EVALUATING MATERIAL APPLICATION WASTE ON BUILDING CONSTRUCTION SITES A CASE STUDY OF KADUNA STATE

BY

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A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL AHMADU BELLO UNIVERSITY ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (CONSTRUCTION MANAGEMENT) IN THE DEPARTMENT OF BUILDING, FACULTY OF ENVIRONMENTAL DESIGN, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

SEPTEMBER 2000

DECLERATION

I hereby declare that this thesis has been prepared by me and is solely the record of my research work. It has not been presented in any previous application for a higher degree.

All quotations are specifically acknowledged by means of references.

ABUBAKAR DARDA'U ABDUL'AZEEZ
September 2000

CERTIFICATION

This thesis entitled "Evaluating Material Application Waste on Building Construction Site – A Case Study of Kaduna State" by Abubakar Darda'u Abdul'Azeez meets the regulations governing the award of the degree of Master of Science (Construction Management) of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my beloved late dad, my mum, my wife and my two little kids Abdul'Azeez and Fatimah.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my supervisors Mr. Kehinde Joseph O. and Dr. Kabir Bala Lecturers in the Department of Building, Faculty of Environmental Design, Ahmadu Bello University, Zaria, for devoting their valuable time in giving constructive and useful ideas, criticisms and guidance towards the completion of this thesis.

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ABSTRACT

This study was aimed at evaluating material application waste on building construction sites in Kaduna State.

The need for the study arose from the observations made on ever-increasing material wastes in most building construction sites in the State. The study centered on magnitude of material waste, causes and how to minimise these waste so as to enhance the maximum utilisation of scarce resources.

The research data were obtained from survey of forty-construction sites in the State through the use of questionnaires, observations and personal interview. The data generated were analysed by simple arithmetic formulae.

The results obtained indicated that the average actual waste of sandcrete blocks material used at these sites is about 9.37%, and that of ready mixed concrete and roofing sheet is 6.32% and 5.93% respectively. The magnitude of these waste obtained during the execution of the work is far more than the normal allowance of 5% made on sandcrete blocks material, 2.5% and 5% on ready mixed concrete and roofing materials respectively, often made in estimating and technical accounting conventions. The analyses of the data also showed contractors have little experience in measuring material wastage on sites.

It is therefore, recommended that to minimize these wastes on sites, control of material usage should be regarded as a continuing process at each successive stage in the life of a building project as it involves a variety of individuals with different job functions.

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CHAPTER ONE

1. INTRODUCTION

Waste on construction sites can sometimes be considerable where poor management is the norm. The overall loss of principal materials is about 100 per cent more than is usually allowed for in estimating and technical accounting conventions. This figure is, of course, highly variable and is much lower on some sites, (BRE Digest, 1981).

According to Ibironke (1994), waste of materials is the most expensive item on any construction site. In extreme cases, it may mean the difference between profit and loss, at the very least, it means a reduction in profit and these profit are often low enough without waste.

In Nigeria most of the small and, to a less degree, medium-sized construction companies in the industry are indigenous. The building industry, a sub-sector of the construction industry in the country, has over the past few years entered into a new and challenging era appearing in the market in an ever-increasing volume. New techniques in building, in the shape of industrialization and pre-fabrication have evolved, bringing with them new problems in design, organization, production, handling and storage with the aim of enhancing production (Tahula, 1982).

According to Enshassi (1996), the scope of materials waste is vast, and this waste occurs in the industry irrespective of the size of the building organization,

the value and duration of the contract or the variety of building type in new buildings, refurbishing and maintenance. It is generally recognized that not all the materials delivered to construction sites are used for the purposes for which they were ordered and that builders frequently use more materials than they receive payment for; either they are lost or they are used in the buildings in ways which are not recognized by estimators and technical accountants (BRE Digest, 1981).

1.1 Definition of Concept

It might be necessary, before assessing the true extent of waste and how it is generated in the whole building process, to attempt at least to arrive at a satisfactory definition of waste for accounting purposes on building site.

It has generally been understood that waste is the difference between materials delivered and those fixed in a building. This definition is unsatisfactory as it does not take into account the material waste before delivery and does not take into account the resulting inefficiencies caused by waste.

An acceptable definition of material waste at site has been therefore suggested as "the difference between the value of those materials delivered and accepted at the site and those properly used as specified and accurately measured in the work, after deducting the cost savings of substituted materials and any materials transferred elsewhere. The loss is expressed as a percentage of the delivery (Walkerdine, 1993).

This definition includes conversion, and it does not include waste occurring before delivery, except where improper materials are accepted at site. It also does not include consequential and indirect waste.

1.2 Significance of the Study

Although the scope of the study is limited to the geographical area of Kaduna State and the building industry, the findings may be applicable to the Nigerian construction industry as a whole and, perhaps, to the construction industry elsewhere.

Waste occurs throughout the industry irrespective of the size of the building organization, the value and duration of the contract or the variety of building type in re-buildings, refurbishing and maintenance.

As natural resources become scarce, so waste will become even more serious and the economic balance between wasting and saving change. Material waste is an increasingly serious matter for the society, which the building industry serves (Enshasis, 1996).

Rising cost of projects, high interest rates, inflation and competitive tendering market due to declining demand for construction products make it necessary for construction firms to give serious consideration to waste generation and reduction of such waste on construction site to an acceptable level if they are to realize reasonable return on investment necessary to remain in business and to satisfy their clients. It must be noted that building materials often account for

more than 60 per cent of the total cost of buildings in Nigeria, therefore, a lot of saving in cost can be achieved by exercising control on material purchases, supply and usage on construction sites (Ibironke, 1994).

1.3 Aim and Objectives

The aim of the research is to investigate material waste generators, and the magnitude of waste on construction sites in Kaduna State. The following are the objectives of the study:

(i) To articulate from literature and records of previous result, materials waste generators on building construction sites.

(ii) To investigate (evaluate) the extent of wastes generated on some selected materials on building sites.

(iii) To investigate the possibilities of minimizing materials waste on building sites in Nigeria.

1.4 Methodology

The methodology adopted for the study are as follow:

(1) Review of literature

(2) Site investigation, and

(3) Case study.

The first aspect was achieved through critical study of texts, journals, seminar papers, proceedings, and other publications related to the subject matter.

On the second and third aspects, data were obtained by means of a formidable inquiry covering detailed information, of the activities on site that generate waste. Detailed information on deliveries and stocks of materials on site, amount of materials used for each work executed were recorded. Area/Volume of the work covered during the exercise were measured and data collected.

Simple arithmetic formulae were used to evaluate the actual waste produced from the measured work on sites, and comparison between the allowable and the actual waste were made.

In the light of the above, conclusion was drawn and recommendations made for areas requiring adjustment and further studies.

1.5 Scope and Limitation

Although the study is more relevant to contractors and direct labour organisations, - clients, building materials manufacturers and researchers may also find it helpful. Owing to limitation caused by time, other resources and numerical number and types of building materials, only a few key materials were selected for the study, namely sandcrete blocks, ready mix concrete and roofing sheets. Furthermore, it may not be possible to conduct the research on a nation wide scout. Kaduna State is therefore, the main focus of the research and the findings of the study could be readily of use throughout the construction industry in Nigeria and probably abroad.

CHAPTER TWO

2. REVIEW OF LITERATURE

2.1 Characteristics of the Construction Industry

Construction industry is an essential contributor to the process of development. Construction works are the physical foundations on which development efforts and improved living standards are established. According to World Bank Publication (1983), the construction industry usually accounts for between 3 percent to 8 percent of a developing country's gross domestic product (GDP).

Construction is essentially a service industry, whose responsibilities are to convert the plans and specifications prepared by an Engineer or an Architect into finished project (Ngoka, 1987). The construction of projects therefore involves thousands of details and complex inter-relationships among clients, architects, engineers, contractors, materials dealers, equipment distributor/hirer, government bodies and agencies, labour and a host of others. The objective of construction work is that of completing a prescribed amount of work within a fixed duration at a previously estimated cost and at a specified quality standard.

The characteristics of the building industry make it indispensable in the development of any nation's economy. According to Kolawale (1994), the building industry has characteristics, which are separately shared by other industries, but the combination appears in construction alone, making it worthy of separate treatment. These characteristics fall into four main groups:

1. the physical nature of the product
2. the structure of the industry together with the organization of the

contribution process

3. the determination of demand, and

4. the method of price determination.

Kolawale (1994) further viewed the characterization of the building industry as a conglomeration of diverse fields that have been lumped together under a common heading for the convenience of reference, and further reported that for practical consideration, the broad spectrum of construction activities may be classified into two main categories:

1. building construction (both residential and non-residential)

2. massive construction which is subdivided into:

   (i) construction of roads

   (ii) commercial buildings, and

   industrial building.

2.2 Categorisation of Construction Firms

Generally, companies are grouped into three broad classes. The small company employs less than one hundred people, the medium sized employs between one hundred and five hundred people, while the large one employs over five hundred people (Ngoka, 1987). But, the classification of these companies on the basis of the size of contract, which a contractor is judged to be able to execute competently is done by various governments and institutions.

According to Kolawale (1994), various authors have attempted to define building industry as that which includes residential construction, civil engineering works and the building materials dealers, while others in an attempt

to define it concentrated on the functional description of its make up. According to him, the Construction Industry is made up of the client, contractor, consultant, material manufacturers and distributors, financial institution and labour force. He further expatiated it to include all those organization or firms engaged in the erection of dwellings, shops, factories, hospitals and similar public and private buildings and those that specialized in particular sections of the trades like plumbing, installation of air conditioners, electrical wiring, aspect of civil engineering works (road, bridges and similar structures).

