AN INVESTIGATION INTO BLOCKS PRODUCTION USING STABILIZED LATERITIC SOIL AND COST COMPARISON WITH SANDCRETE BLOCKS.

(AT KADUNA)

BY

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AUGUST, 2001

DECLARATION

I, Mohammed Sani Sa'idu do hereby declare that the work presented in this project was a result of my own personal effort and as far as I know, it has not been presented to any institution for the award of degree or diploma. All sources of information are duly acknowledged in the references.

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DEDICATION:

TO MY PARENT

ALHAJI SANI MOHAMMED

AND

HAJIYA BILKISU ADAMU

ACKNOWLEDGEMENT

This project has been successfully accomplished with immense help and cooperation and understanding of many people whom I have had the cause to consult in the progress of the work. These contributions have been valuable and indispensable.

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ABSTRACT

The physical and chemical properties of laterite and cement were investigated and the results showed that they could be successfully used for solid soilcrete blocks production. The soilcrete blocks so produced after testing show remarkable improvements in their dry and wet compressive strengths. Water proofing, durability and handling properties of the blocks were also highly enhanced, implying that cement stabilized soilcrete blocks can be suitable in wet weather.

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LIST OF SYMBOLS

AWD	_	AVERAGE WEIGHT OF DRY SAMPLE
AWM	_	AVERAGE WEIGHT OF MOISTURE.
BS	_	BRITISH STANDARD.
FMW	_	FEDERAL MINISTRY OF WORK.
GI	_	GROUP INDEX.
GS	_	SPECIFIC GRAVITY.
LL	_	LIQUID LIMIT.
MC	_	MOISTURE CONTENT.
MDD	_	MAXIMUM DRY DENSITY.
OMC	_	OPTIMUM MOISTURE CONTENT.
OPC	_	ORDINARY PORTLAND CEMENT.
PL	_	PLASTIC LIMIT.
PI	_	PLASTIC INDEX.
WT	_	WEIGHT.

CHAPTER ONE

1.0 INTRODUCTION

Blocks apart from being one of the most important or major component of a building which provides needs such as comfort, privacy, aesthetic, heat resistance, it also provide a security in the form of a fence. It makes about 30 percent of the total construction cost of a house, Taylor (1961). It is however produced in different sizes, shapes and is used for different purposes in a building construction.

In view of the above-mentioned facts, it is necessary to encourage the use of local materials, Ingles O. C & Metealf J.B(1989). Which are in abundance in Nigeria for building houses in order to meet up low cost housing needs of the people. And also to make the set out program by the government 'House for all' a reality, Abejide (1997).

One of the basic necessities of life is shelter. Nigerian Government has been setting out programs for 'housing for all'. But due to the difficult nature of the economy and high cost of building materials, the set objective is not yet realised.

1.1 STATEMENT OF THE PROBLEM

Recently the high cost of cement has directly affected the cost of blocks production to go up. Subsequently, non availability of sand and difficult of conveyance has direct effect on the price of production of blocks. These cumulative effects have affected price of cement to go up and have also affected building materials. This study is aimed at looking into how production of blocks can be reduce using local materials to produce blocks.

Following all these efforts, the government has invested a lot in making the program a success. There is need to periodically assess the quality and stability of some of these building components. These necessitated carrying out research into a particular soil using a stabilizing agent to produce building blocks.

1.2 JUSTIFICATION OF THE STUDY

Laterite is readily obtainable at low cost in almost all part of the country. Places like kano, Borno, Niger, Anambra, Rivers, Ondo, Lagos states e.t.c If this are exploited, replacement for sand will be achieved and the demand for cement will also reduce, thereby reducing the high cost of blocks productions.

1.3 OBJECTIVES OF THE STUDY

1. The objective of this study is to encourage the use of local raw materials.
2. And to suggest the use of stabilized lateritic soil blocks that can be used in place of sandcrete blocks.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

According to Macropeadia (1950), Engineering can be defined as the "professional art of applying science to the optimum conversion of the resources of nature to the uses of mankind".

Civilization is a short hand expression of material and progress, stressing man's conquest and masterly of his environment. His creation and use of artifacts or objects of material culture, his improvement of his skills and methods of doing things and his appreciation of the overall impact of these realities on the quality of his life in the society, Hubert (1994).

2.2 REVIEW of ANCIENT WORK

The most visible legacy of ancient Egypt is in works of architecture and representative art. Until the middle kingdom most of these were mortuary, temples, royal tomb complexes, including pyramid, e.t.c, Encyclopaedia (1990). The Greek adopted a form of construction that had been used in Egypt for centuries. In the same trend, the Romans copies the Greek style for most ceremonial purposes, but in other aspects there are some important innovators in building technology. They make extensive use of fired bricks and tiles as well as stone; they developed a strong cement that would set under, they explored the architectural possibilities of the Arch, the Vault and the Dome, Ghose (1991). They then applied these techniques in amphitheatres, in aqueducts, in tunnels bridged, walls, lighthouses and roads.

