block samples were soaked for seven days prior to crushing. The strength indicated against each age is an average strength of three cubes for each industry.

TABLE 15: MORTAR CUBES STRENGTH OF INDUSTRIES A, B AND C.
DATE IMMERSED IN WATER: 4 - 2 - 97.
AREA OF CUBE: (75 x 75) mm^2

S/No	Date Tested	Age of Curing (Days)	Failure Load (KN)	Average Strength (N/mm^2)
1	5-2-97	1	19.60	3.49
2	6-2-97	2	70.0	12.44
3	7-2-97	3	104.0	18.5
4	11-2-97	7	169.2	30.08

TABLE 16: MORTAR CUBES STRENGTH OF INDUSTRIES D AND E
DATE IMMERSED IN WATER: 1- 4- 97
AREA OF CUBE: (75 x 75) mm^2

S/No	Date Tested	Age of Curing (Days)	Failure Load (KN)	Average Strength (N/mm^2)
1	2-4-97	1	25.30	4.50
2	3-4-97	2	70.90	12.60
3	4-4-97	3	108.60	19.3
4	8-4-97	7	167.60	29.8

The wet compressive strength test results are shown in tables 17 - 21.

TABLE 17: WET COMPRESSIVE STRENGTH OF INDUSTRY A.
DATE IMMERSED IN WATER: 4 - 2 - 97
DATE TESTED: 11 - 2 - 97
AGE: 35 DAYS

S/No	Sample No	Length (mm)	Breadth (mm)	Height (mm)	Failure Load (KN)	Strength (N/MN^2)
1	A1/11/2/ID	459	215	231	40	0.41
2	A2/11/2/ID	459	215	230	40	0.41
3	A3/11/2/ID	460	214	228	39	0.40
4	A4/11/2/ID	458	216	230	41	0.41
5	A5/11/2/ID	460	215	230	39	0.39
6	A6/11/2/ID	460	215	231	41	0.41
7	A7/11/2/ID	459	217	230	45	0.45
8	A8/11/2/ID	458	216	228	40	0.40
9	A9/11/2/ID	459	215	231	42	0.43
10	A10/11/2/ID	460	215	231	40	0.40

AVERAGE STRENGTH = $0.41/mm^2$
STANDARD DEVIATION = $0.061/mm^2$
COEFFICIENT OF VARIATION = 3.90%

TABLE 18: WET COMPRESSIVE STRENGTH OF INDUSTRY B.
DATE IMMERSED IN WATER: 4 - 2 - 97
DATE TESTED: 11 - 2 - 97
AGE: 35 DAYS

S/No	Sample No	Length (mm)	Breadth (mm)	Height (mm)	Failure Load (KN)	Strength (N/MN^2)
1	B1/11/2/OK	459	225	230	50	0.48
2	B2/11/2/OK	458	225	230	38	0.37
3	B3/11/2/OK	460	224	228	40	0.39
4	B4/11/2/OK	459	225	230	45	0.44
5	B5/11/2/OK	459	225	230	38	0.38
6	B6/11/2/OK	460	225	228	48	0.46
7	B7/11/2/OK	458	225	230	42	0.41
8	B8/11/2/OK	458	225	229	47	0.47
9	B9/11/2/OK	460	225	230	38	0.37
10	B10/11/2/OK	460	225	230	44	0.43

AVERAGE STRENGTH = $0.42/mm^2$
STANDARD DEVIATION = $0.039N/mm^2$
COEFFICIENT OF VARIATION = 9.46%

TABLE 19: WET COMPRESSIVE STRENGTH OF INDUSTRY C

DATE IMMERSED IN WATER: 4 - 2 - 97

DATE TESTED: 11 - 2 - 97

AGE: 35 DAYS

S/No	Sample No	Length (mm)	Breadth (mm)	Height (mm)	Failure Load (KN)	Strength (N/MN^2)
1	C1/11/2/LJ	460	222	233	45	0.44
2	C2/11/2/LJ	461	220	232	40	0.39
3	C3/11/2/LJ	460	222	231	41	0.40
4	C4/11/2/LJ	460	222	233	42	0.41
5	C5/11/2/LJ	462	220	233	40	0.39
6	C6/11/2/LJ	460	221	231	48	0.41
7	C7/11/2/LJ	461	220	232	50	0.49
8	C8/11/2/LJ	460	220	232	41	0.41
9	C9/11/2/LJ	460	222	232	55	0.54
10	C10/11/2/LJ	460	221	233	42	0.41

AVERAGE STRENGTH = $0.44/mm^2$

STANDARD DEVIATION = $0.047N/mm^2$

COEFFICIENT OF VARIATION = 10.68%

TABLE 20: WET COMPRESSIVE STRENGTH OF INDUSTRY D

DATE IMMERSED IN WATER: 4 - 2 - 97

DATE TESTED: 11 - 2 - 97

AGE: 35 DAYS

S/No	Sample No	Length (mm)	Breadth (mm)	Height (mm)	Failure Load (KN)	Strength (N/MN^2)
1	D1/8/2/LJ	459	215	231	38	0.39
2	D2/8/2/LJ	460	215	230	40	0.40
3	D3/8/2/LJ	460	215	230	43	0.43
4	D4/8/2/LJ	450	215	230	40	0.40
5	D5/8/2/LJ	458	216	230	44	0.44
6	D6/8/2/LJ	459	216	232	45	0.45
7	D7/8/2/LJ	460	214	230	46	0.48
8	D8/8/2/LJ	460	215	230	45	0.46
9	D9/8/2/LJ	460	215	230	44	0.44
10	D10/8/2/LJ	460	216	231	45	0.45

AVERAGE STRENGTH = $0.43N/mm^2$

STANDARD DEVIATION = $0.027N/mm^2$

COEFFICIENT OF VARIATION = 6.49%

TABLE 21: WET COMPRESSIVE STRENGTH OF INDUSTRY E
DATE IMMERSED IN WATER: 1 - 4 - 97
DATE TESTED: 8 - 4 - 97
AGE: 35 DAYS

S/No	Sample No	Length (mm)	Breadth (mm)	Height (mm)	Failure Load (KN)	Strength (N/MN^2)
1	E1/8/2/LJ	459	215	231	46	0.47
2	E2/8/2/LJ	459	216	230	34	0.34
3	E3/8/2/LJ	460	216	230	40	0.40
4	E4/8/2/LJ	460	215	230	34	0.34
5	E5/8/2/LJ	460	214	231	43	0.44
6	E6/8/2/LJ	459	215	231	40	0.41
7	E7/8/2/LJ	460	215	230	40	0.40
8	E8/8/2/LJ	460	215	230	41	0.41
9	E9/8/2/LJ	460	216	230	40	0.40
10	E10/8/2/LJ	460	216	230	38	0.38

AVERAGE STRENGTH = $0.40N/mm^2$
STANDARD DEVIATION = $0.037N/mm^2$
COEFFICIENT OF VARIATION = 9.45%



PLATE I: BEDDED BLOCK SAMPLES READY FOR TESTING

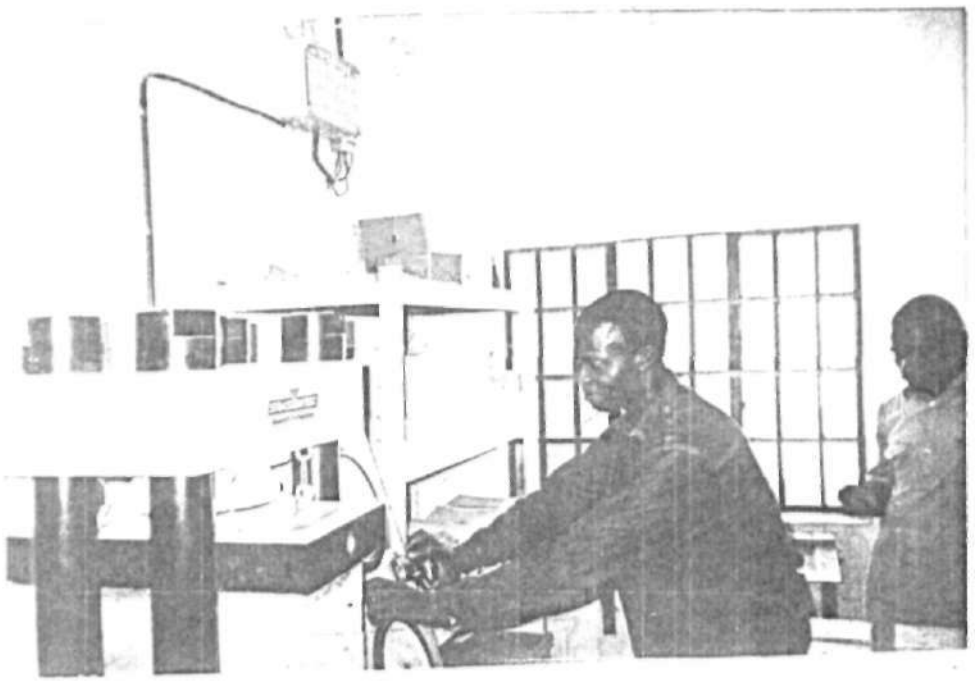

PLATE II: STRASSENTTEST (CRUSHING MACHINE) IN ACTION.

3.4 WET DEVELOPMENT STRENGTH

The west development strength was determined after 28 days of age the blocks were soaked in water and tested for the wet development strength at various ages. The strength value shown at each age is an average of three blocks tested for strength.

The test results are tabulated below in tables 23 to 27. The raw data from which the tables were extracted are shown in appendices A6 to A10.