The construction sector has two main classes. One is building construction which is associated with housing, offices, hospitals, factories, and so forth; the other is the civil engineering construction involved in the construction of infrastructure for water supply, transport, irrigation, power generation, and so on. According to World Bank Publication (1983) building projects tends to account for around 70 per cent of the construction market in both developing as well as developed countries; while civil works takes up the rest. Government usually are the clients for most of the latter and have direct or individual control over a large part of the building demand

2.3 Organisation of a Building Industry

Construction being a service industry must be thoroughly organized to enable the realization of its objectives with minimum effort. It is worthy to note that the industry's success and efficiency largely depend on its organizational structure, a rational or optimal system of task allocation.

The basic purpose of the organization structure is as clarified by Kolawale (1994), as organization(s) that are the natural outcome or mankind's need to co-operate in order to obtain goods and services that would not otherwise be attainable. Organizational structure may also be bureaucratic or associational.

A typical illustration of key sectors in organizational design as stated by Kolawale (1994) is illustrated below.

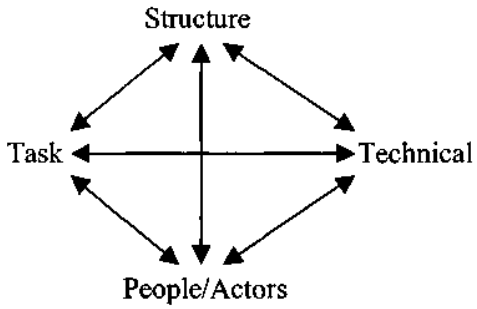


Fig. 1 Key Sectors in Organisational Design

Source: Kolawale (1994)

According to Kolawale (1994) the design of an organization leads to the achievement of desired goals. The healthy interrelatedship between structure, task, people (actors), and technical aspects also leads to efficiency in the construction industry. The success of any organization however depends practically on human participants. In order to achieve that, it is necessary to set up a proper organizational structure, which will facilitate the accomplishment of

objective by people with the minimum unsought consequences or costs. Kolawale (1994) noted that this could be achieved through an organization pyramid (fig.2). Here it can be seen that there is a better co-ordination since any member of the construction organization knows where he is directly responsible.

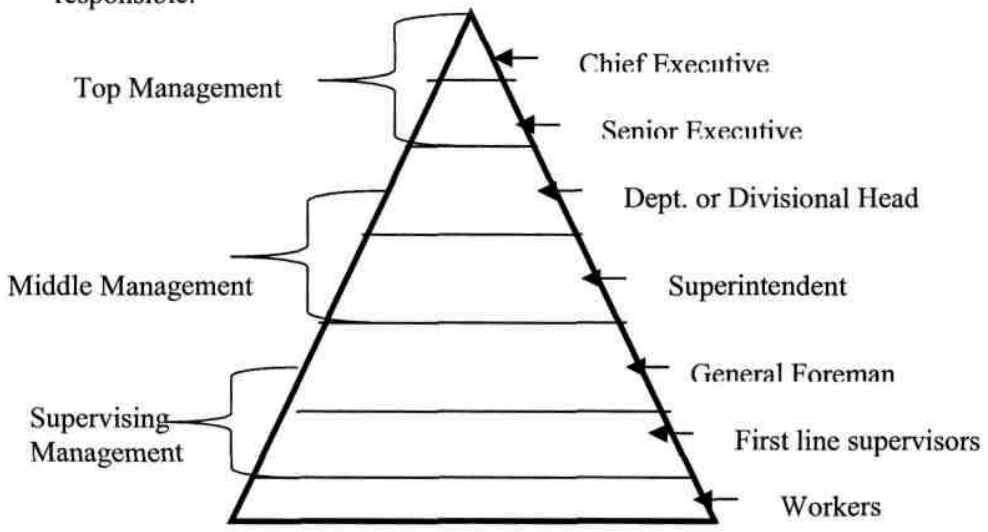


Fig. 2, Organizational Pyramid

Source: Kolawale (1994)

2.3.1 The Structure of a Building Industry

The structure of a building industry is simply defined as the formal organization structure of the firm, as was shown on an organization chart above (fig. 2). Fellows (1983) identified four stages of structural development – integrated, functional, holding company, and multidivisional – which coincided with increasing diversification. These four forms of organization structure adopted in the building industry are explained below: -

(i) **Integrated Organization Structure: -** In this form of structure there is no division of the task of the business into specialised functions, but

many unrelated activities were grouped under a single individual or, in extreme cases, were executed by a single person.

(ii) **Functional Organization Structure**: - In this form of structure the business is subdivided into series of specialized functions, culminating in the office of the chief executive who performed the role of co-ordinator and general manager of all the individual functions.

(iii) **Holding Company**: - This type of structure consist of a system of semi-autonomous subsidiaries or companies, held together only as a corporate legal entity.

(iv) **Multidivisional**: - The structure here is typically composed of a general office, usually divorced from operations, which serviced and monitored the operating divisions. The divisions are based on product, service, geography, or some combination of these.

2.4 Site Operations on Materials Usage

There are a number of activities that takes place on a construction site in relation to materials usage, right from site clearance, to final handing over of the completed project to the client. Among the major activities that take place on the site, include:

(i) **Requisition and ordering of material.** This involves the site supervisors filling a requisition form for ordering the materials that is required to be used at site at a given period of time.

It is the role of the storekeeper to have a complete record of all materials received on site and must be filled in material record book before

delivery notes are sent to the head office. Entries are normally made on the day of delivery.

Materials transfer record is also essential to be used in the store, and this will be used to document materials, which are removed from one site to another for any reason. Its correct use ensures that charges for materials can be made for the receiving project and deducted from the site supplying the goods. In account, the site giving will be credited; the site receiving will be debited.

(ii) **Off-loading and handling of the materials required to be delivered to site.** There are situations where only mechanical means are involved in off-loading materials that are delivered to site such as off-loading sand and crush stones. In many cases, and with regard to most construction firms we have in the country, manual means are applied in off-loading and handling of materials at site, e.g. off-loading of sandcrete blocks, cement, timber, roofing sheets and so on.

(ii) **Storing and protection of materials at site.** This is another important activity that takes place at site. Storage facilities are often provided to keep the materials supplied and off-loaded at site with an arrangement seldom to protect the materials either from misuse or pilferage.

(iv) **Use of materials at site.** By plan, all the materials that are supplied to site are mainly for use at the site for the project, and this involves use of equipment and labour force. As such a lot in terms of planning, organizing, coordinating and controlling on the usage of materials have to be done in order to achieve the maximum utilization of the resources.

CHAPTER THREE

3. WASTE ON CONSTRUCTION SITES

As earlier mentioned, waste on construction site is considerable and the overall loss of materials is about 100 per cent more than is allowed for in estimating and technical accounting conventions. This figure is, of course highly variable and is much lower on some sites. Waste occurs at all stages of materials handling on site; at arrival, during stacking, and when they are moved and in the process of fixing.

On some construction projects, more materials are used than those for which the contractor will receive payment, though usually a considerable waste allowance is included when pricing. The reasons for many of these discrepancies have never been identified, but are commonly known as 'waste' in building. Some materials waste may occur, even under ideal conditions of production, but on many sites the waste of materials is far in excess of what is necessary. Wastes occur in many forms but can be categorized into direct and indirect types (Enshassi, 1996):

3.1 **Direct waste.** The complete loss of materials such as when they are irreparable damaged or just lost from the site. Whilst direct loss can occur at every stage of material handling, the principal loss centers are where materials are stacked and at the place of work.

3.2 **Indirect waste** occur when materials are used either for purposes other than those specified or in excess of measured quantities to meet the dictates of production. It is distinguishable from direct waste because usually the materials are not physically lost. There is, however, a monetary loss and failure to recognize and record indirect waste makes materials accounting meaningless.

According to BRE (1981) indirect waste can be broadly classified into three areas namely:

(i) **Substitution** – when materials are brought onto the site for one use and purposely used for another. In many cases this is when something is damaged and used as functional units in another place e.g., facing bricks in walls, which are to be plastered, or as hardcore. Obviously the initial higher valuation of the material will have been paid rather than the new lower value usage. The cost of waste is at least the difference between the two.

(ii) **Production usage of waste materials:** which are used in excess of the drawings and net measured documents, e.g., due to cutting of blocks or cutting to true lengths of timber joist. This loss is considerable and much of it inevitable. It is essential that more realistic information be given for calculating optimum waste levels. Lack of such information constitute source of error in the present measuring and tendering system.

(iii) **Negligence waste**- Building sites are no less immune from errors than any industry. Excess materials are used due to carelessness in setting out, over-excavating or inaccurate 'reduced' or 'blinding' levels.

3.2 Causes and Effects of Materials Waste on Site

Walkerdine (1993) stated that responsibility for waste concerns all members of the building team. It concerns the general management team as well as site management of a building firm. While any solution to the problem must involve site practice, it also concerns:

(a) Those who design the building

(b) Those who design the machinery and plant used in construction

(c) Those who specify, describe and account for the work

(d) The suppliers of all goods

(e) Those who store, protect and use the material on site or transfer it to another site.

3.2.1 Poor Project Information

Enshassis (1996) observed that considerable waste of resources occurs if the design information available is inadequate or incomplete when construction work begins. Confusion often arises from poor specification and or documentation at the initial stage when materials are being ordered. Part of the effect of this is delay caused while this confusion is being sorted out. The expensive time lost, would have been better devoted, by the buyer, to other facets of material management.

