MATERIAL WASTAGE AND ITS CONTROL IN BUILDING.

Thesis Submitted by:

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TO MY FAMILY FOR THEIR MORAL SUPPORT.

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PREFACE.

Five years prior to the present course of study, I worked as a clerk of works on a number of building sites in Nigeria. Over these years, I noticed with concern the amount of materials being wasted on the building sites. It has neither been possible to qualify the extent of this waste with any accuracy, nor have I been able to suggest any practical ways of reducing such waste which would be accpetable to both my employer and other parties to the contracts.

It has always, therefore, been my interest and intention to have an opportunity, such as this, to research into this aspect of building site economics. "Sufficient building materials are lost annually on site to build 10% more housing units. Not all the losses are avoidable but if only part of these losses could be saved, the gain to the national economy would be substantial".*

Viewed in this light, this research I anticipate, will be of particular value to my employers and to my country - Nigeria, which needs a great deal of development, especially in the field of building and construction.

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* Extract from a paper titled "The Avoidance of Waste", presented to the Chartered Institute of Building Seminar by E.R. Skoyles in Sept. 1976.

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CHAPTER 1.

INTRODUCTION, AIMS AND OBJECTIVES.

INTRODUCTION.

Materials control and avoidance of waste on building sites, is generally recognised to present particular problems due to the nature of the construction process and the involvement of varieties of participants.

The significance of waste until recently was not generally known because of the insensitivity of the accounting methods used for its recording and valuation by the building companies. It is now however, recognised that waste on construction sites is considerable and that materials delivered to construction sites are not wholly used for the purpose for which they were intended. Considerable quantity of these materials are either destroyed or lost during the construction process. It is also recognised in some cases that more materials are used in the construction than those the contractor will receive payment despite the application of normal wastage allowances in estimating procedures. Though the reasons for these differences are difficult to identify, they all are known collectively as "waste".

In its broadest context, waste may be regarded as the general squandering of resources and can be classified into two main categories: avoidable and unavoidable waste. Unavoidable waste is inevitable even under ideal conditions of design and production. This waste arises from factors outside the contractors' control and usually occurs where manufacturers' or suppliers' materials or component sizes do not match the designer's requirements. Examples of this are seen mostly in timbers and reinforcing bars, where the exact lengths or sizes required are not found readily available.

Whilst unavoidable material waste is largely outside the contractors' control avoidable waste falls within his control. Avoidable waste may arise from

mis-use or non-use of materials and components. The causes and control of these waste is our main concern and will be discussed in details in the later chapters.

To many contractors today, material wastage is a problem accepted and vaguely understood by them but rarely controlled. The reasons for these seem to be the inadequate consideration given to this problem. Obviously, material control methods will involve such things as extra supervision, elaborate storage compounds and huts, detailed planning and scheduling of materials. All these will cost money to the contractor, consequently they are quickly overlooked. Secondly, there is lack of sufficient information regarding material wastage from which data is collected. Thirdly, it is usually difficult to distinguish the avoidable from unavoidable waste.

All these factors have discouraging effects on the building industry in giving serious thought to this problem. Moreover it is the conception of majority of people involved in the industry that material control systems are comparatively uneconomical as extra time and money may be required for efficient material control.

Studies have however shown a contrary view. From studies carried out by the Building Research Establishment in 1976 show that material cost represents 50 - 60% of the overall cost of most projects in England and out of this, losses caused by material wastage and lack of proper control systems, account for 5 - 10%. This rate of waste was further confirmed by my recent survey (personal interviews and response to questionnaires) in Ireland.

Furthermore, the significance of waste in the building industry is clearly illustrated by the report published by the Building Research Establishment between 1974 and 1976. A research carried out by the Establishment of 190

traditional building projects, indicated that waste in the industry on site in capital works was accounting for £300 million in a nominal year. Taking into account the rate of inflation of say 10% since 1976, this would amount to about £780 million in 1985.

In addition to waste on new building sites, there are also wastes on maintenance and rehabilitation works to be considered. This figure, if related to the amount of waste each year on building sites in a particular country, will clearly show that wastage of materials is a significant problem worth tackling.