A body by the name Commonwealth Science Council, in collaboration with United Nation Centre for Human Settlements (Habitat) established in Kampala, and Uganda in June 1995 to undertake an African regional project on local building materials technology, Ingles O. C & Metealf J. B (1989). To date, the African project research network comprises of countries like Ghana, Kenya, Malawi, Mauritius, Sierra Leone, Uganda, Tanzania, Nigeria, and Zimbabwe. Others are Cyprus and Malta. They are represented by co-ordinators. The activities of the research network have so far attracted the participation of non-Commonwealth countries.

One of the local materials that a research work was carried out on is lateritic soil. Lateritic Soil are commonly found in Africa, normally with sizes greater than 60mm or in gravel or fined grained soil with gravel fraction less than 10%, Ingles O. C & Metealf J. B (1989).

Some research result on the use of stabilized lateritic soil have already been published. Such a test carried out on limestone and lateritic soil at the Civil Engineering Department Laboratory of the University of Science and Technology, Kumasi in Ghana(8) had shown that limestone which is relatively cheep, lateritic soil and cement produced a mix suitable for making mortars for plastering and for casting building blocks and bricks in construction industries.

Bala (1989) carried out a research on soil stabilization using Limestone, Bitumen and Scale Billet. The result obtained indicated that cement, cement and bitumen are good stabilizing material and have good binding effect with the lateritic soil, which means the only way to use it as stabilizing agent is by compaction or mechanical stabilization, but one of the draw back is that with time when scale billet is expose to water, iron sulphide react and change to iron sulphate which reduces the strength of the stabilized soil.

As an alternative to cement, hydrated lime can be mixed with certain soil to produce a stronger and more workable material and the product of the mixed material, increases strength with age. In Zambia, hydrated lime was used extensively to stabilize the clayey gravel, which are widely available. This is also the case in Nigeria where lateritic soil is found in places like Sokoto, Bauchi, Niger, and Osun, Imo e.t.c.

Soil stabilization is a method of improving the quality of the soil in which the cement is mixed with pulverized soil to form a material which when compacted and allowed to harden, possesses appreciable and considerable resistance to weathering. This form of construction was first used in Great Britain as far back as1917 but was only employed to appreciable extent here in Nigeria by 1945. To date, soil –cement construction has been done covering millions of square metres of land, Ola (1974).

2.3 TECHNIQUES OF STABILIZATION

Certain natural occurring soils may required only compaction and drainage for stabilization, other soils required treatment in various aspects with different materials in order to satisfactorily perform their intended functions. The most common and important methods are discussed below.

2.3.1 MECHANICAL STABILIZATION

This method of stabilization involves the adding o f deficient materials to natural soil to produce a more satisfactorily grading. A poorly graded soil can be modified by adding either fine or coarse particles to achieve better inter locking of soil structure. It entails the use of well graded materials, which ensure the possibility of compaction to a high dry density with low proportion of air voids and so lessen the risk of subsequent increase of moisture content.

This technique is widely use in road construction throughout the world. This is because it makes possible the maximum use of locally available materials in high ways, Embarkment, Sub-base, Road base and surface courses.

2.3.2 CHEMICAL STABILIZATION

This is another method of soil stabilization whereby cement, lime, bitumen or various chemicals are used to bind the particles of the soil, so as to provide an increase in the soil strength.

Chemicals stabilizers may be used to adhere the interface of particles. The development of a cohesive bond depends on the strength of the stabilizer and the surface area of the particles can be designed to meet a wide range of strength requirement for pavement construction. There are many binding materials, which can be use for construction. The common ones are Portland cements, hydrated lime and bitumen.

2.3.3 CODE SPECIFICATIONS

Numerous bodies in various countries specify varying requirements for compliance of various products manufactured or used in their countries. In this context, only two of the standard specifications for sandcrete blocks, which are also applicable to soilcrete blocks, have been considered.

The Federal Ministry of Works (FMW), Abuja specifies a minimum allowable average strength and a least individual strength based on a sample of three (3) specimens. A foreign standard specification, British Standard is also considered. Table 2.1 below summarised the strength requirement of both the Federal Ministry of Works and the British Standard.