The early and accurate scheduling of materials planned to a time schedule and keyed to the master plans for the site storage of materials is highly desirable. However, according to Enshassi (1996), this is frequently impossible because the original details have a limited value, because either they are not complete at

the commencement of a contract, or there are considerable variations even before the contract starts.

The standard form of documentation used by the industry (clients and the contractors) – represented by traditional bills of quantities is geared to the financial control of a contract rather than to material control. This limitation has resulted in much duplication of scheduling and measurement.

3.2.2 Delivery of Goods on Site

The many forms of delivery complicate the checking of goods arriving at site, due to failure to standardize loads and packages. Checking is made more difficult by failure to deliver materials to specified timings so that checkers and off-loaders can spread their workload over the working day, which would enable them to perform their work more thoroughly.

3.2.3 Transportation and Handling of Materials

When wrongly handled, even well packed materials can be damaged. Different types of handling plant will give varying waste levels and the efficiency of any one type of plant will vary with the skills of the operators. Those who handle materials with specialized equipment require proper training. Walkerdine (1993) observed that too many builders allow unskilled people to use costly mechanical handling plant to move costly materials with the consequence of high wastage.

Handling and transportation around the site can be classified into horizontal or vertical movements, and frequently in both directions at the same time. Handling plant should be matched to this classification as well as to building areas and height, site size and complexity, communicating roads, component sizes and many other factors. This implies a sound understanding, by site management, of factors involved.

3.2.4 Site Stacking and Storage

Inappropriate stacking and insufficient storage capacity on site has been highlighted by Building Research Establishment (1982) as two of the principal reasons for waste. Clients and their advisers are rarely aware of the advantages accruing from the provision of adequate storage facilities. Training of both management and labour in the planning and provision of adequate storage is necessary.

Unfortunately, the varying work load of the industry and its consequential disruptive effect on the materials supply position often creates supply bottlenecks, which make a planned flow of materials to site difficult, if not impossible. Storage has to be related to the sequence of construction to ensure the minimum of movement, handling, and ensure security. Goods of high value are frequently held off-site until the last movement.

One of the most significant aspects of storage is that it is common for goods to arrive on site inadequately packaged for the weight involved because sufficient

instructions about handling, storage and stacking are not provided with the goods or sent in advance to the site.

The appropriate protection and security of different categories of goods during storage and stacking is essential.

3.2.5 Waste at work place

This usually stems from five causes as highlighted by Ibironke (1994):

(i) **Cutting waste** – Losses caused by for example, cutting timber to length, blocks to bond and sheeted materials to irregular shapes. Frequently the design of the building takes little account of the size of materials. Dimensional co-ordination is not being applied yet to an effective scale in practice. This means, particularly in the case of sheeting, that extra cutting waste occurs often solely due to the lack of thought by the designer to the manufactured size of the material.

(ii) **Waste due to the wrong use of material** – When the wrong type or quality of materials is used, waste may arise. The materials may be too good a quality and the contractor bears the loss. If the quality is low, the client will lose and defects may arise later. There is a risk that an alert architect or clerk of works may require that it be replaced by the specified material under the contract, at Contractor's expense without provision for extension of contract time.

(iii) **Misbandling** – Much waste is related to ignorance. Often there is a lack of appreciation of the value of materials by operatives; hence they become careless in handling them. Materials are badly handled and there is over – supply to the work place either when operations are nearing completion or at the end of a working day.

(iv) **Application and residue waste** – Materials such as mortar for blockwork, plaster and paint being spilled or dropped because of their nature. Similarly, paint left over in cans which are not properly resealed or expired due to previous exposure to atmospheric condition. Un-used mortar and plaster left to harden at the end of a working day. Wrong measurement and cutting of materials like reinforcement, timber, PVC pipes etc result in waste.

(v) **Mismanagement waste** – This stems from lack of materials control, wrong decision-making or indecision, and is not related to anything other than poor organisation or lack of supervision. For instance, a failure to decide and work out plan for the storage of material often results in unnecessary double handling and therefore the resulting waste falls under this heading.

3.2.6 Criminal Activities

Site security is often very difficult because of continually changing personnel as one trade succeeds another and as the various specialist sub-contractors arrive at

site to perform their part of the contract. Because of "bad housekeeping' theft often goes unnoticed for a long time, making detection of the thief unlikely.

Pilfering by employees is prevalent on building sites. Not infrequently, however, a weak line of action is taken by management, with theft being condoned because of the possible effects of taking corrective action.

3.2.7 Vandalism

Walkerdine (1993) observed that vandalism is considerable on urban sites, particularly when they are sprawling. Watchmen are often unreliable or ineffective. Uncontrolled guard dogs are no longer legal. Police assistance is virtually impossible to obtain owing to the shortage of police personnel.

3.2.8 Non-delivery

A considerable amount of 'waste' stems from deliberate 'non-delivery' – another form of theft. This is due to a lack of manpower for checking or collusion with site office personnel of the contractor. Thus apart from spot checks it is rare for all the materials arriving at site to be counted or measured accurately, particularly where loads consist of many small components or are delivered in bulk. The result is that even if a site official signs for incoming materials, it is often easy for a lorry driver to deliver a small quantity than (or even to take away part of) total consignment.

3.2.9 Misuse and damage by changeover gang

This arises from lack of both supervision and responsibilities. Goods that are not properly stored or controlled are often used for other than their intended purposes by other trades. Materials already fixed are often not protected so that subsequent tradesman damage them. Tradesmen often unavoidably damage the work of others who have, out of sequence, preceded them.

3.2.10 Incorrect ordering due to variations

Variations can lead to considerable waste in the construction industry. They interfere with the contractor's pre-planning, interrupt the flow of materials and often lead to materials waste because the first order is superseded by new requirement and different orders. Variations may even mean that finished work is wasted but paid for by the client anyway.

3.2.11 Training

Material wastes occur during learning or skill acquisition sessions by trainees before becoming proficient. Although this is unavoidable, proper supervision should be ensured to keep it to a minimum.

3.2.12 Consequent waste

Waste of materials produces additional costs in areas that appear to be unrelated. Apart from the costs of re-ordering replacement materials, delays may cause longer hire time of plant and labour, uneconomic use of plant and labour, and increased costs all down the chain as a result of delays.

Waste must not only be seen as a profligate use of materials or even the labour required to correct or replace; waste also represents the resources used in its original manufacture, delivery to site, finance while it was stored at the various points along the line, and not least inevitable leakage from a finite source of raw materials.

3.2.13 Interference

Walkerdine (1993) further stated that proper handling of materials at site relies, on proper programming. Where wheeled or tracked handling plant is used, free access from place of storage to final destination, including the provision of temporary roads is important. Persons who do not conform to builder's programme of work can disrupt the programme of materials deliveries causing excessive stocks to be held at site, all of which are subject to damage, deterioration, theft or vandalism.

If utility services do not conform to the builder's programme, particularly when laying services outside the building, they can disrupt material delivery and even prevent the horizontal transport of materials and the placing in position of plant for vertical transport.

The builder has a remedy with all sub-contractors in that he has a contractual relationship and can use that to ensure that sub-contractors conform to his programme. Unfortunately no such remedy exists as far as public utility organisations are concerned because there is no contractual relationship. These agencies can disrupt builder's programme with impunity by failing to start and

complete work at required dates and by failing to carry out reinstatement work properly.

3.2.14 Supplier monopoly

Suppliers, including state owned industries who hold a monopoly, or near monopoly can, because of lack of competition, apply conditions of supply that place no obligation on them to deliver materials on time or to make full compensation to the builder where the materials are defective.

3.3 Waste Minimisation and Control

It is generally accepted that the initial selection of materials plays a major part in achieving a satisfactory building. Manufacturers and suppliers go to great lengths to provide commodities, which comply with recognised standards. However, much of their efforts can be eroded if the same importance is not attached to the product when it is transferred and used by the construction team (Johnston 1981).

It has been stated above that waste of materials in the construction industry results from many causes, often outside the building company and beyond the influence of the company. It would be sanguine to expect that control and prevention of waste could, therefore, be exercised by any one discipline within the building industry.

In estimating the quantities of materials required on site, it is usual to provide a standard waste allowance based on the cutting and machining required for the

finish product, with a further allowance included to cover the expense of remedial work, damage during storage, and site pilfering. Johnston (1981), observed that most contractors allow 5% for waste, but BRE report showed an average allowance of 1 to 20% waste. Such allowance of 5% according to him, is generally inadequate.

Building Research Establishment Digest (1982) has defined 'materials control as ideal design, specification and procurement, packaging, transportation, reception, handling, storage and co-ordination, based on knowledge of materials and products, so that waste is minimised while other resources employed in the total construction process are used to maximum effect'.

From the overall definition, materials control can be considered in its components as discussed by Walkerdine (1993) as follows:

3.3.1 Design

The design of the building must have regard not only to the sizes of the components which go into it but also to the optimum handling materials within the building's precincts. The design of the components must have regard to the fact that they have to be durable, easily handled, suitably packed and safeguarded before being built into the work.

3.3.2 Specification and Accounting

Pre-contract documentation should be in precise and practical terms, clearly stating the designer's requirements and giving data describing materials which

can be used by builders without alteration or remeasurement before obtaining the quotations (and later ordering by the contractor).

Tabel 1 below gives an example for the specification of producing a concrete that is often used at site.