TABLE 22: WET DEVELOPMENT STRENGTH OF INDUSTRY A
DATE IMMERSED IN WATER: 4 - 2 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm^2
1	1	5-2-97	459	215	230	28	0.28
2	3	7-2-97	459	215	231	36	0.36
3	7	11-2-97	459	216	231	39	0.39
4	14	18-2-97	459	215	231	41	0.41
5	21	25-2-97	459	216	230	42	0.42
6	28	4-3-97	459	215	231	57	0.58

ABLE 23 : WET DEVELOPMENT STRENGTH OF INDUSTY B.
DATE IMMERSED IN WATER: 4-2-97

S/N	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm^2
1	1	5-2-97	459	225	230	23	0.22
2	3	7-2-97	459	225	230	35	0.34
3	7	11-2-97	460	225	229	40	0.39
4	14	18-2-97	459	225	230	44	0.43
5	21	25-2-97	459	225	230	47	0.45
6	28	4-3-97	459	225	230	58	0.56

TABLE 24: WET COMPRESSIVE STRENGTH OF INDUSTRY C

DATE IMMERSED IN WATER: 4 - 2 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm^2
1	1	5-2-97	460	222	233	33	0.33
2	3	7-2-97	460	223	233	37	0.36
3	7	11-2-97	460	222	233	42	0.41
4	14	18-2-97	460	222	233	50	0.49
5	21	25-2-97	460	222	233	55	0.54
6	28	4-3-97	460	222	233	56	0.61

TABLE 25: WET COMPRESSIVE STRENGTH OF INDUSTRY D

DATE IMMERSED IN WATER: 4 - 2 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm^2
1	1	2-4-97	460	215	231	28	0.28
2	3	4-4-97	460	215	230	40	0.40
3	7	8-4-97	460	216	220	46	0.46
4	14	15-4-97	459	214	231	58	0.59
5	21	22-4-97	459	215	230	61	0.62
6	28	29-4-97	450	215	230	66	0.67

TABLE 26: WET COMPRESSIVE STRENGTH OF INDUSTRY E

DATE IMMERSED IN WATER: 4 - 2 - 97

S/No.	Age (Days)	Date Tested	Length (mm)	Breadth (mm)	Height (mm)	Load (KN)	Strength N/mm^2
1	1	2-4-97	459	215	231	34	0.34
2	3	4-4-97	459	215	231	41	0.42
3	7	8-4-97	459	215	231	54	0.55
4	14	15-4-97	460	216	230	57	0.57
5	21	22-4-97	460	216	231	69	0.69
6	28	29-4-97	459	215	230	71	0.72

TABLE 27: COMBINED DRY DEVELOPMENT STRENGTH (N/mm^2)

Age (Days)	Industry A	Industry B	Industry C	Industry D	Industry E
1	0.15	0.10	0.17	0.17	0.12
3	0.32	0.27	0.44	0.30	0.29
7	0.46	0.35	1.01	0.43	0.38
14	0.63	0.50	1.10	0.59	0.62
21	0.73	0.53	1.22	0.71	0.70
28	0.82	0.60	1.40	0.81	0.75

The raw data from which the above table was extracted are shown in appendices A1 to A5.

TABLE 28: COMBINED WET DEVELOPMENT STRENGTH (N/mm^2)

Age (Days)	Industry A	Industry B	Industry C	Industry D	Industry E
1	0.28	0.22	0.33	0.28	0.34
3	0.36	0.34	0.36	0.40	0.42
7	0.39	0.39	0.41	0.46	0.55
14	0.41	0.43	0.49	0.59	0.57
21	0.42	0.45	0.54	0.62	0.90
28	0.58	0.56	0.61	0.67	0.72

The raw data from which the above table was extracted are shown in appendices A_6 to A_{10}.

3.5 DRYING SHRINKAGE

Three blocks were randomly selected from each of the five industries as per clause 16 of the B.S 2028. The drying shrinkage test was then carried out and the test results are shown in table 29 to 33.

TABLE 29: DRYING SHRINKAGE FOR INDUSTRY A

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	150.07	150.01			
2	150.06	149.98			
3	150.05	150.98	150.06	149.99	0.05

TABLE 30: DRYING SHRINKAGE FOR INDUSTRY B

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	150.06	149.99			
2	150.06	149.98			
3	150.06	150.01	150.06	149.99	0.05

TABLE 31: DRYING SHRINKAGE FOR INDUSTRY C

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	150.03	149.98			
2	150.04	149.99			
3	150.05	150.01	150.04	149.99	0.03

TABLE 32: DRYING SHRINKAGE FOR INDUSTRY D

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	150.05	149.99			
2	150.06	149.97			
3	150.04	150.98	150.05	149.98	0.05

TABLE 33: DRYING SHRINKAGE FOR INDUSTRY E

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	150.03	149.99			
2	150.05	149.98			
3	150.06	149.98	150.05	149.98	0.04

3.6 WETTING EXPANSION

Three blocks of drying shrinkage were used for this test in accordance with clause 16 of British standard 2028.

The results of the test are shown in tables 36 to 40 respectively.

TABLE 34: WETTING EXPANSION FOR INDUSTRY A

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	150.03	149.99			
2	150.05	149.98			
3	150.06	149.98	150.05	149.98	0.04

TABLE 35: WETTING EXPANSION FOR INDUSTRY B

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	149.98	150.06			
2	149.99	150.07			
3	150.01	150.08	149.99	150.07	0.05

TABLE 36: WETTING EXPANSION FOR INDUSTRY C

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	149.98	150.06			
2	149.99	150.08			
3	150.01	150.07	149.99	150.07	0.05

TABLE 37: WETTING EXPANSION FOR INDUSTRY D

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	149.98	150.08			
2	149.97	150.11			
3	149.98	150.10	149.98	150.10	0.08

TABLE 38: WETTTNG EXPANSION FOR INDUSTRY E

S/No	Wet Length (mm)	Dry Length (mm)	Average Wet Length (mm)	Average Dry Length (mm)	Drying Shrinkage (%)
1	149.99	150.07			
2	149.98	150.10			
3	149.98	150.10	149.98	150.09	0.07

3.7 DENSITY DETERMINATION

The density was determined in accordance with the specification for precast concrete blocks (BS: 2028).

TABLE 39: DENSITY DETERMINATION

INDUSTRY	DENSITY (Kg/m^3)
A	967.85
B	912.90
C	862.50
D	1028.60
E	1016.82

3.8 SIEVE ANALYSIS

The sand samples used in all the five industries were tested to determine their particle size distribution. The results of the test are shown below I able 42 to 46.

TABLE 40: SIEVE ANALYSIS OF INDUSTRY A

WEIGHT OF SAND SAMPLE: 1300g.

MESH. NO	WEIGHT RETAINED (9)	% RETAINED	WEIGHT PASSED (g)	CUMULATIVE PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE PASSING (%)
7	28.4	2.18	1271.6	2.0	98.0
10	82.6	6.35	1189.0	9.0	91.0
14	180.1	13.85	1008.9	22.0	78.0
18	208.9	16.07	800.0	38.0	62.0
25	270.0	20.77	530.0	59.0	4.0
36	141.0	10.85	389.0	70.0	30.0
52	100.4	87.72	288.6	78.0	22.0
72	87.0	6.69	201.6	84.0	16.0
100	78.4	6.03	123.2	90.0	10.0
150	60.3	4.64	62.1	95.0	5.0
200	36.1	2.78	26.8	98.0	2.0
300	19.5	1.50	7.3	99.0	1.0
PAN	7.3	0.60	-		-

TABLE 41: SIEVE ANALYSIS OF INDUSTRY B

WEIGHT OF SAND SAMPLE: 1300g.

MESH. NO	WEIGHT RETAINED (9)	% RETAINED	WEIGHT PASSED (g)	CUMULATIVE PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE PASSING (%)
7	16.8	1283.2	1.29	99.0	1.0
10	32.2	1260.0	1.78	97.0	3.0
14	40.5	1219.5	3.12	94.0	6.0
18	40.5	1179.3903.8	7.71	86.0	14.0
25	100.2	637.7	16.58	70.0	30.0
36	215.5	437.1	20.47	49.0	51.0
52	266.1	297.1	15.43	34.0	66.0
72	200.6	194.8	10.77	23.0	77.0
100	140.0	98.8	7.87	15.0	85.0
150	102.3	37.7	7.38	8.0	92.0
200	96.0	7.7	4.70	3.0	97.0
300	61.1	-	2.31	1.0	99.0
PAN	30.07.7		0.60	-	-

TABLE 42: SIEVE ANALYSIS OF INDUSTRY C

WEIGHT OF SAND SAMPLE: 1400g.

MESH. NO	WEIGHT RETAINED (9)	% RETAINED	WEIGHT PASSED (g)	CUMULATIVE PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE PASSING (%)
7	20.6	1379.4	1.47	99.0	1.0
10	70.2	1309.2	5.01	94.0	6.0
14	103.2	1206.0	7.37	86.0	14.0
18	200.2	1005.8	14.30	70.0	28.0
25	220.9	784.9	15.78	56.0	44.0
36	240.7	544.2	17.19	39.0	61.0
52	204.3	539.9	14.59	24.0	76.0
72	118.3	221.6	8.57	16.0	84.0
100	79.0	142.6	5.64	10.0	90.0
150	70.1	72.5	5.05	5.0	95.0
200	44.0	28.5	3.14	2.0	98.0
300	20.1	8.4	1.44	1.0	99.0
PAN	8.4	-	0.60	-	-

TABLE 43: SIEVE ANALYSIS OF INDUSTRY D

WEIGHT OF SAND SAMPLE: 1200g.

MESH. NO	WEIGHT RETAINED (9)	% RETAINED	WEIGHT PASSED (g)	CUMULATIVE PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE PASSING (%)
7	26.0	1174.0	2.17	98.0	2.0
10	78.4	1095.6	6.53	91.0	9.0
14	99.8	995.8	8.32	83.0	17.0
18	163.2	832.6	13.60	69.0	31.0
25	200.7	631.9	16.73	54.0	46.0
36	190.3	441.6	15.86	38.0	62.0
52	110.6	331.0	9.22	28.0	72.0
72	98.1	323.9	8.18	20.0	80.0
100	82.2	150.7	6.85	13.0	87.0
150	76.8	73.9	6.40	7.0	93.0
200	40.1	33.8	3.34	4.0	96.0
300	20.4	13.4	1.70	2.0	98.0
PAN	13.4	-	1.12	-	-

TABLE 44: SIEVE ANALYSIS OF INDUSTRY E

WEIGHT OF SAND SAMPLE: 1000g.

MESH. NO	WEIGHT RETAINED (9)	WEIGHT PASSED (g)	% RETAINED	CUMULATIVE PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE PASSING (%)
7	21.4	978.6	2.14	98.0	2.0
10	82.1	896.5	8.21	90.0	10.0
14	100.9	795.6	10.09	80.0	20.0
18	180.1	615.5	18.01	62.0	38.0
25	151.7	463.8	15.17	46.0	54.0
36	140.1	323.7	14.01	32.0	68.0
52	90.1	233.7	9.00	23.0	77.0
72	60.1	173.7	6.60	17.0	83.0
100	50.1	123.6	5.01	12.0	88.0
150	40.7	82.9	4.07	8.0	92.0
200	30.8	44.1	3.88	4.0	96.0
300	29.9	14.2	2.99	1.0	99.0
PAN	8.2	-	0.82		

4.0 CHAPTER FOUR

4.1 ANALYSIS AND DISCUSSION OF RESULTS

In this chapter, the various tests carried out in chapter three are analysed and discussed so that a reasonable conclusion can be arrived at. This would be based on the tests carried on the samples collected from all the industries.

4.2 STRENGTH

The strength tests carried out include the dry development strength, the wet development strength and the wet compressive strength.

4.2.1 DRY DEVELOPMENT STRENGTH

The results of the dry development strength tests for the five industries are presented in tables 10,11, 12,13 and 14 of chapter three and shown in figures 1-5 below.