TABLE 2.1 SPECIFICATIONS FROM SOME CODES

STANDARD	MIN.AVERAGE STRENGTH ALLOWED N/MM2	MIN. LEAST INDIVIDUAL STRENGTH ALLOWED N/MM2	NUMBER OF SPECIMENS REQUIRED	PERIOD OF IMMERTION IN WATER	CONTACT LAYER
FMW	2.10	1.70	3 BLOCKS	Not specified	Not specified
BS 2028/A	3.50	2.80	10 BLOCKS	7-8 days	Cement
BS 2028/B	2.80	2.25	10 BLOCKS	7-8 days	Mortar

(SOURCE: FEDERAL MINISTRY OF WORKS, BS2028, 1364, 1968)

CHAPTER THREE

3.0 METHODOLOGY

3.1 LATERITE ANALYSIS

The laterite employed was dug from a burrow pit within Kaduna Polytechnic main campus. The site is located behind the Civil Engineering Department (about 500m from the department). Three samples of lateritic soil obtained were analysed for moisture content, liquid limit, plastic limit, plastic index, group index, linear shrinkage, maximum dry density, optimum moisture content and specific gravity.

The result obtained after the laboratory investigation, which is tabulated below, show that the laterite is suitable for Civil Engineering Works.

TABLE 3.1 SUMMARY OF PHYSICAL PROPERTIES OF THE LATERITE

SAMPLE	%MC	%LL	%PL	%PI	%GI	%LS	OMC	GS
1	48.0	48.8	37.4	10.0	6	7.4	17.2	2.45
2	42.4	43.2	40.5	13.4	6	7.4	21.0	2.4
3	45.3	41.0	41.0	12.5	6	7.4	18.6	2.4

3.2 PRODUCTION OF THE SOIL BLOCKS

3.2.1 Equipment

The equipment used in the laboratory in the production of the blocks included manual process for moulding blocks, shovels for mixing, head pans and wheel barrow for measuring laterite and admixture and bucket for water fetching.

3.2.2 Mixing

Batching by weight and hand mixing was adopted. The hand mixing was carried out on a platform which is a clean layer of concrete floor. The measured quantities:- 1:28, 1:14, 1:9, and 1:7 by weight of each laterite, stabilizer (cement) is poured onto the platform as a heap. The dry materials was mixed together with shovels by turning the mixture in and out, side to side until the heap shows an even colour, that is the laterite and the cement can not be visually distinguished from one another at any point in the mixture. The mixture at this point is considered homogenous. Water was added and it gives a mix the required workability. The percentage of water required for mixing was obtained through moisture content of three workable samples.

3.2.3 Block Moulding

The manual process used for the moulding of the blocks consists of three moulds of equal dimensions (225mm x 100mm x 75mm). Above the mould rests a metal compressor of the same dimensions as the moulds. The compressor is moveable in the vertical direction so that it can either be brought down to rest directly on the mould to effect compaction or push up to expose the moulds for filling in the mix. It also has a manual lever for lifting and releasing the moulds.

When the desired workable mix was made, the moulds were filled up with it and compacted. The corners were manually pre-compressed using a timber rod of size 25mm x 50mm to compensate for the low compression at that part.
The mix was subjected each time to about a minute compression after which the compressor was pushed up to bring out the fresh blocks. The blocks were lifted using the manual lever and transferred to the drying platform. This process was performed several times while producing blocks each time (see Appendix 1).

Plate 1: PICTURE SHOWING SOME SELECTED SAMPLES OF THE MOULDED SOILCRETE BLOCKS.