Table 1:

Batching of Concrete by Volume

The Quantities of Materials per Cubic Meter of Concrete using Broken Stone, Sand and Ordinary Portland Cement						
Nominal mix by volume Dry materials			Appropriate water cement ratio by weight	Dry sand		
				Coarse aggregate	Sand	Cement
Coarse aggregate	Sand	Cement		M^3	M^3	tonnes
2	1	1	0.35	0.76	0.38	0.552
3	2	1	0.50	0.75	0.50	0.369
4	2	1	0.55	0.88	0.44	0.320
6	3	1	0.75	0.92	0.46	0.227
8	4	1	0.80	0.96	0.48	0.173
10	5	1	0.85	0.90	0.45	0.131

Source: Spence Geddes, (1985)

3.3.3 Procurement and delivery

The programme must give sufficient time for delivery and manufacturing delays and allow for special design and manufacturing requirements. Materials with long delivery dates should have a review procedure to allow for revision to the programme if the dates are not eventually met.

A schedule of timing and contractual responsibility in delivering orders should be agreed with the suppliers. A sub-contractor's schedule should also be produced for their materials to ensure adequate reception (particularly if the subcontractor is not yet on site) and the inter-relationship with storage of other materials.

Principal materials should have their delivery times and methods of packaging related to planned progress on site and means of handling them. The arrival of goods must be supervised so that they are off-loaded carefully and stacked on a good surface where they will not be damaged by passing transport, and are accessible for future movement to the workplace.

Information on the quality and quantity of goods required, the marking defining this quality and the quantities carried by each vehicle when fully loaded must be readily available for use by checkers.

Any damaged materials should be noted when they are off-loaded and the vehicle's driver informed. In the case of sub-standard goods it must be at the discretion of the site manager to accept or reject them but, in either case, an immediate complaint must be made to the supplying company

3.3.4 Storage and internal support

Adequate storage positions must be provided, taking account the possibility of using one position for several materials used at different stages of the project. Double handling should be avoided.

A clear site layout plan showing the places for reception, storage, handling and final delivery of goods to fixing positions must be agreed and deviated from with the site manager's approval. A system of marking goods to show that they are in position has advantages.

The most appropriate type of storage should be provided for materials, depending upon their value. Lock-up bins, other containers, which cannot easily be removed from the site, should be provided for all materials and plant, which are expensive, or the loss of which would cause considerable disruption to building operations.

The advantage of laying roads and hard – standings early to allow their secondary use for stacking materials should be considered. The principal routes for transporting materials from stores and stacking areas on the site should be planned. The routes used for the removal of spoil be used to avoid unnecessary disturbance of reduced levels. And the inevitable mud during wet weather of these access routes on site should be clearly defined.

Materials should be unpacked carefully so that packs do not collapse when packaging is removed or the bands cut. Any damaged materials should be reported at this stage and set aside if possible. Materials to be removed must be carefully loaded on to suitable vehicles which must not be overloaded. Forks of trucks should be adjusted to the appropriate workload. If many bricks are rejected at the stack because of quality, shape, size or colour, it must be reported to the contractor's quantity surveyor as this could be the first stage when rejection of materials is noted.

3.3.5 At the workplace

Supervisor should ensure that only adequate materials are taken to the workplace and that materials are not dropped, spoiled or discarded unnecessarily during the operation. Materials found unsuitable should be immediately reported and, if rejected, the supplier should be informed and a credit obtained.

Only sufficient mortar and plaster required for the day's work should be 'knocked up'. At the end of the working day, tools should be returned to the store; cement bags, which have been opened, should be placed under watertight cover for the night.

When the operation is completed, surplus materials should be removed to the next workplace; this could be done by leaving pallets at suitable places to which a forklift or other vehicles have access. All work must be protected from damage by later trades; particular care should be taken where access is required so that materials are not dropped in a way to cause damage, for example hair crack on asphalt roofs could lead to latent constructional defects. This is one of the principal reasons for consequential waste on this type of roof.

Some cutting waste is inevitable: excess cutting should be brought to the attention of the contractor's quantity surveyor to ensure that an appropriate variation is sought if waste is greater than the assessment based on data printed in tendering documentation.

3.3.6 Security

On most sites security of materials poses the biggest problem to site supervisors. Theft, pilfering, vandalism and other losses adds to the value of materials to be written off as loss or waste. Practical site security, with fencing if necessary, must be arranged. Stout gates should have thief-proof locks and be so fixed that they cannot be easily removed. Fencing should be adequate for the purpose and compounds must be as secure as possible. Means of controlling the movement of people on and off the site should be instituted. The local police should be informed of arrangements and their co-operation sought.

The site manager or the principal staff responsible for materials control should have his office or hut situated at vantage point to have the widest view of the site, particularly the vehicle entry, and ideally in a position where he can look into vehicles entering and leaving the site, thus adding to security and enabling a secondary control over delivery (and removal) of vehicles.

Arrangement must be made to stop-check vehicles arriving and leaving. Goods transferred to another site should be credited and the goods being moved must be checked to ensure that they are of the quality and quantity stated in the documentation. Records should be kept of all transactions.

In constantly being vigilant to the serious problem of waste, a suitable system of materials control should be adopted using specially designed forms to show present stock, deliveries, amounts used and percentage wastage thereby monitoring usage and wastage.

Since waste of materials is everyone's concern, then everyone can contribute to its reduction. Simple and clear rules were adopted by BRE in March 1981 that can be used to tackle the problem. The rules are:

1. **The architect should**
   - (i) Take account of standard manufactured sizes of materials to avoid unnecessary cutting on site.
   - (ii) In pre-contract documentation, specify work in precise and practical terms so that estimators can predict likely waste.
   - (iii) State clearly the materials to be used and acceptable alternatives to facilitate ordering.

2. **The Manufacturer and Supplier should**
   - (i) Design components and materials to be durable, easily handled and suitably packaged for safe transport to and on site.
   - (ii) Supply components and materials to standards, sizes and tolerances specified by the industry.
   - (iii) Arrange deliveries at specified, agreed times.

3. **The independent Quantity Surveyor should**
   - (i) Ensure that the specifications in the tendering documents match the standards of work required and the format used clearly communicates likely waste levels arising from the design.

4. **The Estimator should**
   - (i) Record waste levels used in unit rates so those analogous rates can be negotiated amicably if an issue arises during the settlement of variations.

5. **The Managing Director should**
   - (ii) Ensure that those involved in materials controls are trained and motivated, delegated the necessary responsibility and authority.
   - (iii) Establish procedures within the firm to ensure effective handling of materials and recording of waste levels.

6. **The Buyer should**

(i) Specify precisely the quality of materials, the timing and method of delivery and the method of packaging.

7. **The Site Manager should**

(i) Plan in advance adequate storage space in the correct position to ensure security, safety and protection

(ii) Carry out procedures and delegate responsibility for reception of materials including checking quantity, inspection and documentation

(iii) Provide adequate handling resources to take account of the means of access, and co-ordinate and plan their use

(iv) Lay down procedures for on-site issue of materials and reception by fixers including the necessary transport handling and recovery of unused materials (and the return of packages)

(v) Initiate feed-back to buyer if delivered materials do not meet standard required and to quantity surveyors if design waste is not explicit in tendering document

(vi) Lay down adequate instructions for fixers and handlers for the best current practice and have a control system so that when avoidable waste levels are identified, action can be taken.

8. **The Site Operative should**

(i) Take (ensure proper) care in handling and transporting materials

(ii) Not use materials for purposes other than intended

(iii) Not leave materials laying carelessly around the site.

There are fundamental faults in procedures on construction sites with regard to materials delivery, handling and fixing, which most often lead to waste of materials on site.

CHAPTER FOUR

4. DATA COLLECTION AND ANALYSIS

In the fieldwork emphasis was given on three important materials that are being used in most if not all-building project. These materials as stated in the scope of work include sandcrete blocks, ready-mix concrete and roofing sheet materials.

The fieldwork was conducted to establish factors that generate materials waste on building sites with more emphasis on the selected materials for this study. To this end information was sought as to the actual materials delivered and used on site with the aim of obtaining the data on actual magnitude of waste on these selected materials with a view to compare the allowable percent of waste with the actual as computed from the findings.

For the purpose of the study forty (40) building sites were used for the study in Kaduna and a questionnaire was designed to obtain data that contain the general areas that generated materials waste on site, and the other part of the questionnaire was used to collect data used in measuring the actual works that took place on site physically.

4.1 Investigation and Observations

Data in the study were obtained through physical measurement and observations during site visits. Competent technical people were fully involved in the data collection. Direct observations were made during the execution of the various activities that took place at site particularly on materials delivery to site, handling and fixing.

Records of the materials that were delivered and used at the sites were also taken. The building team members were also engaged in a form of formal/informal discussion so as to get more information that might assist in the study.

4.2 Areas that Generate Waste

From the observation made on site, the data collected from the questionnaire and discussion held with those involved in the execution of work, it was found that most of the areas that generate waste are those discussed in the literature review. But some emphasis has been given on the selected materials for this study namely sandcrete blocks, ready mix concrete and roofing sheet materials, and these items are discussed as follow:

4.2.1 Sandcrete Blocks

Sandcrete blocks are considered for this study considering it's economic importance in the building construction site where it is considered as one of the basic elements that is used to put on the structure, and it is usually applied right from foundation to roofing level. Thus the need to study how the material is being used on site.