Aims and Objectives:

The author's objectives of this study is to investigate into the causes and extent of material wastage in the building industry with greater emphasis on site management of materials to provide a better understanding of the subject matter.

In my approach to this problem, I therefore intend to evaluate the extent and the causes from four principal points of view: that of the designer, the building organisation, the suppliers and the sub-contractors. The field research work carried out will be analysed with the view to establishing some facts on the general principles of material wastage presently prevailing on building sites in Ireland.

As a construction economist, it is my interest to exploit the possible ways of measuring waste as works progress, and to examine the effect of wastage on tendering.

Finally, it is intended to indicate how the problem of wastage may be reduced by adoption of acceptable and practical material control systems.

C H A P T E R 2.

"TYPES OF WASTE ENCOUNTERED IN THE INDUSTRY. "

2.1. Extent of Waste

2.2 Types and Classifications of Waste.

2.3 Summary.

TYPES OF WASTE ENCOUNTERED IN THE INDUSTRY.

2.1 Extent of Waste:

The extent of waste is vast. Waste occurs throughout the construction industry irrespective of the size of a building organisation, the value and duration of a contract or the type of building involved. They occur through the construction process, through the participants and construction activities. The occurrence of waste is not peculiar to new buildings, waste also occurs in maintenance and refurbishing works.

In its widest context, waste may be regarded as a general squandering or extravagant use of resources. Waste therefore does not only involve material but all other factors of production, such as labour, plant, time and money.

Waste problems in the building industry can be seen to take many forms covering the misuse or non-use of human and material resources, excessive time wasting in administrative procedures and extra cost of labour arising as a result of indirectly connected events, e.g. variations due to delay.

From the research it is found that there are little published information on material wastage on building sites but there is sufficient indication of its significance on all sites visited.

As mentioned earlier in my introduction, some wastes are inevitable even under ideal conditions of design and production. But excessive waste is found particularly in building process which never receive proper consideration

by most contractors. Waste is not just a site problem. In fact inadequate brief by the client at the planning stage of the project can lead to over-provision and to countless variations or unfulfilled needs. All these waste the money of the client and sometimes that of the contractor. When work starts, the waste is clearly seen in form of physical loss of material or damage but it can also take the form of inefficient use of resources by the contractor and his sub-contractors.

Waste does not stop at the completion of the building. It continues to occur throughout the life cycle of the building in such things as inadequate insulation and excessive energy consumption. It can therefore be seen that waste is not just loss of money or physical waste of material but it is a wearing away of the standards required by a society. For example, if the building fails, after its completion, to satisfy the requirements for which it was originally constructed, then loss is derived due to its incapability to perform its functions to the required standard.

Waste is not just a site responsibility, its cause concerns all members of the building team. It is however, generally noticed that a greater percentage of waste occurs on the site. This is due to lack of sufficient time spent by the site supervisors on activities concerned with material control and prevention of waste. From the recent research conducted, it was found that less than 1/5th of the normal working time of the site supervisors is spent on material control. Another contributory factor is the mindless attitude of the operatives in carrying out building operations.

Material wastage on the site cannot always however, be avoided by those in the operations. Waste may be caused by the nature of the site, the design priorities, the form of contract used, the various terms and contract conditions, the priorities of manufacturers and suppliers.

For a better understanding of the causes and control of material waste, the responsible factors are dealt with in greater details in Chapter 3, but the types and general classification of waste are outlined below.

2.2. Types and Classifications of Waste:

Classified under two principal headings of direct and indirect waste, waste covers several forms of loss. In the earlier discussion, waste was broadly grouped into avoidable and unavoidable. However, in order to understand the detailed measure of waste, further classification is given below.

1. Direct Waste:

Direct waste is defined as the loss of those materials which are physically damaged and cannot be repaired and consequently used or which are lost during the building process. This type of waste is avoidable and is further classified as follows:

(a) Transport and delivery waste.

This covers all damages caused during loading and losses in transit to site or from the site in case of transfers from one contractor's site to another, unloading and placing into the initial storage.