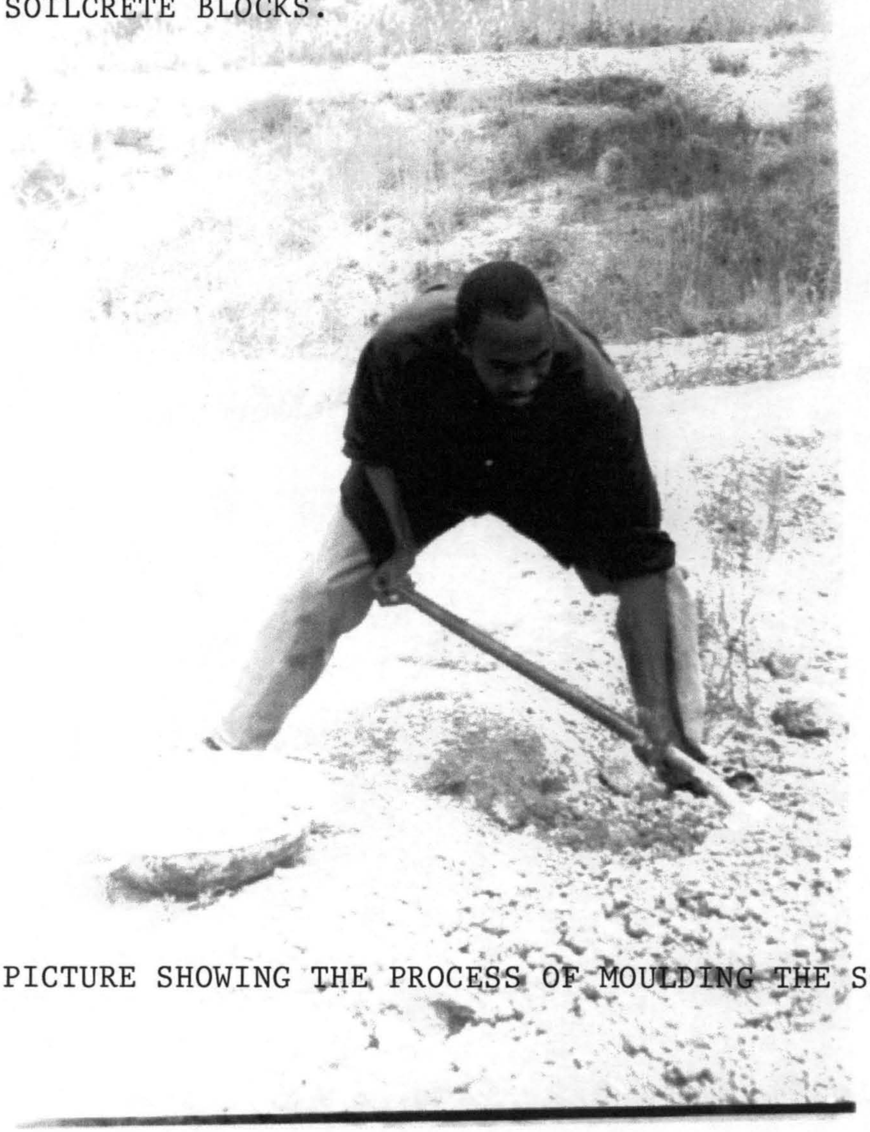

Plate 2: PICTURE SHOWING THE PROCESS OF MOULDING THE SOILCRETE BLOCKS.

3.2.4 Curing

The blocks were allowed to dry for about 24 hours and cured by spraying them with water in the morning for about 28 days.

All the block samples were kept under moist conditions by covering them with a polythene sheet. By so doing, excess loss of moisture is prevented and the process of cement hydration enhanced. This increases the strength of the blocks with time.

3.2.5 Samples Specifications

A total of eighty blocks were produced with different mix proportions. That is the ratio of cement to lateritic soil in kilograms. All the blocks were produced in the Civil Engineering Laboratory of Kaduna Polytechnic, Kaduna. A breakdown of the blocks produced is shown below.

	MIX PROPORTION			BLOCKS PRODUCED
0.5	CEMENT	14	LATERITE	20
1.0	CEMENT	14	LATERITE	20
1.5	CEMENT	14	LATERITE	20
2.0	CEMENT	14	LATERITE	20

3.3 TESTS

3.3.1 Dry Compressive Strength

This test was carried out after the blocks have attained the ages of 1, 3, 7, 14, 21, and 28 days after production. In each case, three blocks samples were tested and average value obtained.

3.3.2 Wet Compressive Strength

28 days cured samples were soaked in water. Three blocks also were tested each time for the period of 1, 3, 7, 14, 21, and 28 days. The average wet compressive strengths of these periods are then computed.

3.3.3 Moisture Absorption

The test was carried out to determine the amount of moisture absorbed by the block samples soaked in water for the period of 1, 3, 7, 14, 21, and 28 days.

3.4 MEASUREMENT

Before conducting compressive strength and moisture absorption tests, the gross surface area of each specimen was calculated as 22,500mm2 and an average weight as 3.7kg.

3.4.1 Strength Determination

The compressive strength of all samples was determined in accordance with the standard procedure giving in appendix C of BS2028, 1364 and amendment NO. 1:1970[14](). Each specimen was capped with mortar on both bed faces before crushing. The bed faces are normally rough and may be inclined from one end to the other. Capping is therefore, necessary to produced a plane surface upon which the pressure from the platens of the crushing machine will be applied.

The mortar mix ratio of 1:1 is necessary in order to produce a capping surface stronger than the block so as to ensure that the mortar does not fail before the block itself. The specimen were tested using hand operated cube crushing machine.

Each specimen was placed on the machine with soft boards beneath and above it so that its axis coincided with the center of thrust of the platens of the machine. The soft boards served to compensate for any inclinations of the block bed faces and produced a leveled crushing surface. The machine dial pointer was brought to zero with the specimen in position and the upper platen just touching the upper soft board.