All the sandcrete blocks that were used for this study were made from a mixture of ordinary Portland cement and sharp sand, and they are of sizes, 150 x 225 x 450mm and 225 x 225 x 450mm.

The areas found that generate waste from the usage of sandcrete blocks include the following:

(i) Failure to Allocate Storage Areas

Some of the sites visited during the exercise had no proper plan with regard to where the sandcrete blocks are stored. Some were stored very close to the main road, some were even stored where the building was to be sited. Some wastes were therefore observed during the relocation of the blocks to another place – double handling.

(ii) No Materials Handling Policy

Most of the sites have no proper methods of carrying these sandcrete blocks from where they are stored to the place of construction. It was observed that often labourers carry blocks on their heads and hands at the same time. Alternatively, others convey with overloaded wheelbarrow. The methods of conveying blocks are major sources of wastage through spoilage.

(iii) Quality of Sandcrete Blocks

It was observed that waste of blocks on site also resulted when the quality of the sandcrete blocks is below standard, i.e. the materials used in mouldings the blocks is not good or the mix ratio used is poor. Another source of waste observed was, the use of the blocks before maturing in strength.

(iv) Excessive Cutting of Materials

Waste of sandcrete blocks was also observed due to excessive cutting of the blocks and this was basically due to the nature of the design. It was observed

most blocks were damaged when they are to be fixed at areas having many curves

(v) Application of the Material

Waste of sandcrete blocks was also observed when the blocks were used at site by the masons. Some of the masons are not experienced enough especially when it comes to the material at curve areas or fixed above the lintel level.

(vi) Failure to Account for Waste

Most of the wastes observed above were not accounted for in any form. The people involved in using the blocks right from the tradesman to the site supervisors are hardly directed to account for these wastes. In most cases no corrective action was taken.

4.2.2 Ready Mix Concrete

This is another major building material that is highly used on building construction sites. They are basically used in foundation, floors and structural frames. Because of its importance, hardly is there any building that has no concrete element in it. Two types of concrete were used on construction sites, mass or plain concrete and reinforced concrete. Their mix ratios vary, and depend on the design provided by the professionals.

The area covered during the study is the casting of concrete floor slab, and the areas that generates waste during the execution of these works are as follows:

i. **Concrete spilled around the site**

Some amount of concrete often spilled around during the transportation from mixing area to where it is poured due to overloading of either headpan or wheelbarrow. Sometime it is during pouring at the required area the concrete will spill.

ii. **Excessive Concrete mix**

Quite often waste of concrete was observed when the quantity of concrete mixed exceeded the required. The results of this effect is to use the excess concrete where it is not required or the surplus materials often left at workplace when the operation is completed.

4.2.3 Roofing Sheet

Even though this aspect of the building materials is important, hardly much attention is given to it with regard to waste. During the course of the study it was observed that many building projects, especially in urban cities goes for long span roofing sheets as against the normal ordinary roofing zinc or asbestos sheet often used some years ago. The price of these long span roofing sheets is much as seven times the ordinary roofing sheets.

During the exercise the following factor was observed to be the main waste generators on roofing sheets.

i **Cutting waste**

It was observed in most sites that cutting of roofing sheet is really the main source of waste. This is usually due to the design of the building, which hardly takes account of the manufactured size of materials to be used in roofing the building. This problem was observed to be common where ordinary roofing sheets are used, and the type of roof design is the modern design that has many valleys and different height of pitches, all in one roof.

The waste was observed to be minimal where long span roofing sheets are used. This is because the roofing sheets are cut to size based on the physical measurements of the roof structure taken on site.

4.3 Calculations

The data obtained during the field study was evaluated so as to compare the allowable per cent of waste provided in using these materials at the site with the actual percent of waste recorded.

4.3.1 Sandcrete Blocks

The sizes of the sandcrete blocks used are the normal sizes often used in most building construction sites in the State i.e.

225x 225 x 450mm

150 x 225 x 450mm

According to Building Research Establishment Digest (1981), the normal allowable percent of waste for sandcrete blocks is five percent (5%).

To determine the actual percent of waste obtained from the study, a simple arithmetic formula was adopted, i.e.

$$\frac{\sum Bu - \sum Bm}{\sum Bu} x100 = Wa \text{ ----------} Equation\ 1$$

Where $\sum B_u$ = total no. of blocks used during the execution of the work

$\sum B_m$ = total no. of blocks obtained from the area measured after execution of the work

Wa = actual percent of material waste.

B_m = area measured * 10 (ie 10 no. of blocks is required to build a 1sq. m of a wall)

The percent difference between allowable waste to actual is calculated using equations 2

Equation 2

d = (Wal – Wa) * 100 / Wal

Where Wal = allowable waste

Wa = actual waste

The above were used to compute the actual waste for all the sites and arrived at an average actual waste of about 9.37% and a total percent difference of 87.35% above the allowable percent (5%). The detail of the results is shown in Table 2 and Fig. 3.

Table 2:

Details of Sandcret Blocks Usage

Site	No. of blocks delivered to site	No. of blocks used at site	No. of blocks remaining at site	Area covered (m2)	Allowable % of waste	Actual % of waste	% Difference
1	3,800	3,270	530	295.23	5	9.72	94.31
2	4,500	3,526	974	315.73	5	10.46	109.13
3	2,300	1,720	580	157	5	8.72	74.42
4	6,500	4,402	2,098	398.60	5	9.45	89
5	6,000	3,950	2,050	358.07	5	9.35	87
6	6,400	4,395	2,005	398.19	5	9.4	88
7	5,900	4,460	1,440	403.18	5	9.6	92
8	5,600	4,405	1,195	398.87	5	9.45	89
9	6,500	4,570	1,930	412.90	5	9.65	93
10	5,900	3,960	1,940	359.01	5	9.34	86.8
11	5,400	4,655	745	421.60	5	9.43	88.6
12	5,500	4,465	1,035	404.44	5	9.42	88.4
13	6,200	4,500	1,700	407.25	5	9.5	90
14	5,500	4,399	1,101	398.4	5	9.43	88.68
15	3,000	2,363	637	215.5	5	8.8	76.05
16	2,000	1,751	249	160	5	8.62	72.47
17	4,200	3,643	557	328.6	5	9.8	95.99
18	7,000	6,037	963	545.3	5	9.67	93.47
19	7,200	6,961	239	624.36	5	10.31	106.12
20	3,200	2,950	250	267.71	5	9.25	85
21	3,000	2,850	150	258.92	5	9.15	83
22	3,000	2,930	70	266.04	5	9.2	84
23	3,100	2,905	195	263.92	5	9.15	83
24	3,100	3,000	100	271.80	5	9.4	88
25	2,900	2,870	30	260.71	5	9.16	83.2
26	3,000	2,940	60	266.72	5	9.28	85.6
27	3,000	2,900	100	262.89	5	9.35	87
28	6,200	5,700	500	515.85	5	9.5	90
29	7,700	7,350	350	672.89	5	8.45	69
30	6,100	5,830	270	529.36	5	9.2	84
31	3,500	3,260	240	294.05	5	9.8	96
32	3,400	3,250	150	293.31	5	9.75	95
33	3,400	3,200	200	289.02	5	9.68	93.6
34	3,400	3,300	100	297.50	5	9.85	97
35	3,300	3,100	200	282.26	5	8.95	79

Table 2: (Cont.)

Details of Sandcret Blocks Usage

Site	No. of blocks delivered to site	No. of blocks used at site	No. of blocks remaining at site	Area covered (m2)	Allowable % of waste	Actual % of waste	% Difference
36	5,500	4,180	1,320	379.54	5	9.2	84
37	1,320	1,060	260	97.31	5	8.2	64
38	4,000	3,730	270	338.12	5	9.35	87
39	3,200	2,300	900	208.73	5	9.25	85
40	6,500	4,280	2,220	387.55	5	9.45	89
				SUM	200	**374.69**	**3,493.84**
				AVERAGE	5	**9.37**	**87.35**

Source: Field Survey: 1999/2000

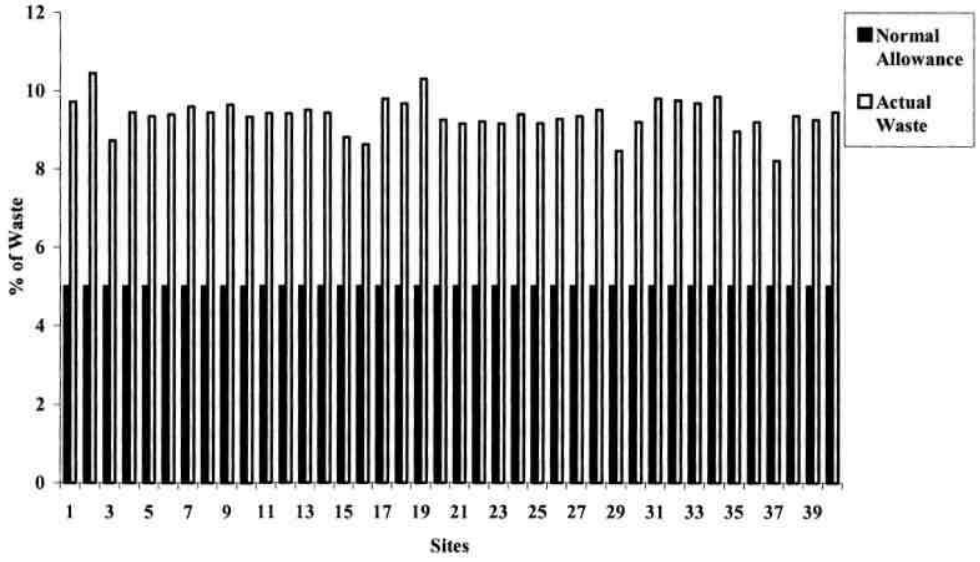


Fig. 3 Comparison between normal allowance and actual waste of sandcrete blocks materials

4.3.2 Ready-Mix Concrete

Table 1 was used as a guide in calculating the quantity of concrete used at site, as there was no available device that can be used for easier measurement better than the one adopted here.