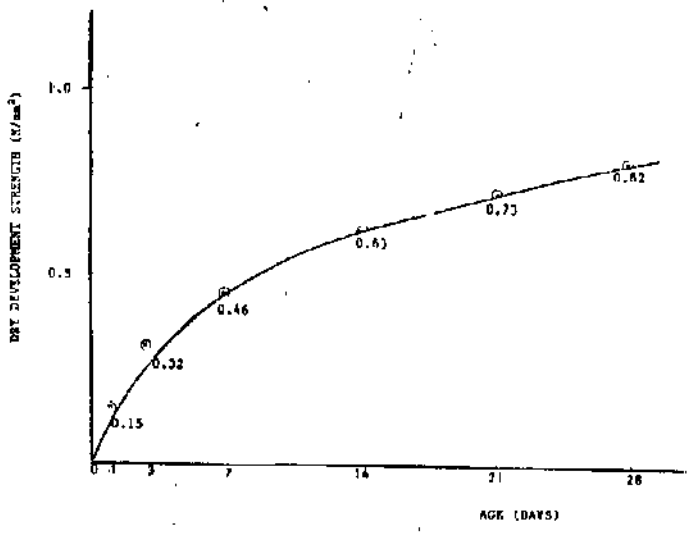

FIG 1: DRY DEVELOPMENT STRENGTH FOR INDUSTRY A

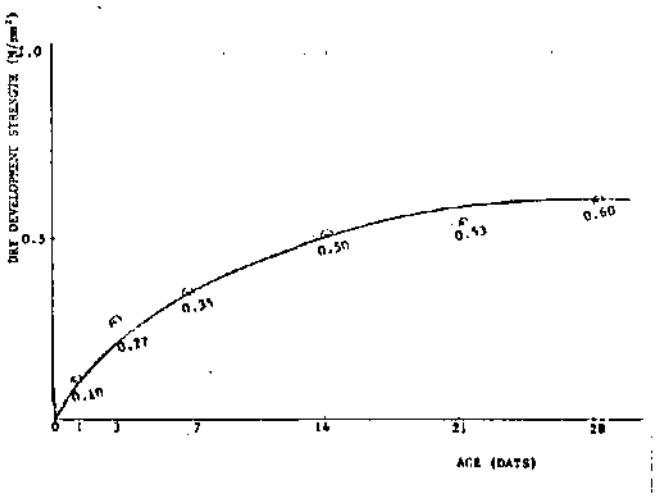

FIG. 2: DRY DEVELOPMENT STRENGTH FOP INDUSTRY B

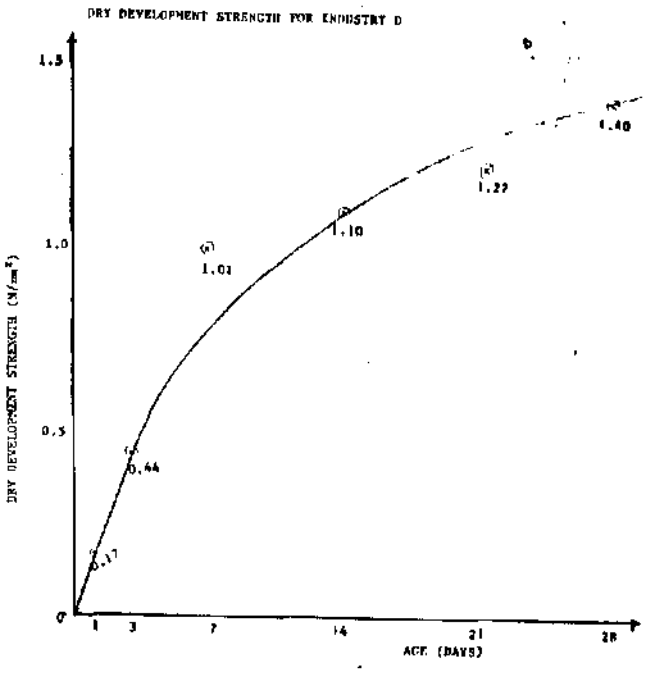

FIG.3: DRY DEVELOPMENT STRENGTH FOP INDUSTRY C

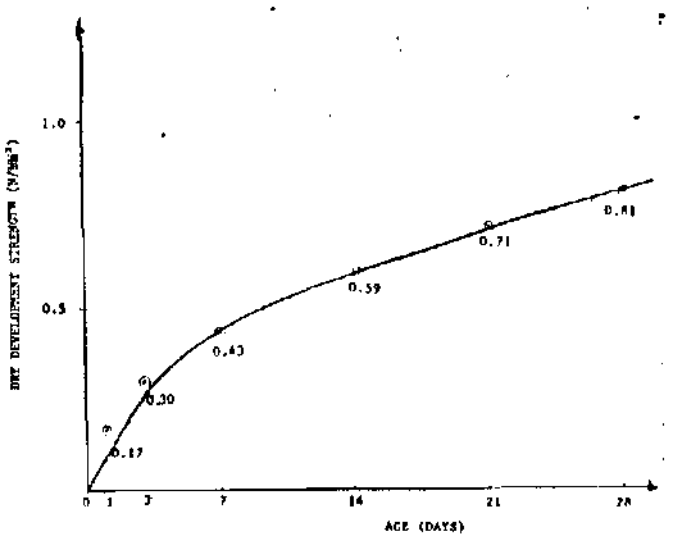

FIG 4: DRY DEVELOPMENT STRENGTH FOP INDUSTRY D

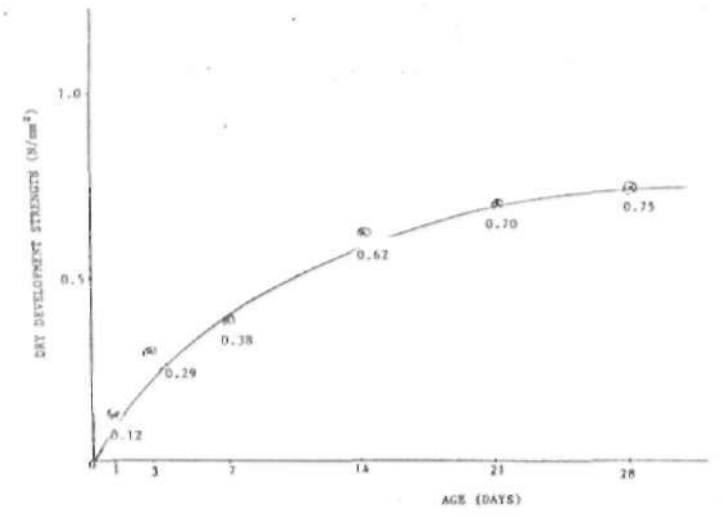

FIG 5: DRY DEVELOPMENT STRENGTH FOR INDUSTRY E

It is observed from the graphs above that sandcrete blocks have generally low dry development strength. The value of the average dry development strength at one day are 0.15N/mm^2, 0.10N/mm^2, 0.17N/mm^2, 0.17N/mm^2 and 0.12N/mm^2 for industries A,B,C,D and e respectively. This strength developed rapidly for the first 14 days with over two third of the 28--day development strength being attained. It indicates that the rate of hydration is rapid at early age and continues with time but at a diminishing rate. The value of the average dry development strength at 28 days are 0.82N/mm^2, 0.60N/mm^2, 1.40N/mm^2, 0.81N/mm^2 and 075N/mm^2 for industries A,B,C,D and E respectively. These values when compared to the 3.45N/mm^2 specified by the Nigeria industrial standard are low.

4.2.2 WET COMPRESSIVE STRENGTH

The average values of the wet compressive strength for the five industries are shown in the table below.

TABLE 45: COMBINED WET COMPRESSIVE STRENGTH.

INDUSTRY	A	B	C	D	E
STRENGTH (N/mm^2)	0.41	0.42	0.44	0.43	0.40

The average wet compressive strength for industries A, B, C, D and E are $0.41N/mm^2$, $042N/mm^2$, $0.42N/mm^2$, $044.N/mm^2$, $0.43N/mm^2$ and $0.40N/mm^2$ respectively. These values when compared to the British standard specification average compressive strength of $3.5N/mm^2$ and the lowest individual block strength of$2.8N/mm^2$ arelow. These values of $0.41N/mm^2$, $042N/mm^2$, $0.44N/mm^2$, $0.43N/mm^2$ and $0.40N/mm^2$ are about 20%,20%,21%,20%and 19% of the $2.1N/mm^2$ average compressive strength values specified of the ministry of works and housing.

However, the coefficient of variation of the block samples from the five industries satisfy the 20% limit specified for concrete structure. The values are 3.9%,9.46% 10.68%, 6.49% and 9.45% for industries A, B, C, D and E respectively. These values indicate that the manufacturing process employed by each industry is consistent and there isn't much variance in the level of production of the sandcrete blocks.

4.2.3 WET DEVELOPMENT STRENGTH

The results of the wet development strength tests for the five industries are presented in tables 23,24,25,26 and 27 of chapter three and shown in figures 6-10 below.