The load was applied without shock and continuously increased at a rate such that failure occurred within 1 to 1 ½ minutes. Maximum load in Newton carried by the specimen before failure was recorded. The maximum load was divided by the gross surface area of the specimen in mm^2 to give the compressive strength of the block in N/mm^2 to the nearest two decimal places. The arithmetic mean of the compressive strengths of three blocks was taken as the average compressive strength of the sample the results are shown in chapter four.

3.4.2 <u>Moisture Absorption Determination</u>

This test was carried out to determine the amount of water absorbed by the block samples soaked in water for the different number of days as earlier stipulated. The blocks were weighed on a scale before immersion in order to determine their dry weights. At 1, 3, 7, 14, 21 and 28 days, three blocks were removed from the water and reweighed to determine their wet weights. The different between the wet and dry weight gives the weight of moisture absorbed by the block sample during the periods of immersion. This value was divided by the dry weight to obtain the percentage water absorption.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS.

The result of tests on the soil blocks are shown in the following tables. Tables 4. 1 – 4.4 shows dry and wet compressive strength of stabilized leteritic Soil blocks.

4.1 DRY COMPRESSIVE STRENGTH.

Dry compressive strength test is essential in predicting suitability of any type of block for building the result for this study are presented in tables 4.1 – 4.4.

It can be inferred from the values obtained that soilcrete blocks with lower proportions of cement have lower compressive strength values as shown in Table 4.1. The ratio 1cement to 28 laterite moulded blocks attained a dry compressive strength of 0.63 N/mm^2 after 28 days of curing. This value rose steadily as the proportion of mixture in the blocks was increased. Also, from Table 4.4., a maximum average value of 1.8 N/mm^2 dry compressive strength was obtained for the ratio 1 cement to 7 laterite blocks at 28^{th} day. Hence, it appears more ideal and suitable mix proportion, and also complying with the strength requirement (1.7 N/mm^2) specified by the Federal Ministry of Works. Similarly, Table 4.2 shows the mix of ratio 1 cement to 14 leterite gives the least compressive strength of 0.19 N/mm^2. The low value obtained may be due to chemical relations between the stabilizer that was used with laterite. However, the durability of cement and laterite materials has lasted over the centuries and this should not be doubted.

4.2 Wet Compressive Strength and Water Absorption.

Similarly, Tables 4.1 - 4.5 show the results for wet compressive strength and water obsorption. This confirm the suitability of the block when subjected to wet conditions, for example during rains. Mix ratio 1 cement to 28 laterite block (Table 4.1) dissolved completely in water. The mix ratio 1:14, 1:9 and 1:7 of cement to laterite did not dissolve in water and their wet compressive strength and water absorption were recorded as shown in tables 4.1 – 4.4. The ratio 1cement to7 laterite gave the highest wet compressive strength, which shows that at 1:7cement to laterite content, the blocks are most suitable for wet areas of the tropics. The value of the wet compressive strength was 1.47 N/mm^2 after one day immersion in water.

Figure 4.1 – 4.8 shows the behaviors of the soilcrete blocks at various mix ratios with respect to time or days. It can be inferred from figures 4.1 – 4.4 of dry compressive strength, there is approximately linear increase strength by the number of days. There by certifying the suitability of the blocks. While figures 4.5 – 4.7 of wet compressive strength shows appropriately linear decrease in strength by the number of days of immersion in water. Which also certify the suitability of the blocks in wet areas. Figure 4.8 shows the percentage moisture absorption of mix 1:14, 1:9 and 1:7. The mix of 1:28 dissolved completely in water, thereby showing is a bad mix for wet areas.

Table 4.1 (1 Cement to 28 Laterite)

		DAYS						
Stength Test	Block Number	1	3	7	14	21	28	Remarks
Dry Compressive Strength (N/mm^2)	1 2 3	0.23 0.28 0.19	0.31 0.28 0.19	0.39 0.41 0.35	0.48 0.53 0.47	0.54 0.62 0.55	0.61 0.70 0.63	Blocks produced were neat with dimension 225 x 100 x 75 (mm)
	Average	0.23	0.30	0.38	0.49	0.57	0.65	-
Wet Compressive Strenth (N/mm^2)	1 2 3	- - -	- - -	- - -	- - -	- - -	- - -	Blocks dissolved in water
	Average	-	-	-	-	-	-	
% Moisture Absorption	$\frac{AWM}{AWD} \times 100$	-	-	-	-	-	-	

Table 4.2 (1 Cement to 14 Laterite)