The normal ratios, viz 1: 2: 4, 1: 3: 8 and 1: 4: 8 were considered for this study as those were the most frequently used ratios that were specified in the design of the projects. Based on the practical measurement taken at site, we have a bag of ordinary Portland cement (50kg) = 2 no. the capacity of normal headpan used at site. The standard capacity of wheel barrow used at most sites = 4 times the capacity of normal headpan

The above measurements were considered, because all the construction sites considered for the study were using these facilities in measuring quantities of sand and crush stones as a guide for mixing cement mortar and concrete.

Therefore, to obtain 1 cu m. of ready-mix concrete, using Table (1) above, we have Tables 3 and 4 below that summarizes the materials required of cement, sand and crush stone that was used in producing 1 cu m. of concrete using measure in terms of bags, headpans and wheelbarrows.

Table 3:

Batching of concrete by volume using headpans measure to produce 1 m^3 of concrete

The Quantities of Materials per Cubic Meter of Concrete using Broken Stone, Sand and Ordinary Portland Cement						
Nominal mix by volume Dry materials			Appropriate water cement ratio by weight *	Dry sand		
				Coarse aggregate	Sand	Cement
Coarse aggregate	Sand	Cement		Headpan	Headpan	Bags
4	2	1	0.55	51.20	25.60	6.40
6	3	1	0.75	54.48	27.24	4.54
8	4	1	0.80	55.36	27.68	3.46

Source: Field survey: 1999/2000

* Source: Spence Geddes, (1985)

Table 4:

Batching of Concrete by Volume using Wheelbarrows Measure to Produce 1 M^3 of Concrete

THE QUANTITIES OF MATERIALS PER CUBIC METER OF CONCRETE USING BROKEN STONE, SAND AND ORDINARY PORTLAND CEMENT						
Nominal mix by volume Dry materials			Appropriate water cement ratio by weight *	Dry sand		
				Coarse aggregate	Sand	Cement
Coarse aggregate	Sand	Cement		Wheel barrow	Wheel barrow	Bags
4	2	1	0.55	12.80	6.40	6.40
6	3	1	0.75	13.62	6.81	4.54
8	4	1	0.80	13.84	6.87	3.46

Source: Field survey: 1999/2000

* Source: Spence Geddes, (1985)

According to Building Research Establishment Digest (1981), the normal allowable percent of waste for concrete = 2.5%.

To determine the actual percent of waste obtained from the work, a simple arithmetic formula was adopted, i.e.

$$(\sum Cu - \sum Cm)* 100/\sum Cu = Wa$$

Where $\sum Cu$ = volume of concrete produced from the site

$\sum Cm$ = volume of measured concrete on site

Wa = actual percent of waste concrete

The above equation was used to compute the actual waste obtained for all the sites and an average actual waste of about 6.32% was arrived at, and a total percent difference is 148.43% above the allowable percent 5%. The summary of the results is shown in Table 5 and Fig. 4.

Table 5:
Details of Ready Mix Concrete usage

Site	Volume of ready mixed concrete supplied (m3)	Area covered (m2)	Thickness of concrete floor (m)	Volume of concrete used at site (m3)	Allowable % of waste	Actual % of waste	% difference
1	18.2	169.92	0.1	16.99	2.5	6.65	165.93
2	20.66	191.94	0.1	19.19	2.5	7.12	184.61
3	4.88	46.44	0.1	4.64	2.5	4.92	96.72
4	24	149.5	0.15	22.43	2.5	6.54	161.67

Table 5: (cont.)

Details of Ready Mix Concrete usage

Site	Volume of ready mixed concrete supplied (m3)	Area covered (m2)	Thickness of concrete floor (m)	Volume of concrete used at site (m3)	Allowable % of waste	Actual % of waste	% difference
5	24	149.73	0.15	22.46	2.5	6.42	156.67
6	24	149.68	0.15	22.45	2.5	6.46	158.33
7	24	149.18	0.15	22.38	2.5	6.75	170.00
8	24	150.62	0.15	22.59	2.5	5.88	135.00
9	24	149.23	0.15	22.38	2.5	6.75	170.00
10	24	149.84	0.15	22.48	2.5	6.33	153.33
11	24	150.96	0.15	22.64	2.5	5.67	126.67
12	24	149.79	0.15	22.47	2.5	6.38	155.00
13	24	150.06	0.15	22.51	2.5	6.21	148.33
14	24	149.8	0.15	22.47	2.5	6.38	155.00
15	14.78	136.1	0.1	13.61	2.5	7.92	216.64
16	5.47	51.1	0.1	5.11	2.5	6.58	163.25
17	16	143.3	0.1	14.33	2.5	10.44	317.50
18	37.34	342.19	0.1	34.22	2.5	8.36	234.23
19	28.45	251.89	0.1	25.19	2.5	11.46	358.35
20	12	75.48	0.15	11.32	2.5	5.67	126.67
21	12	75.04	0.15	11.26	2.5	6.17	146.67
22	12	75.56	0.15	11.33	2.5	5.58	123.33
23	12	75.48	0.15	11.32	2.5	5.67	126.67
24	12	74.92	0.15	11.24	2.5	6.33	153.33
25	12	75.49	0.15	11.32	2.5	5.67	126.67
26	12	75.11	0.15	11.27	2.5	6.08	143.33
27	12	75	0.15	11.25	2.5	6.25	150.00
28	17	105.97	0.15	15.9	2.5	6.47	158.82
29	52	209.74	0.23	48.24	2.5	7.23	189.23
30	15	141.68	0.1	14.17	2.5	5.53	121.33
31	12	114.54	0.1	11.45	2.5	4.58	83.33
32	12	113.76	0.1	11.38	2.5	5.17	106.67
33	12	114.38	0.1	11.44	2.5	4.67	86.67
34	12	114.18	0.1	11.42	2.5	4.83	93.33
35	12	114.54	0.1	11.45	2.5	4.58	83.33
36	10	64	0.15	9.6	2.5	4.00	60.00
37	7	28.91	0.23	6.65	2.5	5.00	100.00
38	16	149.6	0.1	14.96	2.5	6.50	160.00
39	*N.C.	N.C.	N.C.	N.C.	0	0	0
40	25	154.67	0.15	23.2	2.5	7.20	188.00
				SUM	97.5	**246.37**	5,788.69
				AVERAGE	2.5	6.32	148.43

Source: Field Survey: 1999/2000

*N.C. means No concrete material was used

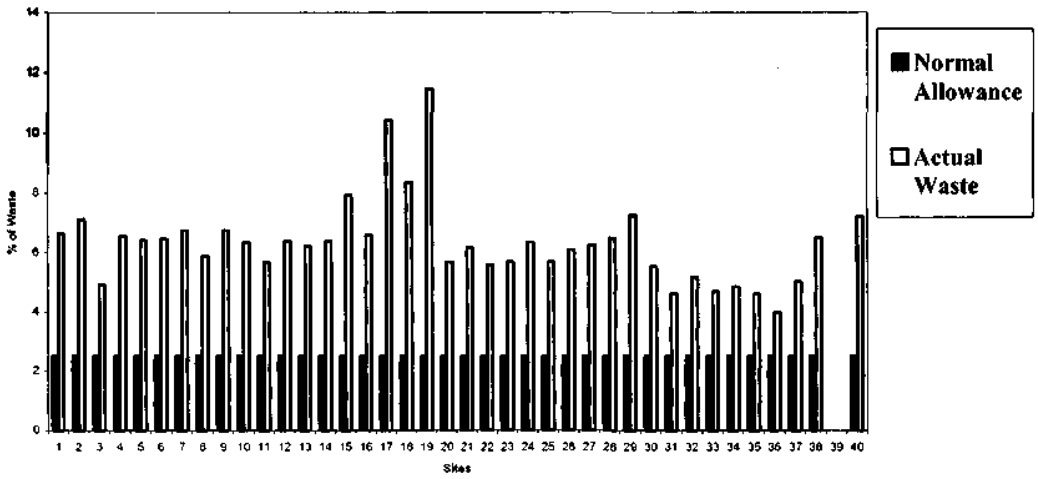


Fig. 4 Comparison between normal allowance and actual waste of ready mixed concrete material

4.3.3 Roofing Sheets

Three different sizes of the roofing sheets were encountered during the field work as follows:

(i) **Ordinary zinc roofing sheets**, which contains 20 sheets in a bundle, and each sheet is 600 x 1800mm in size, therefore a bundle covers an area of

$$A1 = 0.6*1.8*20 = 21.60\text{sq.m}$$

(ii) The second type is also zinc roofing sheet, but with different size. There are 15 sheets in a bundle and each sheet is 600 x 2400mm.

Therefore a bundle covers $A_{ii} = 0.6*2.4*15 = 21.60\text{sq.m}$

(iii) The third type of roofing sheet that was used is long span aluminium roofing sheets, and they were produced on request after taking physical measurement of the roof areas to be covered.