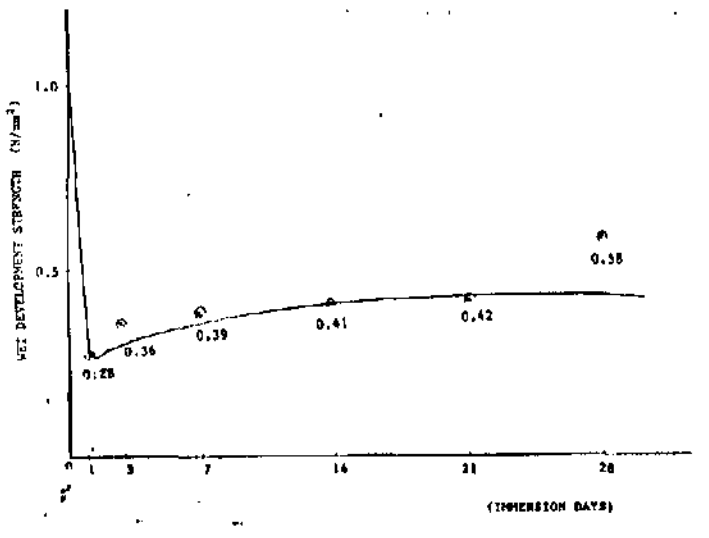

FIG. 6: WET DEVELOPMENT STRENGTH FOR INDUSTRY A

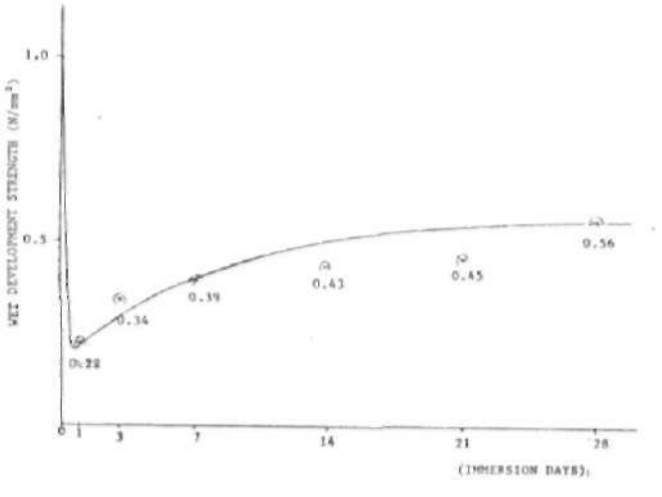

FIG. 7: WET DEVELOPMENT STRENGTH FOR INDUSTRY B

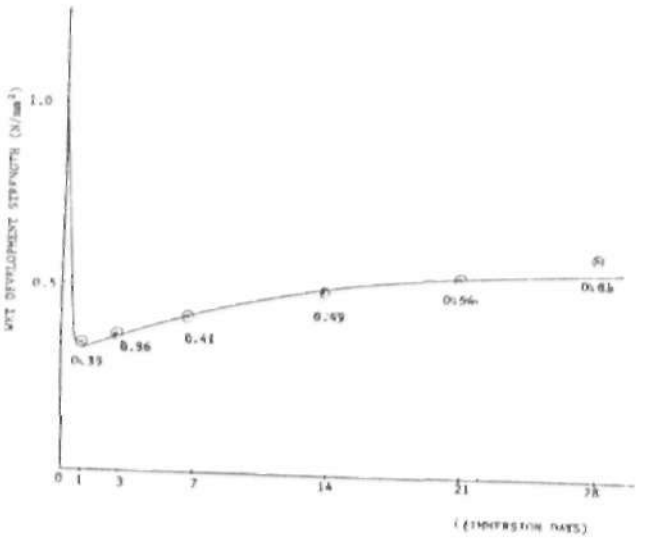

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FIG. 8: WET DEVELOPMENT STRENGTH FOR INDUSTRY C

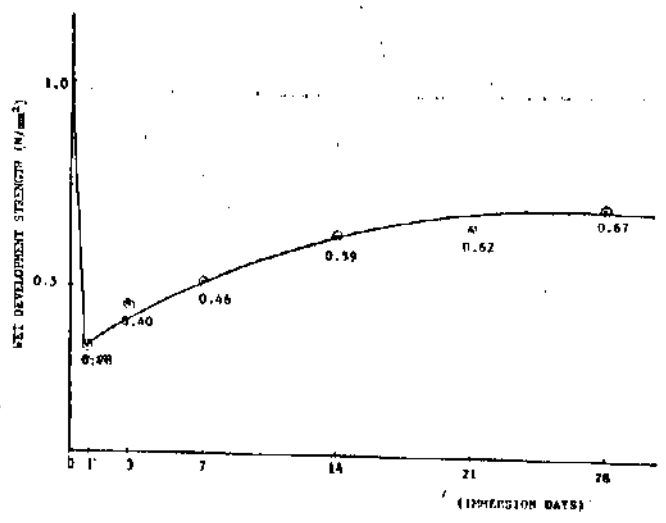

FIG. 9: WET DEVELOPMENT STRENGTH FOR INDUSTRY D

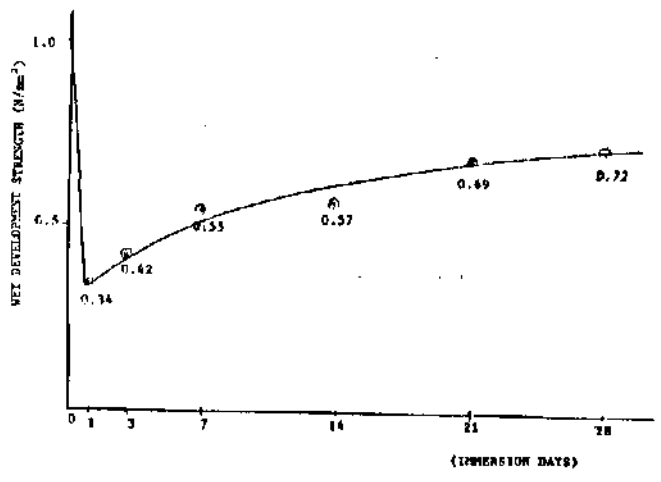

FIG. 10: WET DEVELOPMENT STRENGTH FOR INDUSTRY E

From the graphs above, it is observed that the 28th day average dry development strength of the sandcrete blocks start to drop rapidly after soaking the blocks in water for 24 hours prior to testing to minimum strength of 0.28N/mm^2, 022N/mm^2, 0.33N/mm^2,0.28 and 0.34N/mm^2 for industries A, B, C,D and E respectively. As from the 3rd day, the block samples start to gain strength until the 14th day when the strength becomes gradually steady with time.

The sudden drop in strength could be attributed to soaking, the blocks samples absorb water and this occupies the cavities or voids within the sandcrete blocks leading to low values when blocks are tested.

The average wet development strength at 28 days of soaking are 0.58N/mm^2, 0.56N/mm^2, 061N/mm^2,0.67N/mm^2 and 0.72N/mm^2 for industries A, B, C, C, D and E. These values when compared to the average value of 3.45N/mm^2 specified by the Nigerian industrial standard are low.

4.2.4 RATIO OF WET TO DRY DEVELOPMENT STRENGTH

The ratio of the wet development strength at various soaking ages after 28 days of age to the dry development strength at 28 days for the fives industries was also determined. The results are shown in tables below and presented in figures 11,12,13,14 and 15 for industries A, B,C,D and E respectively.

TABLE 46: WET DEVELOPMET STRENGHT TO DRY DEVELOPMENT STREGH RATIO IN PERCENTAGES

Days of immersion After 28 Days	FWET/ FDRY (28)				
	INDUSTRY A	INDUSTRY B	INDUSTRY C	INDUSTRY D	INDUSTRY E
0	100	100	100	100	100
1	34	37	24	35	45
3	43	57	26	49	56
7	48	65	29	57	73
14	50	72	35	73	76
21	51	75	39	77	92
28	71	93	44	83	96