		DAYS						
Strength Test	Block Number	1	3	7	14	21	28	Remarks
Dry Compressive Strength (N/mm^2)	1 2 3	0.14 0.22 0.21	0.22 0.31 0.29	0.34 0.46 0.38	0.54 0.58 0.48	0.72 0.76 0.69	1.08 1.14 1.10	Blocks were produced neatly
	Average	0.19	0.27	0.39	0.53	0.72	1.10	-
Wet Compressive Strenth (N/mm^2)	1 2 3	0.73 0.78 0.76	0.67 0.67 0.67	0.58 0.58 0.58	0.49 0.51 0.48	0.42 0.38 0.40	0.37 0.32 0.36	Blocks were produced neatly
	Average	0.76	0.67	0.58	0.49	0.40	0.35	
% Moisture Absorption	$\frac{AWM}{AWD}$ x 100	13.51	22.97	14.59	18.37	16.75	15.40	

Table 4.3 (1 Cement to 9 Laterite)

		DAYS						
Strength Test	Block Number	1	3	7	14	21	28	Remarks
Dry Compressive Strength (N/mm²)	1 2 3	0.37 0.32 0.41	0.42 0.41 0.49	0.59 0.53 0.64	0.81 0.61 0.86	0.07 0.88 1.17	1.15 1.01 1.24	Blocks were produced neatly
	Average	0.87	0.44	0.59	0.78	1.04	1.13	
Wet Compressive Strenth (N/mm²)	1 2 3	0.86 0.84 0.84	0.82 0.82 0.82	0.76 0.71 0.73	0.73 0.68 0.68	0.69 0.62 0.62	0.67 0.58 0.58	
	Average	**0.85**	**0.82**	0.73	0.70	0.64	0.61	
% Moisture Absorption	AWM x 100 / AWD	11.08	20.00	14.05	17.57	15.14	14.86	