For the actual percent of waste obtained from the exercise, a similar arithmetic formula in equation (1) was adopted, i.e.

$$(\sum Ru - \sum Rm)^* 100/\sum Ru = Wa$$

Where $\sum Ru$ = total no. of roofing sheets used at site (in sq.m)

$\sum Rm$ = total area measured covered by the used roofing sheets

Wa = actual waste.

Difference between allowable and actual waste was calculated using

d = (Wal – Wa) *100/Wal.

The above equations were used to compute the actual waste for all the sites and an average actual waste of about 5.93% was arrived at, while the total percent difference is 18.97% above the allowable percent (5%). The summary of the results is shown in Table 6 and Fig. 5.

Table 6:

Details of the Roofing Sheet usage

Site	Quantity of roofing sheets materials delivered to site (m2)	No. of bundles used at site (m2)	Area covered (m2)	Allowable % of waste	Actual % of waste	% difference
1	212	212	200	5	5.66	13.21
2	220	220	210	5	4.55	9.09
3	86.4	86.4	78.96	5	8.61	72.22
4	222	222	210.21	5	5.31	6.22
5	222	222	210.12	5	5.35	7.03
6	222	222	210.23	5	5.30	6.04

Table 6: (Cont.)

Details of the Roofing Sheet usage

Site	Quantity of roofing sheets materials delivered to site (m2)	No. of bundles used at site (m2)	Area covered (m2)	Allowable % of waste	Actual % of waste	% difference
7	222	222	210.35	5	5.25	4.95
8	222	222	210.1	5	5.36	7.21
9	222	222	210.28	5	5.28	5.59
10	222	222	210.23	5	5.30	6.04
11	222	222	210.15	5	5.34	6.76
12	222	222	210.35	5	5.25	4.95
13	222	222	210.19	5	5.32	6.40
14	222	222	212.34	5	4.35	12.97
15	189	189	180.82	5	4.33	13.44
16	108	87.4	82.66	5	5.42	8.47
17	222	212	197.13	5	7.01	40.28
18	410	341	310.25	5	9.02	80.35
19	367.2	340	325.74	5	4.19	16.12
20	172.8	162	151.39	5	6.55	30.99
21	172.8	162	151.55	5	6.45	29.01
22	172.8	162	151.34	5	6.58	31.60
23	172.8	162	151.88	5	6.25	24.94
24	172.8	162	151.47	5	6.50	30.00
25	172.8	162	151.55	5	6.45	29.01
26	172.8	162	152.04	5	6.15	22.96
27	172.8	162	151.71	5	6.35	27.04
28	237.6	199.2	187.95	5	5.65	12.95
29	*N. R.	N. R.	N. R.	0	0	0
30	129.6	114.95	105.93	5	7.85	56.94
31	151.2	149.5	139.86	5	6.45	28.96
32	151.2	149.5	140.01	5	6.35	26.96
33	151.2	150.2	140.44	5	6.50	29.96
34	151.2	149.5	139.81	5	6.48	29.63
35	151.2	149	139.61	5	6.30	26.04
36	194.4	170	160.4	5	5.65	12.94
37	*N. R.	N. R.	N. R.	0	0	0
38	183.6	168	158.84	5	5.45	9.05
39	165	154.58	146.54	5	5.20	4.02
40	*N. R.	N. R.	N. R.	0	0	0
				SUM	**219.35**	687.09
				AVERAGE	**5.93**	**18.57**

Source: Field Survey: 1999/2000

*N.R. means No roofing sheet material was used

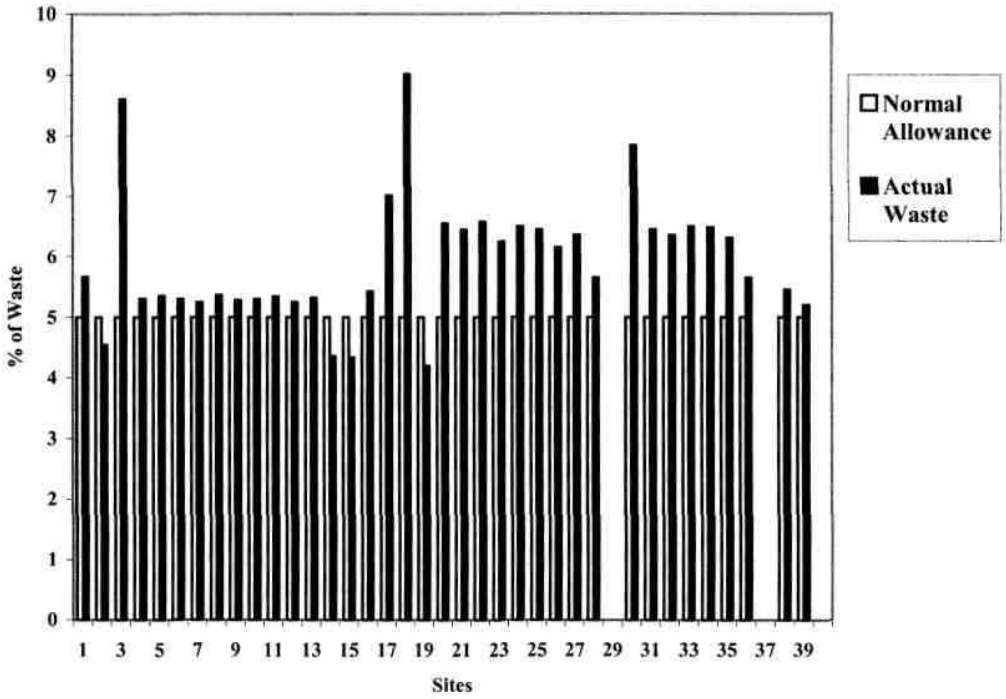


Fig. 5 Comparison between normal allowance and actual waste of roofing sheeet materials

4.4 Results

The results of these calculations from the analysed data as shown in the previous tables and fig. 6, showed that the average actual waste of sandcrete blocks material is 9.37% as against the normal allowance of 5% often made in estimating. While that of ready mix concrete and roofing sheet is 6.32% against 2.5% and 5.93% against 5% respectively.

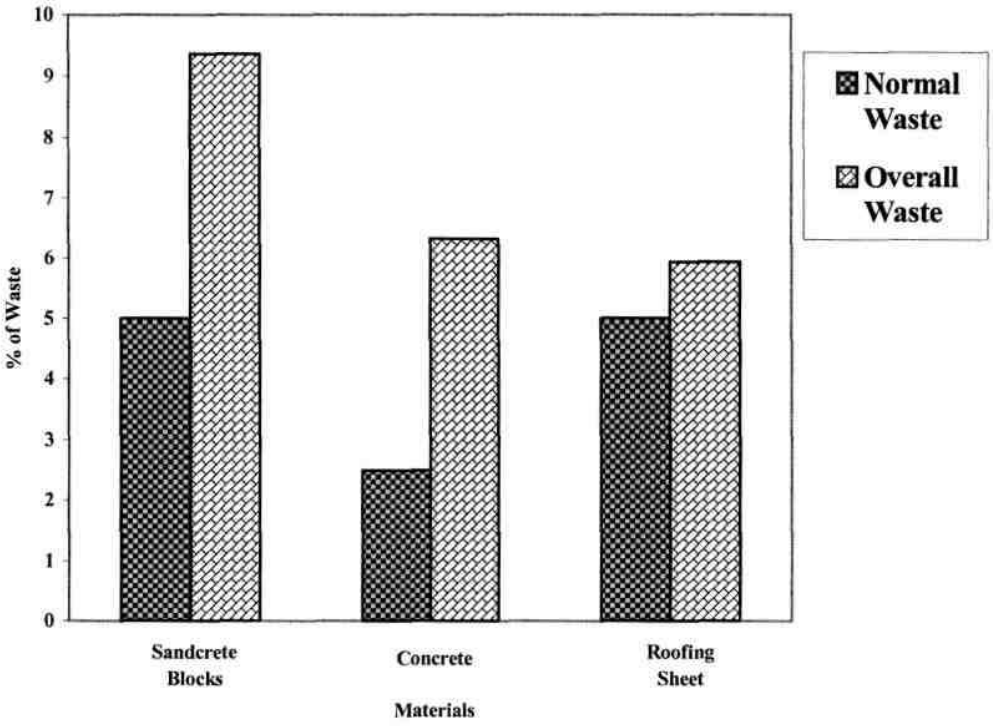


Fig. 6 Comparison between overall waste and normal allowance for selected materials

CHAPTER FIVE

5. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

From the results obtained from the case studies discussed in this write-up, it can be concluded that waste of materials results from many causes. It will be sanguine to expect that control of these wastes could, therefore, be exercised by anyone within the building construction sites.

5.1 Findings

Most of the construction firms covered by this study could be said to belong to small and medium-sized categories. Below are the findings of the survey conducted through the use of questionnaires, and personal interviews:

1 Majority of the firms do not regard materials schedule and effective stock control as ways of reducing materials wastage on sites. And since material alone has been said to cover more than half of the contract sum, any effort spent in reducing material wastage on site will eventually go along way in reducing the total cost of construction work, and increase the profit accumulation of the construction firm.

2 Many firms had adequate site storage capacity for keeping cement, working tools and so on, with a store-keeper in most cases, therefore there were not much problems of materials shortage resulting from site storage. Major storage problems observed was on storing of blocks and aggregates that in most cases comes in bulk.

3 Some of the sites visited during the exercise had no proper plan with regard to where the sandcrete blocks are stored. Some were stored very close to the main road, some were even stored where the building was to be sited. Some wastes were therefore observed during the relocation of the blocks to another place – double handling.