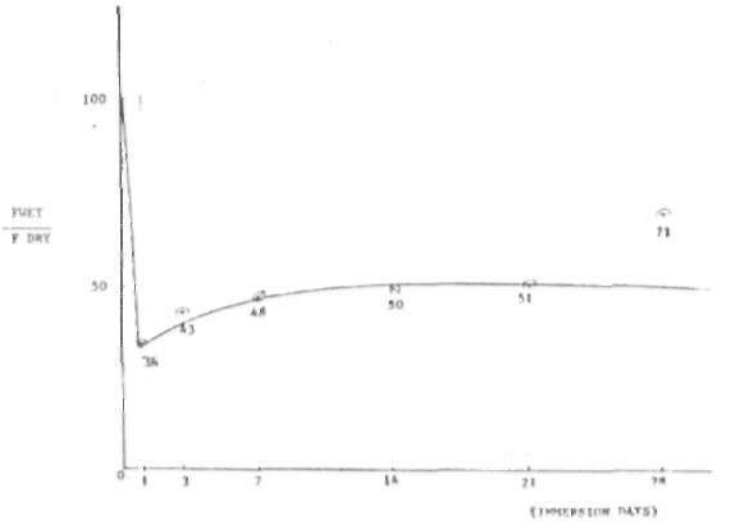

FIG. 11: FWET/ FDRY RATIO PERCENTAGES FOR SAMPLE A

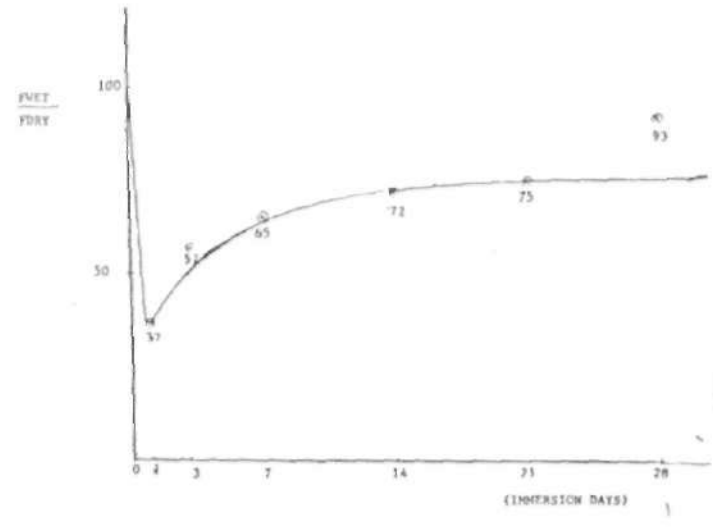

FIG. 12: FWET/ FDRY RATIO PERCENTAGES FOR SAMPLE B

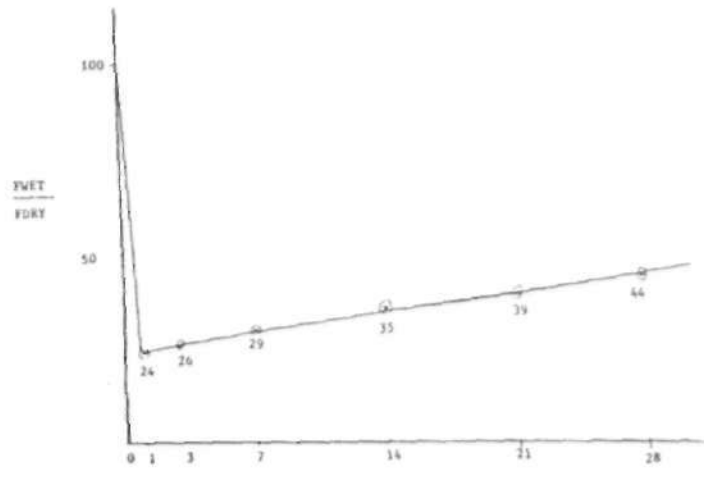

FIG. 13: FWET/ FDRY RATIO PERCENTAGES FOR SAMPLE C

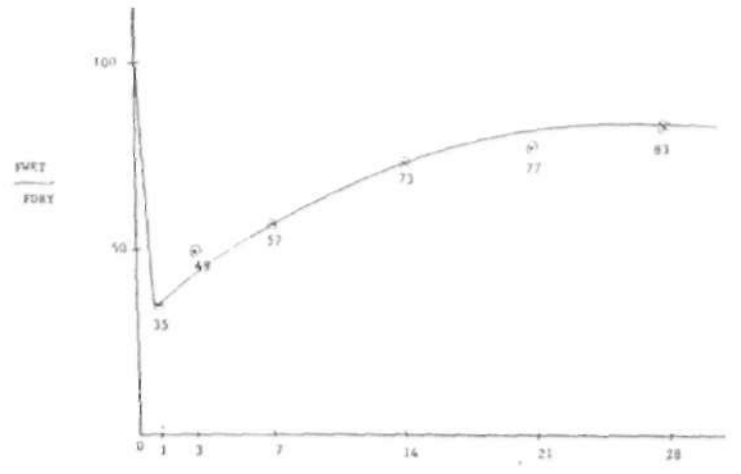

FIG. 14: FWET/ FDRY RATIO PERCENTAGES FOR SAMPLE D

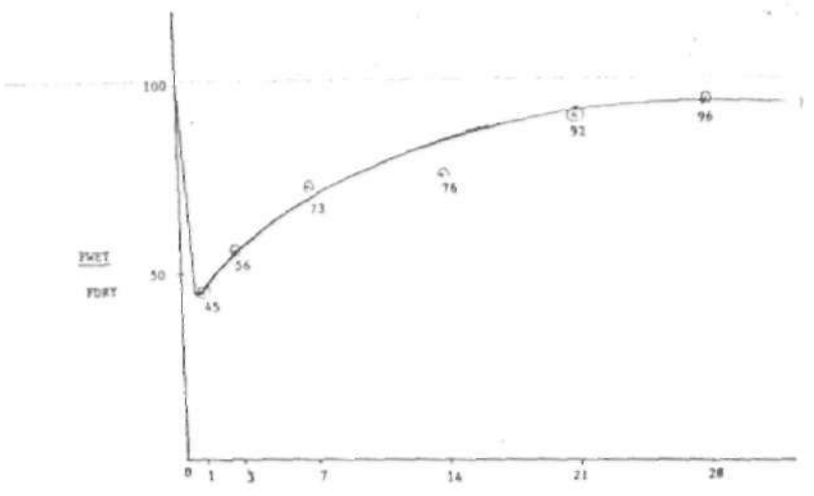

FIG. 15: FWET/ FDRY RATIO PERCENTAGES FOR SAMPLE E

The results from the graphs above show that the average wet development strength of industries A, B, C, D and E dropped to 34%, 73%,24%, 35.5% and 45% after 24 hours of soaking prior to testing. The values increased from 48%,65%,29%,57%, and 73% on the 7th day to 71%, 93%,44% 83% and 96% on the 28th day. The minimum wet strength values are 34%,37%,24%,35% and 45% for industries A, B, C, D and E respectively. While the constant wet strength ratios are 51%,77% ,39%,83% and 96%.

From the tests conducted, the dry development strength values do not satisfy the requirement specified in the different standards. The strength values of the blocks produced in all the industries could be attributed to the presence of silt in sand use, inadequate curing, lack of proper shade, inaccurate proportioning of sand and cement, exposure to harsh condition of wind and sun and improper compaction of sandcrete blocks.

Silt in sand forms coating on the coarse sand particules when mixed with the cement. This weakens the bond between the coarse sand particles and cement. This weakening ultimately leads to low strength of the end product.

For sandcrete blocks to attain adequate strength, it must be cured for at least seven days by spraying water twice daily. It is observed that in all the industries, the blocks were cured for maximum of three day. Proper curing of the sandcrete block would keep the blocks saturated until the original water filled space in the fresh cement paste had been filled by products of hydration. As long as moisture is present and the temperature if right, the process of hydration will continue at diminishing rate for an indefinite period of time.

Non provision of proper shade for newly moulded sandcrete blocks lead to reduced strength of the block sample as they are exposed to severe effect of

temperature, wind and sun. This leads to rapid evaporation of mixing and curing water.

Industries A, B, and D used mix ratios, of part of cement to twelve parts of sand (1:12) and 1 part of cement to ten parts of sand respectively. This mix proportion is lower than the specification recommended by the Nigerian industrial standard which is one part by volume of cement to six parts of sand (1:6) up to eight parts sand (1:8). It is observed that this inadequate proportioning of cement and sand leads to low strength values of the blocks experienced in all the industries.

Due to fatigue and irregular servicing of the block moulding machine, poor compaction is experienced. This, ultimately give the sandcrete blocks more voids in excess of those due water which is needed for hydration. Excessive voids lead to lower strength of the sandcrete blocks.

4.3 DRYING SHRINKAGE AND WETTING EXPANSION

The average drying shrinkage values for industries A, B, C, D and E are 0.05%,0.05% 0.03%.0.05% and 0.4% respectively. These values are within the limit of 0.05% specified by the B.S 2023 for type A blocks.

Industries A, B, C, D and E have average wetting expansion values of 0.05%, 0.05%, 0.05%, 0.08% and 0.07% respectively. The British standard specification specifies that the wetting expansion should not exceed the drying shrinkage by more than 0.02 percent. Since the difference in the values in industries D. and E exceed the 0.02% limit, these values do not conform with the specification. It then indicates that the blocks produced in industries D and E not exhibit normal change in volume as their water content changes.

4.4 DENSITY

The average density values for industries A, B, C, D and E are 967kg/m^3. 85kg/m^3, 912.90kg/m^3, 862.50kg/m^3 1028.60kg/m^3 and 1016.82kg/m^3 respectively. A values not less than 1500kg/m^3 for Type A blocks is specified by the British standard 2028. The values are below the specified standard.

4.5 SAND

The result of the particle size distribution for industries A, B, C, D and E are shown in tables 42-46 and presented in figures 16-20

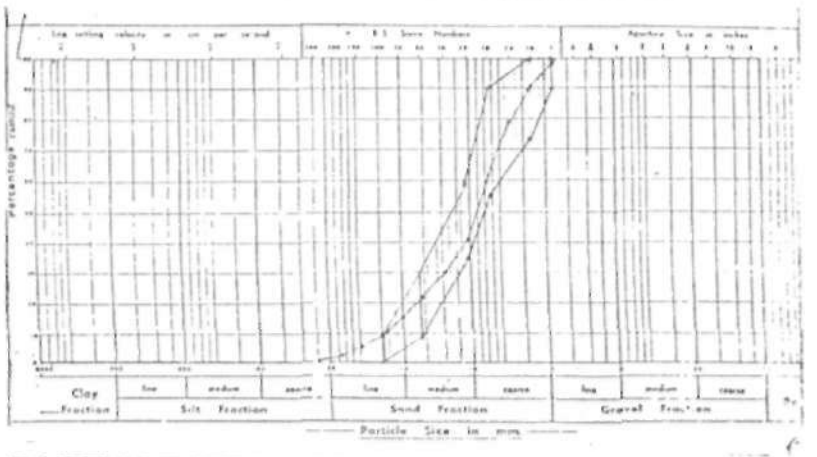

FIG.16: PARTICLE SIZE DISTRIBUTION CURVE FOR SAMPLE A.

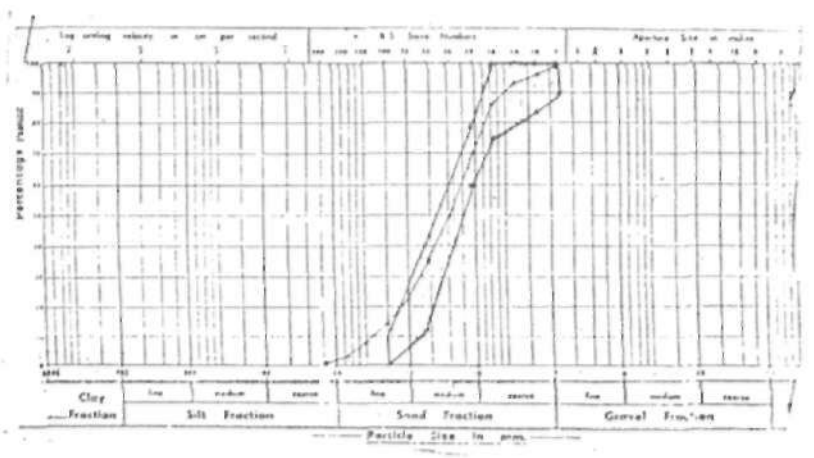

FIG.17: PARTICLE SIZE DISTRIBUTION CURVE FOR SAMPLE B.

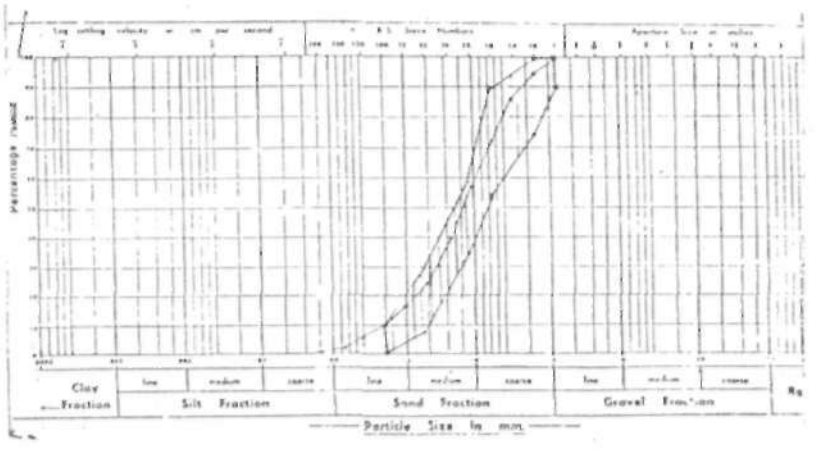

FIG.18: PARTICLE SIZE DISTRIBUTION CURVE FOR SAMPLE C

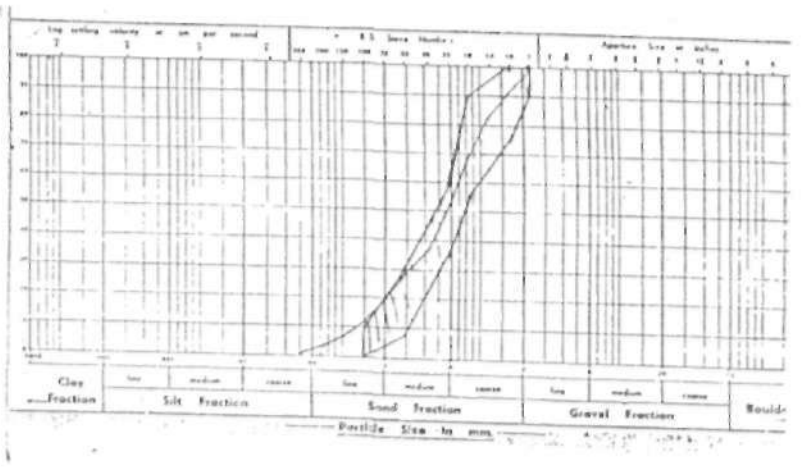

FIG.19: PARTICLE SIZE DISTRIBUTION CURVE FOR SAMPLE D

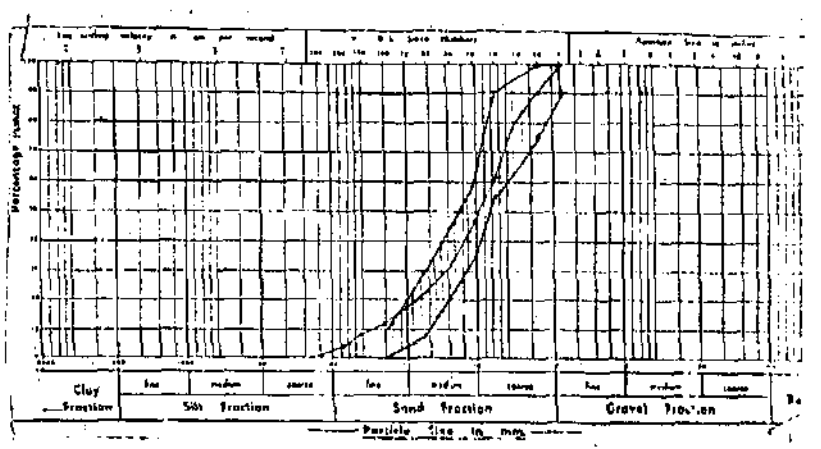

FIG.20: PARTICLE SIZE DISTRIBUTION CURVE FOR SAMPLE E

From the figures above, it is observed that the sand particles fall within medium and coarse sand fractions. While the sand particles from industries A, C,D and E fall within zone 2 of the British standard sieve sizes, industry B falls within zone 3 of the B. S. sieve sizes. The Nigerian industries standard specifies that the best sand for the production of sandcrete blocks should be that which falls within zone 1 or 2 of the British standard sieve sizes. Industries A, B, C, D and E meet this specification while industry B doesn't .