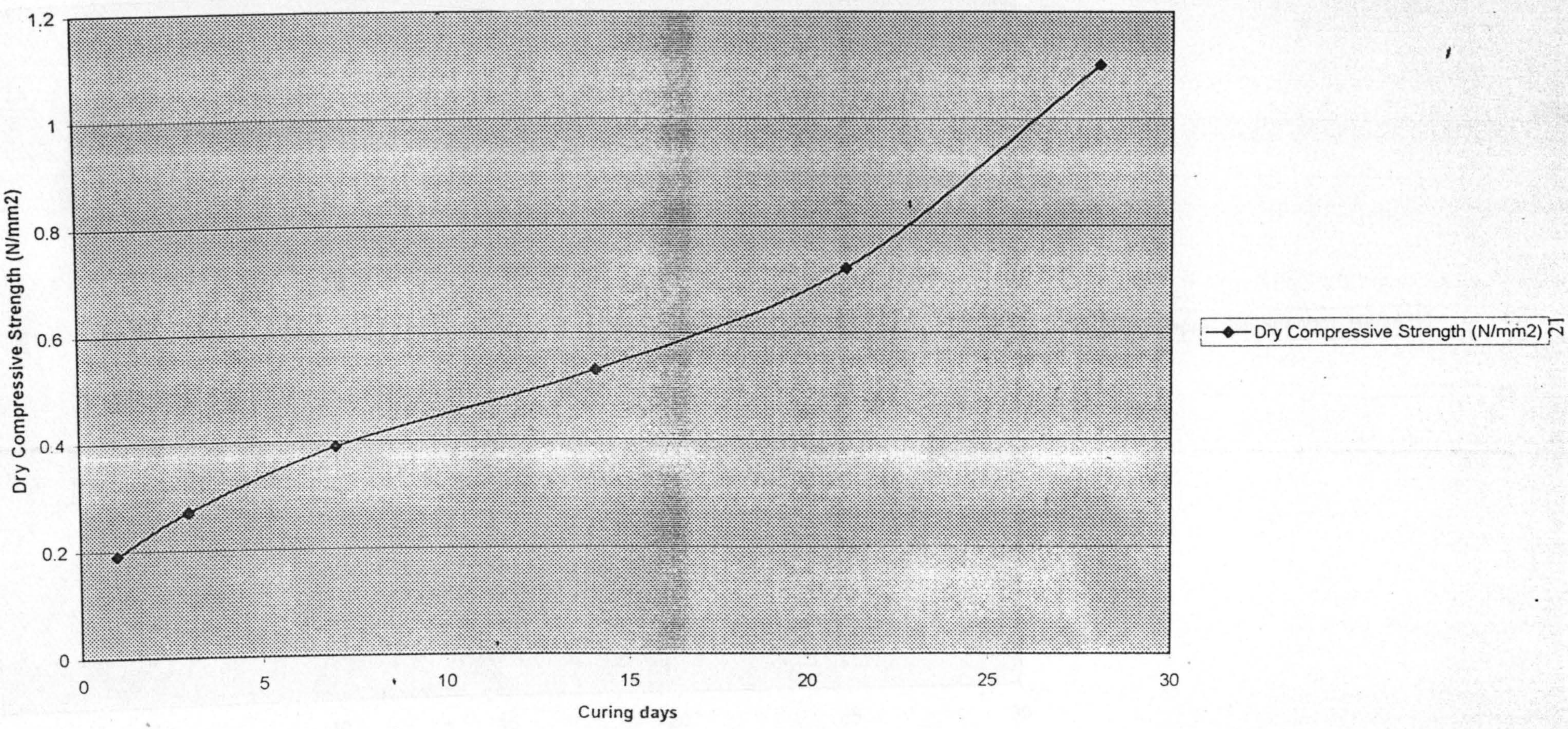

Fig.4. 2 : Dry Compressive Strength of Soilcrete Blocks with 1:14

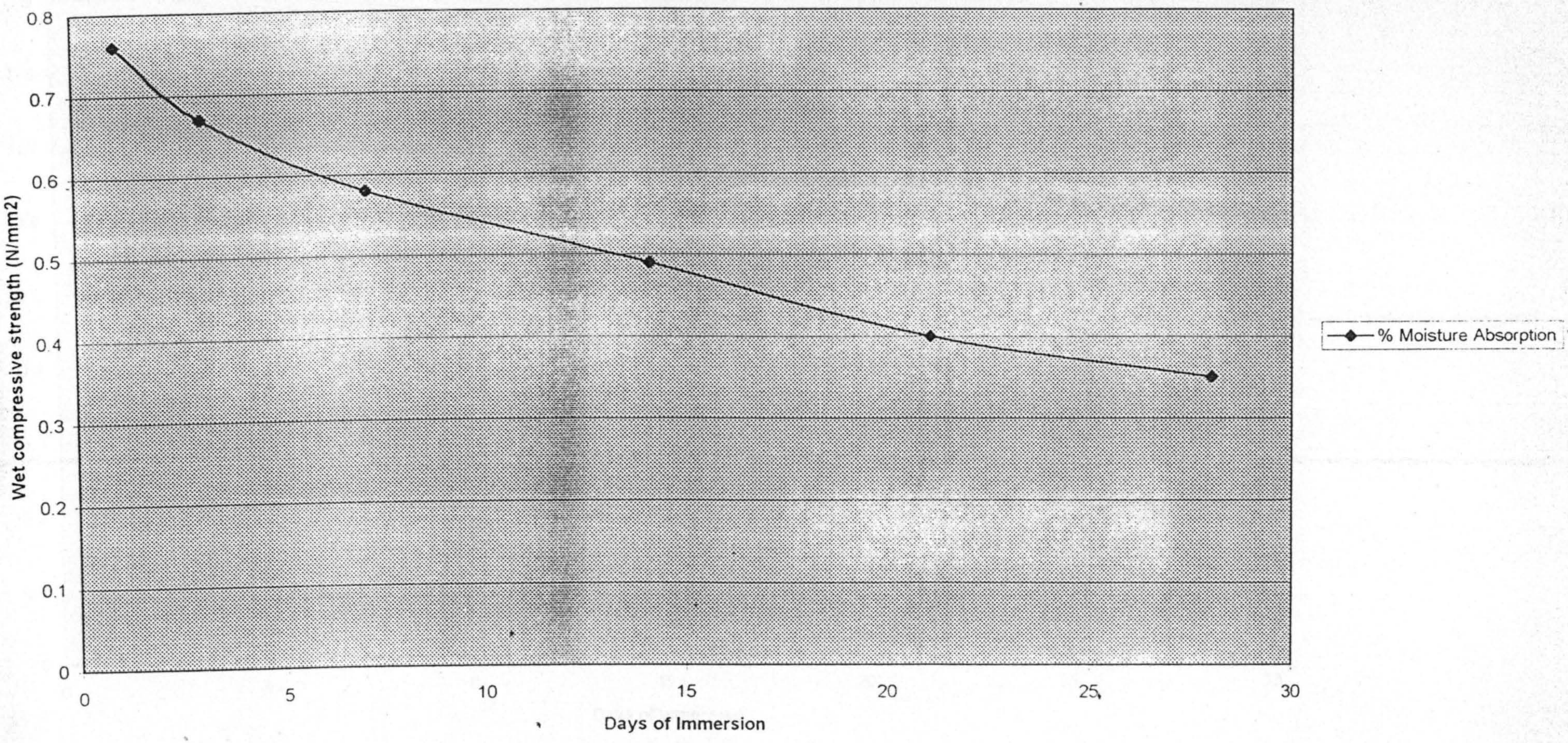

Fig. 4 . 5: Wet Compressive Strength of Soilcrete Blocks with 1:14

4.3 Price Analysis.

The constituent of moulded Soilcrete blocks are laterite, and cement. A breakdown of the cost of each constituent is shown below.