4 Most of the sites have no proper methods of carrying sandcrete blocks from where they are stored to the place of construction. It was observed that often labourers carry blocks on their heads and hands at the same time. Alternatively, others convey with overloaded wheelbarrow. The methods of conveying blocks are major sources of wastage through spoilage.

5 It was observed that waste of blocks on site also resulted when the quality of the sandcrete blocks is below standard, i.e. the materials used in mouldings the blocks is not good or the mix ratio used is poor. Another source of waste observed was, the use of the blocks before maturing in strength.

6 Waste of sandcrete blocks was also observed due to excessive cutting of the blocks and this was basically due to the nature of the design. It was observed that most blocks were damaged when they are to be fixed at areas having many curves

7 Waste of sandcrete blocks was also observed when the blocks were used at site by the masons. Some of the masons are not experienced enough especially when it comes to the material at curve areas or fixed above the lintel level.

8 Most of the wastes observed above were not accounted for in any form. The people involved in using the blocks right from the tradesman to the site supervisors are hardly directed to account for these wastes. In most cases no corrective action was taken.

9 Concrete spilled around the site: - Some amount of concrete often spilled around during the transportation from mixing area to where it is poured due to overloading of either headpan or wheelbarrow. Sometime it is during pouring at the required area that the concrete spills.

10 Excessive Concrete mix: - Quite often waste of concrete was observed when the quantity of concrete mixed exceeded the required. The results of this effect is to use the excess concrete where it is not required or the surplus materials often left at workplace when the operation is completed.

11 Cutting waste:- It was observed in most sites that cutting of sheet materials is really the main source of waste. This is usually caused from the design of the building, which hardly takes account of the manufactured size of materials to be used in roofing the building. This problem was observed to be often where ordinary roofing sheets are used, and the type of roof design is the modern design that has many valleys and different height of pitches, all in one roof.

Most of the construction sites have one way or another by which they adopt in minimizing the material waste in their sites, but still the amount of waste being experience, particularly from the study of these building materials is far more than the normal allowance provided.

From the results obtained, the average actual waste calculated for the sandcrete blocks (9.37%) is almost 100 percent more than the allowable waste (5%) often provided in estimation, while that of concrete (6.32%) is more than 100% of the normal allowance (2.5%). The average actual waste of the roofing sheet

(5.93%) is within the normal allowance of 5% often made for the purpose of estimation.

Therefore, this is a major problem and it does not apply to our construction sites only. From similar exercise conducted by BRE in March 1981 in UK and another exercise carried out by Enshasis (1995) at Gaza Strip, revealed similar findings obtained from this research. They also found that the overall loss of principal materials is about 100 per cent more than what is usually allowed for in estimating and technical conventions.

5.2 Conclusions

Generally, problems observed at the site that generate material waste on the building construction sites were mainly due to the following.

(i) Organizational problem

This is with regard to the type of supervision, inadequate knowledge, volume of materials needed on site, poor storage, fixing etc. And the problem encountered from these include poor specification, poor handling and fixing resulting in waste, and total lack of awareness on waste.

(ii) Site Requirement

The problems of materials handling and waste avoidance with respect to site requirements fall into the following categories:

(a) Proper site layout and provision of adequate access roads to the **site**

(b) Ground condition that is untarred and muddy road often make it difficult to move and store materials on site, these often result to breakages or damage along the route.

(iii) Nature of Material

The movement techniques to be employed, the distance to be moved and the type of site storage of materials would have to reflect their physical

nature, that is, size, volume, length etc, to avoid excessive material handling on site and waste.

(iv) **Nature of Job**

The size and nature of job also determine to a large extent the volume of material handling and waste encountered.

5.3 Recommendations

Based on the findings of this research work, the following are hereby recommended for effective material waste control on building construction sites with the aim of saving clients time and maximising the contractor's profit:

(i) Workers should be made aware of the cost of materials and the significance of every bit of waste in materials to the project. This could be effected by frequent reminder or by placing 'warning boards' at strategic positions.

(ii) Workers should be commended and encouraged for handwork and good handling of materials by giving them incentives. Workers can also be penalised for poor material handling and acts of laziness.

(iii) Construction firms should embark on research studies into how materials handling methods could be improved and how waste on site could be reduced to a minimum level.

(iv) Construction firms should as much as possible purchase construction materials from factories.

(v) Material control should start at the design stage. Designers of buildings should consider their clients' real needs and resources and ensure that they are correctly briefed. Every attempt should be made to avoid variations, at later stage. The design should allow for the effective handling and convenient manoeuvring of materials and components of preferred sizes during construction and subsequent maintenance within the confines of site and buildings.

(vi) Building design should take account of the size of the units of the materials and the components to the used in order to minimize cutting.

Accurate scheduling of materials to programmed delivery dates, which are keyed to actual site layout and storage arrangement is recommended.

(vii) Procurement must specify quality, quantity and the timing of deliveries of materials precisely.

(viii) Effective planning programme should be prepared, allowing sufficient time for manufacture and delivery of all materials including purpose-made components, especially those covered by the prime cost and other provisional sums.

(ix) On the construction site, management must establish procedures for the reception of goods, plan in advance adequate storage space and provide adequate handling resources and methods, taking into account a variety of factors including means of access. Effective procedures should be developed for the receipt and issue of materials within the site. Such procedures should give adequate instructions to fixers, handlers and other regarding the most effective practices relating to these respective tasks.

REFERENCES

Building Research Establishment Digest (1981). *Waste of Building Materials*, Chartered Institute of Building, Wartford. pp.1-8

Building Research Establishment Digest (1982). *Materials Control to Avoid Waste*, Chartered Institute of Building. Wartford. pp. 1-4

Enshasis, A (1996). *Materials Control and Waste on Building Sites*, Islamic University of Gaza, Israel. Building Research and Information journal, volume 24: pp. 31-34

Fellows, R. F. (1983). *Construction Management In Practice*, First Edition, Burnt Mill, Harlow, England. pp. 26-27

Geddes, S. (1985). *Estimating for Building and Civil Engineering Works*, Eight Edition, Butterworth, London. pp. 150-169

Ibironke, O. T. (1994). The Impact of Waste Control on Contractor's Profit, *Builders Magazine Marina*, Lagos, Nigeria pp. 10-13

Kolawale, J. O. (1994). A Complete Indigenous Domination of the Building Industry in Nigeria, A Vision or an Illusion? *Builders Magazine Marina*, Lagos, Nigeria pp. 11-12

Ngoka, N. I. (1987). *Project Management and Cost Control*, Dunert Publishers and Media Co. Ltd., Nigeria pp. 63 - 95

Tahula, E. M. (1982). Materials Handling and Waste on Construction Sites. Unpublished B Sc. Project, Department of Building Ahmadu Bello University, Zaria, Nigeria pp. 1

Walkerdine, J. (1993). *Materials Control and Waste in Building*, Institute of Building. Englemere, Kings Ride, Ascot, Berkshire. pp. 3-12

World Bank Publication ((1984): The Construction Industry, Issues And Strategies In Developing Countries., Washington, D. C., U. S. A. pp. 3-35

BIBLIOGRAPHY

Illingworth, J.R (1974). Materials Handling, Projected Developments, Building Technology & Management, *Journal of the Institute of Building* Vol. 12 No. 12, PP. 8-17

Skoyles, E.R. (1974). Material Waste on Building Waste on Building Sites. Municipal Building Management, *Journal of the Institute of Municipal Building Management,* 57 Marine Drive, Colwyn Bay, Denbighshire, Vo. 3, pp. 19-26

APPENDIX 1

QUESTIONNAIRE "A"

This questionnaire is on the assessment of "Evaluating Material Application Waste on Building Construction – A case study of Kaduna State". It is purely an academic exercise. Kindly fill in the following:

Q1 Details of construction firm:

(a) Name of firm:.....

(b) Rank of reporting officer:.....

(c) Nature/type of construction firm:.....

(d) Types of work executed by the firm:.....

(e) Maximum cost of a single project handled by the firm at a time:

(i) N1M (ii) 5M (iii) 10M (iv) N50M and above

Q2 (i) Kindly state below sources of materials waste generated on your construction site:

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(i) Could you please state below why these waste occur at your site:

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(ii) What measures do you usually adopt to minimise such wastes

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(iv) How often do you quantity the magnitude of these wastes

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(v) Please could you state below any other means apart from those mentioned in item (iii) above that could be used to minimise materials waste generally on building construction sites:

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(vi) Other relevant information that could assist in the research work will be highly appreciated.

QUESTIONNAIRE "B"

This questionnaire is on the assessment of "Evaluating Material Application Waste on Building Construction – A case study of Kaduna State". It is designed to obtain some raw data on the activities that took place in the building construction site. The data would be restricted to this research work only. Thank you.

Kindly fill below the information that relates to the activities going on at your site:

No. of blocks delivered to site	No. of blocks used at site	No. of blocks remaining at site	Area covered (m^2)	Remarks

Volume of ready mixed concrete supplied (m^3)	Area covered (m^2)	Thickness of concrete floor (m)	Volume of concrete used at site (m^3)	Remarks

Quantity of roofing sheets materials delivered to site (m2)	No. of bundles used at site (m^2)	Area covered (m^2)	Remarks

If you have any additional information relevant to this study, you may kindly, write it at the back of this questionnaire. Thank you for your anticipated co-operation.

Abubakar Darda'u Abdul'Azeez