The silt content for industries A, B, C, D and E are 8%, 10%, 8%,8% and 5% respectively. These values exceed the 6% limit in the specification except for industry E which is less than 6%.

It shows that from the results of the particles size distribution and silt content that the worst sand was used in industry B.

The comparison of dry development strength and wet development strength for the five industries are shown in figures 21 and 22 respectively.

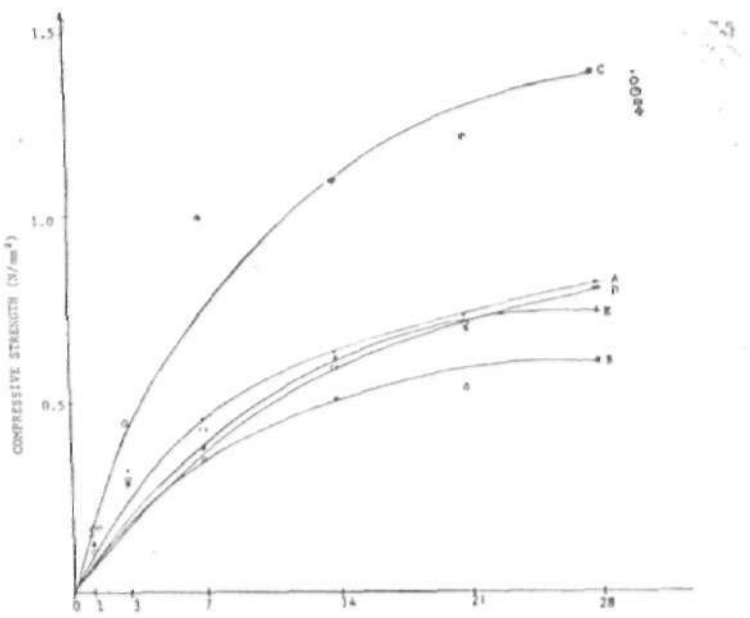

FIG.21: COMPARISON OF DRY DEVELOPMENT STRENGTHS

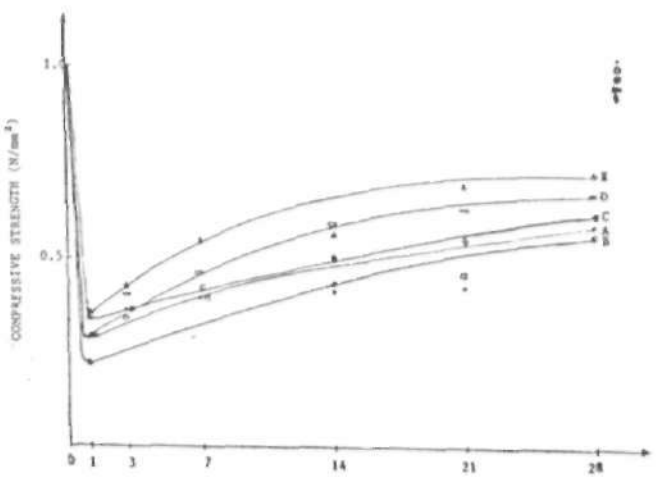

FIG.22: COMPARISON OF DRY DEVELOPMENT STRENGTHS

From the graphs above, it can be sen that industry C has the best result in terms of dry development strength and industry B the worst. Industry E has the highest values of wet development strength of 0.72N/mm^2 and industry B the lowest strength values of 0.56N/mm^2.

The average dry development strength at 28 days age of curing for the five industries are 0.82N/mm^2 ,0.60N/mm^2 ,1.40N/mm^2 , 0.81N/mm^2 and 0.75N/mm^2 while the average wet development strengths are 0.58N/mm^2 , 0.56N/mm^2, 0.61N/mm^2 0.67N/mm^2 and0.72N/mm^2 for industries A, B, C, D and E respectively. All these values when compared to the specification in the different codes of practice are low.

The average wet compressive strength values are 0.41N/mm^2, 0.42N/mm^2, 0.44N/mm^2 0.43N/mm^2 and 0.40N/mm^2 for industries A, B, C, D and E respectively.

In terms of strength values, industry C could be said to have the best blocks because of its high dry development and wet compressive strength values and industry B has the worst strength values in terms of dry development strength and wet development strength.

CHAPTER FIVE

5.1 CONCLUSION

5.1.1 The strength of the sandcrete hollow blocks produced in Kogi state is far below the requirement set by various codes and organisation. While the Federal Ministry of Works recommended 2.1N/mm^2 as the minimum wet compressive strength, the highest wet compressive strength tested was 0.44N/mm^2.

5.1.2 The blocks produced in Kogi state have lower density compared to the specified value of 1500kg/m^3 by B. S. 2028. The maximum density for the state is 1029kg/m^3.

5.1.3 The sand used for the production of blocks in Kogi state do not comply with the specified standard.

5.1.4 As for drying shrinkage and wetting expansion requirements, the block produced in Kogi state satisfies the code.

5.1.5 The industries that produce blocks in Kogi state don't cure the blocks as it is required by the codes/standards. The blocks are cured mostly once between one to three days as against twice for a minimum of seven days. Proper shade are not provided from the time of curing to stacking.

5.1.6 The proportion used by block industries in Kogi state is generally between one part of cement to ten or twelve parts of sand by volume (1:10 or 12) as against one part of cement to six or 8 parts of cement by volume (1:6 or 1:8) as specified by the code.

5.1.7 Most of the blocks produced in Kogi state are within dimensional tolerance as the average dimension is 230mm X 229mm X 460mm.

5.1.8 The cost of buying and transporting the blocks to various sites of need are very high. This is due to high cost of the constituent materials and spare parts.

5.2 RECOMMENDATION

5.2.1 Strength tests for blocks in the state of the Federation should be conducted with a view to arriving at an average strength value for the whole country.

5.2.2 Government of various states should establish standard block moulding industries which shall have professional employees and should serve as pace setter as per the production of standard blocks.

5.2.3 The standard of the blocks produced in Kogi state could be improved upon if all the parameters like mix proportion, curing shading etc. are properly taken care of.

5.2.4 Since the international standards are too high and very expensive, we should try to come to an agreed value of strength that is favourable to us.

5.2.5 The block moulding industries in Kogi state should employ a head man who has the know -how of what they do.

5.2.6 The state government should have a control unit that checks and balances the production of various block industries as per quality. Any industry that refuses to adhere to any given standard after lots of warning shall be punished.

5.2.7 The block manufacturers should be educated on the existing standards and how to come by them. Then we can be sure of having blocks of high quality as required.

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13. British Standard 6073: 1981 precast concrete Mansonary Units, Part 1: Specification for concrete Mansory Units. Part 2: Method for specifying precast concrete Mansory units.
14. Specification for sandcrete blocks by the Nigeria Industrial Standard Part II

APPENDIX A1

INDUSTRY: A

DATE OF CASTING: 23 -11-96

TEST: DRY DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		A1/24/11/ID	459	216	230	22.8	16.00	0.16	
2	24-11-96	A2/24/11/ID	460	215	230	23.44	14.00	0.15	0.15
3		A3/24/11/ID	459	216	230	23.68	15.00	0.14	
4		A4/26/11/ID	460	215	230	22.1	29.00	0.29	
5	26-11-96	A5/26/11/ID	461	214	230	23.0	33.00	0.33	0.35
6		A6/26/11/ID	460	215	230	22.4	35.00	0.35	
7		A7/30/11/ID	459	215	231	21.8	44.00	0.45	
8	30-11-96	A8/30/11/ID	454	215	232	21.5	45.00	0.46	0.46
9		A9/30/11/ID	459	215	231	22.2	46.00	0.47	
10		A10/7/12/ID	460	216	231	21.8	62.00	0.63	
11	07-12-96	A11/7/12/ID	459	215	231	22.6	60.00	0.61	0.67
12		A12/7/12/ID	459	214	231	22.3	65.00	0.66	
13		A13/14/12/ID	459	232	232	22.1	69.00	0.75	
14	14-12-96	A14/14/12/ID	459	231	231	21.8	80.00	0.81	0.73
15		A15/14/12/ID	459	230	230	22.04	68.00	0.69	
16		A16/21/12/ID	459	231	231	22.14	75.00.8	0.76	
17	21-12-96	A17/21/12/ID	460	231	231	22.00	0.00	0.81	0.82
18		A18/21/12/ID	459	231	231	21.8	88.00	0.89	

APPENDIX A2

INDUSTRY: B

DATE OF CASTING: 23 -11-96

TEST: DRY DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM^2	AVE
1		B1/24/11/OK	459	225	230	22.6	12.00	0.12	
2	24-11-96	B2/24/11/OK	460	225	230	22.5	10.00	0.10	0.10
3		B3/24/11/OK	459	225	230	22.3	10.00	0.10	
4		B4/26/11/OK	459	225	230	21.6	25.00	0.24	
5	26-11-96	B5/26/11/OK	459	225	230	22.0	30.00	0.29	0.27
6		B6/26/11/OK	459	225	230	21.10	28.00	0.27	
7		B7/30/11/OK	459	225	230	18.00	35.00	0.34	
8	30-11-96	B8/30/11/OK	458	225	230	21.20	36.00	0.35	0.35
9		B9/30/11/OK	459	225	230	20.90	36.00	0.35	
10		B10/7/11/OK	459	225	230	21.10	55.00	0.53	
11	07-12-96	B11/7/11/OK	459	225	230	22.00	40.00	0.39	0.50
12		B12/7/11/OK	459	225	230	21.80	60.00	0.58	
13		B13/7/12/OK	459	225	230	22.0	50.00	0.48	
14	14-12-96	B14/7/12/OK	459	225	231	21.2	55.00	0.53	0.53
15		B15/7/12/OK	459	225	230	21.7	61.00	0.59	
16		B16/7/12/OK	459	225	230	21.9	62.00	0.60	
17	21-12-96	B17/7/12/OK	459	225	230	22.18	60.00	0.58	0.60
18		B18/7/12/OK	459	225	230	22.10	65.00	0.63	