Weight of 1 tipper-load of laterite = 4480kg

Cost of 1 tipper-load of laterite = N2200.00

Cost of 1kg of laterite $= \frac{2200}{4480}$ = 0.49

Weight of 1 bag of cement = 50kg

Cost of 1 bag of cement = N900.00

Cost of 1kg of cement = 900/50 =18.00

From the result of dry and wet compressive strengths of the moulded Soilcrete blocks, the most satisfactory mix ratio is that containing 1 cement to 7 laterite.

Weight of 1 Soilcrete block = 3.7kg

Weight of cement = 1/8 x3.7 = 0.46kg

Cost of 0.46kg of cement = N8.28

Weight of laterite ratio = 7/8x3.7 = 3.24kg

Cost of 3.24kg of laterite = 1.59

Total Cost of block Materials = N9.87

Cost of labour = 25% of N9.87 = N2.47

Overall Cost of 1 Soilcrete block = N12.34

Surface area of 1 Soilcrete block = 0.225x0.075 = 0.016875

Number of Soilcrete bocks per m^2 of wall = 1/0.016875 = 59. 26

Cost of Soilcrete blocks per m^2 of wall = 59.26x12.34 = N731.27

But, cost of sandcrete blocks per m^2 of wall = N2192.62

Therefore, the Soilcrete block is more economical.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION.

From the results obtained in this work, it can be comprehensively concluded that Solid Soilcrete blocks stabilized with cement, and made up of readily available lateritic soil materials give a high compressive strength similar to that of SandCrete blocks use for building.. The results of wet compressive strength and moisture absorption test indicate that cement stabilized Soilcrete blocks can be used for buildings in wet conditions. This property is most significant in the Southern part of Nigeria where the rainfall is usually heavy.

The blocks are made with locally available materials thus, making the task of providing shelter of millions of people of economically backward countries, a realistic and cheap venture. Thee adoption of simple production procedure would create more employment for individuals and corporate bodies.

Finally, when used in buildings only the internal face of the blocks need be rendered and painted. This is because the architectural beauty of the building is enhanced by the red colour of the blocks while contributing to reduction in the overall cost of the building.

5.2 RECOMMENDATION.

Soil blocks in the near future will be the most predominant blocks for building works and other construction projects despite the advent of burnt clay bricks. This calls for further research on this construction material with a view to finding economic ways of improving the quality.

Further research can be engineered towards the following:

1. More research on the stabilizer (cement, composite cement, pozzolana) should be carried out of determined whether other organic compounds are present which could be useful for Civil Engineering Construction purposes.

2. Standard and specifications should be formulated for the stabilizers and their use should be enforced. Building codes of practice and regulations regarding locally produce should also be formulated.

3. Possibility of including colour admixture in the mix to serve different tests the blocks.

4. At the end, Government (Federal, State and Local government should encourage the use of this type of blocks by evolving a medium through which this technology can get to the rural dwellers and the urban poor man.

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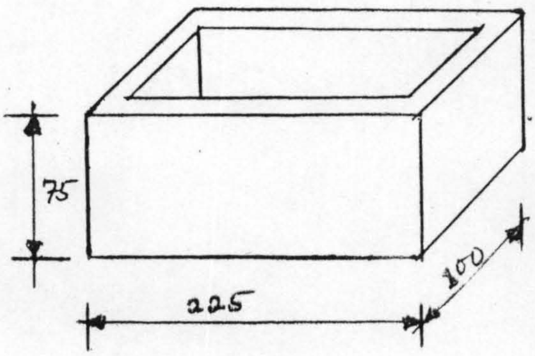
APPENDIX



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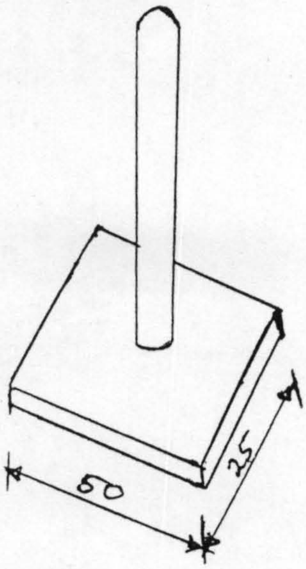

TIMBER ROD