APPENDIX A3

INDUSTRY: C

DATE OF CASTING: 23 -11-96

TEST: DRY DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		C1/24/11/LI	460	222	233	22.0	20.00	0.20	
2	24-11-96	C2/24/11/LI	461	223	231	22.4	15.00	0.15	0.17
3		C3/24/11/LI	460	222	235	22.1	15.00	0.15	
4		C4/26/11/LI	460	222	232	22.0	40.00	0.39	
5	26-11-96	C5/26/11/LI	460	222	233	22.1	50.00	0.49	0.44
6		C6/26/11/LI	460	222	233	22.1	40.00	0.44	
7		C7/30/11/LI	460	222	233	22.2	100.0	0.98	
8	30-11-96	C8/30/11/LI	461	222	232	21.7	98.00	0.96	0.01
9		C9/30/11/LI	462	222	233	22.1	110.0	1.08	
10		C10/7/12/LI	460	221	233	22.3	115.0	1.13	
11	07-12-96	C11/7/12/LI	460	222	233	21.8	120.0	1.18	1.10
12		C12/7/12/LI	460	222	233	22.4	100.0	0.96	
13		C13/14/12/LI	461	220	233	21.42	125.0	1.22	
14	14-12-96	C14/14/12/LI	460	222	233	22.10	130.0	1.27	1.22
15		C15/14/12/LI	460	223	233	22.33	120.0	1.18	
16		C16/21/12/LI	460	222	233	22.00	140.0	1.37	
17	21-12-96	C17/21/12/LI	460	222	233	22.80	140.0	1.37	1.40
18		C18/21/12/LI	460	222	233	21.98	150.0	1.47	

APPENDIX A4

INDUSTRY: D

DATE OF CASTING: 3 - 3 - 97

TEST: DRY DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		D1/4/3/WY	459	215	231	23.80	15.00	0.15	
2	4-11-97	D2/4/3/WY	458	215	230	23.00	20.00	0.20	0.17
3		D3/4/3/WY	459	215	231	22.70	15.00	0.15	
4		D4/6/3/WY	459	215	230	23.00	30.00	0.30	
5	6-3-97	D5/6/3/WY	459	216	230	22.50	28.00	0.28	0.30
6		D6/6/3/WY	459	214	231	22.70	31.00	0.31	
7		D7/10/3/WY	460	216	231	22.80	40.00	0.41	
8	10-3-97	D8/10/3/WY	459	216	231	21.90	45.00	0.46	0.43
9		D9/10/3/WY	460	215	231	22.00	40.00	0.41	
10		D10/17/3/WY	459	216	231	21.88	55.00	0.56	
11	17-3-97	D11/17/3/WY	459	216	230	22.10	60.00	0.61	0.59
12		D12/17/3/WY	459	215	231	22.30	60.00	0.61	
13		D13/24/3/WY	459	215	231	23.20	70.00	0.71	
14	24-3-97	D14/24/3/WY	459	215	231	22.50	68.00	0.69	0.71
15		D15/24/3/WY	460	215	231	21.90	71.00	0.72	
16		D16/24/3/WY	460	216	231	22.60	82.00	0.83	
17	31-3-97	D17/24/3/WY	460	215	231	21.90	80.00	0.81	0.81
18		D18/24/3/WY	459	216	230	22.10	78.00	0.79	

APPENDIX B5

INDUSTRY: E

DATE OF CASTING: 3 - 3 - 97

TEST: DRY DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		E1/4/3/AK	459	215	231	22.80	12.00	0.12	
2	4-3-97	E2/4/3/AK	460	215	231	21.90	10.00	0.10	0.12
3		E3/4/3/AK	459	215	231	22.50	13.00	0.13	
4		E4/6/3/AK	460	215	230	23.20	31.00	0.31	
5	6-3-97	E5/6/3/AK	459	216	231	22.60	28.00	0.28	0.29
6		E6/6/3/AK	459	215	230	22.40	29.00	0.29	
7		E7/10/3/AK	459	217	232	22.10	35.00	0.35	
8	10-3-97	E8/10/3/AK	460	214	230	22.18	40.00	0.41	0.38
9		E9/10/3/AK	459	215	231	22.18	38.00	0.39	
10		E10/17/3/AK	460	216	231	21.98	58.00	0.59	
11	17-3-97	E11/17/3/AK	459	215	231	21.68	60.00	0.61	0.62
12		E12/17/3/AK	459	215	231	22.00	64.00	0.65	
13		E13/24/3/AK	459	215	231	20.98	58.00	0.69	
14	24-3-97	E14/24/3/AK	459	215	231	21.68	69.00	0.70	0.70
15		E15/24/3/AK	459	215	231	22.10	69.00	0.70	
16		E16/24/3/AK	459	215	231	21.60	74.00	0.75	
17	31-3-97	E17/24/3/AK	459	215	231	21.00	70.00	0.71	0.75
18		E18/24/3/AK	459	215	231	22.00	78.00	0.79	

APPENDIX A6

INDUSTRY: A

DATE IMMERSED IN WATER: 4-2-97

TEST: WET DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		A1/5/2/ID	459	215	230	22.40	28.00	0.28	
2	5-2-97	A2/5/2/ID	459	216	230	22.16	30.00	0.30	0.28
3		A3/5/2/ID	459	215	230	21.98	26.00	0.26	
4		A4/7/2/ID	460	215	231	22.50	37.00	0.37	
5	7-2-97	A5/7/2/ID	459	215	231	22.18	31.00	0.31	0.36
6		A6/7/2/ID	459	215	231	22.08	40.00	0.41	
7		A7/11/2/ID	458	216	231	22.30	30.00	0.41	
8	11-2-97	A8/11/2/ID	459	216	230	22.16	35.00	0.36	0.39
9		A9/11/2/ID	459	215	231	22.88	41.00	0.42	
10		A10/18/2/ID	459	215	231	22.10	40.00	0.41	
11	18 2-97	A11/18/2/ID	459	215	231	21.90	45.00	0.46	0.41
12		A12/18/2/ID	459	215	230	22.10	39.00	0.40	
13		A13/25/2/ID	459	216	230	22.10	45.00	0.46	
14	25-2-97	A14/25/2/ID	459	215	230	21.98	40.00	0.41	0.42
15		A15/25/2/ID	459	216	230	22.40	40.00	0.41	
16		A16/4/3/OK	459	215	231	23.00	52.00	0.53	
17	4-3-97	A17/4/3/OK	459	215	231	22.18	58.00	0.59	0.58
18		A18/4/3/OK	459	215	231	21.98	60.00	0.61	

APPENDIX A7

INDUSTRY: B

DATE IMMERSED IN WATER: 4-2-97

TEST: WET DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM^2	AVE
1		B1/5/2/0K	459	225	230	22.18	20.00	0.19	
2	5-2-97	B2/5/2/0K	460	225	230	21.80	23.00	0.22	0.22
3		B3/5/2/0K	459	226	231	22.60	26.00	0.25	
4		B4/7/2/0K	459	225	230	22.00	36.00	0.35	
5	7-2-97	B5/7/2/0K	460	225	230	21.80	38.00	0.37	0.34
6		B6/7/2/0K	459	225	230	21.88	30.00	0.29	
7		B7/11/2/0K	460	226	229	22.18	40.00	0.39	
8	11-2-97	B8/11/2/0K	459	225	230	22.00	38.00	0.37	0.39
9		B9/11/2/0K	459	225	229	21.80	42.00	0.29	
10		B10/18/2/0K	460	226	230	22.10	45.00	0.44	
11	18-2-97	B11/18/2/0K	459	225	230	21.16	48.00	0.46	0.43
12		B12/18/2/0K	459	225	230	22.19	38.00	0.37	
13		B13/25/2/0K	459	225	230	21.90	50.00	0.48	
14	25-2-97	B14/25/2/0K	459	225	230	22.10	38.00	0.37	0.45
15		B15/25/2/0K	459	226	229	22.36	52.00	0.50	
16		B16/4/3/0K	459	225	230	22.00	56.00	0.54	
17	4-3-97	B17/4/3/0K	459	225	230	21.18	58.18	0.56	0.56
18		B18/4/3/0K	459	225	229	22.10	60.00	0.58	

APPENDIX A8

INDUSTRY: C

DATE IMMERSED IN WATER: 4-2-97

TEST: WET DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		C1/5/2/LJ	460	222	233	21.60	36.00	0.35	
2	5-2-97	C2/5/2/LJ	460	221	232	22.00	34.00	0.33	0.33
3		C3/5/2/LJ	460	222	233	21.80	30.00	0.29	
4		C4/7/2/LJ	461	223	233	20.80	40.00	0.39	
5	7-2-97	C5/7/2/LJ	460	223	233	21.70	35.00	0.34	0.36
6		C6/7/2/LJ	460	222	232	22.00	37.00	0.36	
7		C7/11/2/LJ	461	222	233	20.00	45.00	0.44	
8	11-2-97	C8/11/2/LJ	460	222	233	21.60	40.00	0.39	0.41
9		C9/11/2/LJ	460	222	233	21.38	41.00	0.40	
10		C10/18/2/LJ	460	221	232	21.88	55.00	0.53	
11	18-2-97	C11/18/2/LJ	460	222	232	22.40	50.00	0.49	0.49
12		C12/18/2/LJ	460	222	232	22.20	48.00	0.47	
13		C13/25/2/LJ	460	221	233	22.18	56.00	0.55	
14	25-2-97	C14/25/2/LJ	460	222	233	21.90	50.00	0.51	0.54
15		C15/25/2/LJ	460	222	223	22.10	58.00	0.57	
16		C16/4/3/LJ	460	222	233	22.28	62.00	0.61	
17	4-3-97	C17/2/3/LJ	460	222	233	22.10	64.18	0.63	0.61
18		C18/4/3/LJ	460	222	233	22.40	61.00	0.60	

APPENDIX A9

INDUSTRY: D

DATE IMMERSED IN WATER: 1-4-97

TEST: WET DEVELOPMENT STRENGTH.

S/No	Date Tested	Sample No.	Length mm	Breath mm	Height mm	Weight mm	Failure Load (KN)	Strength	
								N/MM²	AVE
1		D1/2/4/WY	460	215	231	22.70	25.00	0.25	
2	2-4-97	D2/2/4/WY	460	216	231	21.88	30.00	0.30	0.28
3		D3/2/4/WY	461	215	230	22.18	30.00	0.30	
4		D4/4/4/WY	461	215	230	22.10	38.00	0.39	
5	4-4-97	D5/4/4/WY	460	215	230	21.90	40.00	0.41	0.40
6		D6/4/4/WY	460	215	231	22.20	43.00	0.44	
7		D7/8/4/WY	460	216	230	22.18	44.00	0.45	
8	8-4-97	D8/8/4/WY	460	216	230	21.80	50.00	0.51	0.46
9		D9/8/4/WY	460	215	231	22.10	45.00	0.46	
10		D10/15/4/WY	459	214	231	23.00	48.00	0.59	
11	15-4-97	D11/15/4/WY	460	214	231	22.60	60.00	0.61	0.59
12		D12/15/4/WY	459	215	231	22.30	55.00	0.56	
13		D13/22/4/WY	459	215	230	22.30	60.00	0.61	
14	22-4-97	D14/22/4/WY	459	215	231	22.18	62.00	0.63	0.62
15		D15/22/4/WY	459	216	230	21.98	60.00	0.61	
16		D16/29/4/WY	460	215	230	22.70	68.00	0.69	
17	29-4-97	D17/29/4/WY	460	215	230	21.98	64.18	0.65	0.67
18		D18/29/4/WY	459	215	231	22.64	66.00	0.67	

APPENDIX A11

INDUSTRY: A

TEST: WET COMPRESSIVE STRENGTH

DATE IMMERSED IN WATER: 4 - 2 - 97

DATE TESTED: 11 - 2 - 97

DATE MORTAR CUNE ATTAINED LEAST STRENGTH

S/No.	Sample Number	Length (mm)	Breadth (mm)	Height (mm)	Volume (m^3)	Weight (kg)	Density (kg/m^3)	Failure Load (kg)	Strength N/mm^2	Average Strength (N/mm^2)
1	A1/11/2/ID	459	216	231	0.022	22.08	1003.6	40	0.41	
2	A2/11/2/ID	459	215	230	0.022	22.30	1013.6	40	0.41	
3	A3/11/2/ID	460	214	228	0.022	22.11	1004.54	39	0.40	
4	A4/11/2/ID	458	216	230	0.022	21.88	994.5	41	0.41	
5	A5/11/2/ID	460	215	230	0.022	22.10	1004.5	39	0.39	
6	A6/11/2/ID	469	215	231	0.22	22.03	1001.36	41	0.41	0.41
7	A7/11/2/ID	459	217	230	0.22	21.90	995.45	45	0.45	
8	A8/11/2/ID	458	216	228	0.22	21.98	999.09	40	0.40	
9	A9/11/2/ID	459	215	231	0.22	22.16	1007.27	42	0.43	
10	A10/11/2/ID	460	215	231	0.22	22.40	1018.18	40	0.40	

APPENDIX A12

INDUSTRY: B

TEST: WET COMPRESSIVE STRENGTH

DATE IMMERSED IN WATER: 4 - 2 - 97

DATE TESTED: 11 - 2 - 97

DATE MORTAR CUNE ATTAINED LEAST STRENGTH

S/No.	Sample Number	Length (mm)	Breadth (mm)	Height (mm)	Volume (m^3)	Weight (kg)	Density (kg/m^3)	Failure Load (kg)	Strength N/mm^2	Average Strength (N/mm^2)
1	B1/11/2/0K	459	225	230	0.024	21.90	912.5	50	0.48	
2	B2/11/2/0K	458	225	230	0.024	22.10	920.8	38	0.37	
3	B3/11/2/0K	460	224	228	0.023	22.18	924.17	40	0.39	
4	B4/11/2/0K	459	225	230	0.024	22.10	920.83	45	0.44	
5	B5/11/2/0K	459	225	230	0.024	22.00	916.67	38	0.38	
6	B6/11/2/0K	460	225	228	0.024	22.16	923.33	48	0.46	0.42
7	B7/11/2/0K	458	224	230	0.024	21.80	908.33	42	0.41	
8	B8/11/2/0K	458	225	229	0.024	22.12	921.67	47	0.47	
9	B9/11/2/0K	460	225	230	0.024	21.90	912.5	38	0.37	
10	B10/11/2/0K	460	225	230	0.024	22.06	919.178	44	0.43	

APPENDIX A13

INDUSTRY: C

TEST: WET COMPRESSIVE STRENGTH

DATE IMMERSED IN WATER: 4 - 2 - 97

DATE TESTED: 11 - 2 - 97

DATE MORTAR CUNE ATTAINED LEAST STRENGTH

S/No.	Sample Number	Length (mm)	Breadth (mm)	Height (mm)	Volume (m^3)	Weight (kg)	Density (kg/m^3)	Failure Load (kg)	Strength N/mm^3	Average Strength (N/mm^3)
1	C1/11/02/LI	460	222	233	0.024	20.00	833.33	45	0.44	
2	C2/11/02/LI	461	220	232	0.024	21.60	900.00	40	0.39	
3	C3/11/02/LI	460	222	231	0.024	21.38	890.83	31	0.40	
4	C4/11/02/LI	460	222	233	0.024	22.99	954.17	42	0.41	
5	C5/11/02/LI	462	220	233	0.024	20.80	866.67	40	0.39	0.44
6	C6/11/02/LI	460	221	231	0.023	22.20	925.00	48	0.47	
7	C7/11/02/LI	461	220	232	0.024	22.40	933.33	50	0.49	
8	C8/11/02/LI	460	220	232	0.023	21.38	890.83	41	0.41	
9	C9/11/02/LI	460	222	232	0.024	21.88	911.67	55	0.54	
10	C10/11/02/LI	460	221	233	0.024	21.80	908.838	42	0.41	

APPENDIX A14

INDUSTRY: E

TEST: WET COMPRESSIVE STRENGTH

DATE IMMERSED IN WATER: 1 - 4 - 97

DATE TESTED: 11 - 4 - 97

DATE MORTAR CUNE ATTAINED LEAST STRENGTH

S/No.	Sample Number	Length (mm)	Breadth (mm)	Height (mm)	Volume (m^3)	Weight (kg)	Density (kg/m^3)	Failure Load (kg)	Strength N/mm^2	Average Strength (N/mm^2)
1	D1/8/4/WY	459	215	231	0.023	22.10	960.87	38	0.39	
2	D2/8/4/WY	460	215	230	0.023	21.90	952.17	40	0.40	
3	D3/8/4/WY	460	215	230	0.023	22.20	965.22	43	0.43	
4	D4/8/4/WY	460	215	230	0.023	22.07	959.56	40	0.400	
5	D5/8/4/WY	458	216	232	0.023	22.18	964.35	44	0.44	0.43
6	D6/8/4/WY	459	216	230	0.023	22.10	960.86	45	0.45	
7	D7/8/4/WY	460	214	230	0.023	22.03	957.83	46	0.48	
8	D8/8/4/WY	460	215	230	0.023	21.80	947.83	45	0.46	
9	D9/8/4/WY	460	215	230	0.023	22.18	964.35	44	0.44	
10	D10/8/4/WY	460	215	231	0.023	22.10	960.87	45	0.45	

APPENDIX A15

INDUSTRY: E

TEST: WET COMPRESSIVE STRENGTH

DATE IMMERSED IN WATER: 1 - 8 - 97

DATE TESTED: 8 - 4 - 97

DATE MORTAR CUNE ATTAINED LEAST STRENGTH

S/No.	Sample Number	Length (mm)	Breadth (mm)	Height (mm)	Volume (m^3)	Weight (kg)	Density (kg/m^3)	Failure Load (kg)	Strength N/mm^2	Average Strength (N/mm^2)
1	E1/8/4/OK	459	215	231	0.023	22.08	960.00	46	0.47	
2	E2/8/4/OK	459	216	230	0.023	21.60	939.13	34	0.38	
3	E3/8/4/OK	460	216	230	0.023	22.00	956.52	40	0.40	
4	E4/8/4/OK	460	215	230	0.023	22.90	952.17	34	0.34	
5	E5/8/4/OK	460	214	231	0.023	23.00	1000.00	443	0.44	
6	E6/8/4/OK	459	215	231	0.023	21.00	913.04	40	0.41	0.40
7	E7/8/4/OK	460	215	230	0.023	21.68	942.61	40	0.40	
8	E8/8/4/OK	460	215	230	0.023	21.90	952.61	41	0.41	
9	E9/8/4/OK	460	216	230	0.023	21.80	947.83	40	0.40	
10	E10/8/4/OK	460	215	230	0.023	21.18	964.35	38	0.38	

APPENDIX A16

TEST: MORTAR CUBES STREGTH FOR INDUSTRIES A, B AND C

S/No.	DATE TESTED	SAMPLE NUMBER	AGE OF CURING (DAYS)	FAILURE LOAD (KN)	STRENGTH (N\mm^2)	AVERAGE STREMGTI N\mm^2)
1		A1/5/2/97	1	17.80	3.16	
2	5-2-97	A2/5/2/97	1	18.20	3.24	3.38
3		A3/5/2/97	1	21.00	3.73	
4		A4/6/2/97	2	74.60	13.26	
5	6-2-97	A5/6/2/97	2	65.40	11.63	12.44
6		A6/6/2/97	2	70.00	12.44	
7		A7/7/2/97	3	101.60	18.06	
8	7-2-97	A8/7/2/97	3	110.20	19.59	18.49
9		A9/7/2/97	3	100.20	17.81	
10		A10/11/2/97	7	165.80	29.48	
11	11-2-97	A11/11/2/97	7	170.30	30.28	30.08
12		A12/11/2/97	7	171.50	30.49	

APPENDIX A17

TEST: MORTAR CUBES STREGTH FOR INDUSTRIES D AND E

S/No.	DATE TESTED	SAMPLE NUMBER	AGE OF CURING (DAYS)	FAILURE LOAD (KN)	STRENGTH (N\mm^2)	AVERAGE STREMGTI N\mm^2)
1		B1/2/4/97	1	26.20	4.66	
2	2-4-97	B2/2/4/97	1	27.20	4.84	4.5
3		B3/2/4/97	1	22.50	4.00	
4		B4/3/4/97	2	72.80	12.90	
5	3-4-97	B5/3/4/97	2	69.90	12.43	12.59
6		B6/3/4/97	2	70.00	12.44	
7		B7/4/4/97	3	110.20	19.59	
8	4-4-97	B8/4/4/97	3	106.40	18.92	19.31
9		B9/4/4/97	3	109.20	19.41	
10		B10/8/4/97	7	170.50	30.66	
11	8-4-97	B11/8/4/97	7	170.90	30.38	29.79
12		B12/8/4/97	7	159.40	28.34	