(b) Site Storage and Internal Transit Waste:

This waste arises from bad stacking and initial storage, transporting around the site to stack at the work place or placing into position.

(c) Conversion Waste:

Losses arising due to cutting uneconomical shapes e.g. timbers, reinforcement bars.

(d) Fixing Waste:

These are materials dropped, spoiled or rejected during the fixing operations.

(e) Cutting Waste:

Losses caused by, for example cutting timber to length, brick to bond

and sheeted materials to irregular shapes.

(f) Application and Residue Waste:

Materials such as mortar for brickwork, plaster and paint being spilled or dropped because of their nature or due to say paint in cans left which are not re-sealed. Mixed mortar and plaster left to harden at the end of a working day.

(g) Waste caused by Other Trades:

Losses due to borrowing by trades for other purposes other than the work and not returning the plan or material. Also due to damages caused by the succeeding trades e.g. a painter spilling paint on glass windows fixed by the glazer needing extra cleaning.

(h) Criminal Waste:

This covers pilfering, theft from sites and also vandalism.

(i) Waste due to the Wrong Use:

When the wrong type or quality of materials are used waste may arise. The material may be too good a quality and the contractor bears the loss. If the quality of material is low, the client will lose. An alert architect or clerk of works may require the material to be replaced by the specified material under the contract.

(j) Waste stemming from Material Wrongly Specified:

Waste due to errors in the bills of quantities. The contractor is compensated by variation orders but the client bears the financial loss.

(k) Waste due to Uneconomic Use of Plant:

This covers plant left running and not in use and plant not employed to its optimum use. e.g. a concrete mixer left running during a tea break.

(l) Management Waste:

This covers waste which stems from wrong decision making or indecision and is related to poor organisation and lack of supervision e.g. failure of management to decide and work out plan for storage of material until material are delivered to the site.

2. Indirect Waste:

Indirect waste is that type of waste which normally only represents a monetary loss and usually materials are not physically lost. Such losses arise principally from three sources:- substitution of material, use of material in excess of quantities allowable under the contract and from errors.

(a) Substitution Waste:

This is not a form of waste causing direct losses, it causes a monetary loss because the materials are used for a different purpose from that specified. Thus ready-mixed concrete delivered to a high strength specification may be used in place of a weaker mix; facing bricks in place of common bricks or partition blocks.

(b) Production Waste:

It occurs when some of the materials are used for which the contractor does not receive any payment due to the fact that the basis of measurement does not allow fully for the effects of the size of plant , for example, extra concrete may be required in a trench because the designer's specified width does not coincide with any size of bucket available for the mechanical plant.

(c) Negligence Waste:

This occurs when more material is used than is specified e.g. due to over-digging of trenches resulting in more use of concrete in foundations; or due to poor workmanship.

2.3. Summary:

The scope of waste in the industry is vast in nature. Waste occurs from the inception of a building to its completion and also during its maintenance Waste in general terms embraces not only material waste but all other factors of production - labour, plant, time and money.

Material wastage, though not only a site problem, most of the avoidable waste occurs on the building site. The control of avoidable waste is therefore within the control of the building companies.

Unavoidable waste occurs even under perfect conditions of design and production and therefore falls outside the control of both the designer and the contractor.

Material wastage is of various types. For clarity and ease of measurement, they are frequently classified into various forms to identify their sources of occurrence. For example, 'cutting waste' which indicates that waste of this type is cuased by cutting, say timber, or bricks etc.

CHAPTER 3.

"FACTORS INFLUENCING MATERIAL WASTAGE AND ITS CONTROL".

Section 1: Design and Contract Planning

Section 2: General Management.

Section 3: Site Management.

SECTION 1.

3.1: DESIGN & CONTRACT PLANNING.

3.1.1. Design

3.1.2. Contract Planning.

3.1.1. Design:

To minimise waste and to effect economies, the design of building should be oriented to the building process. The design and ease of construction should be closely inter-related. But in the building industry, this seldom occurs because of the gap that exists between the design and the construction process. The design is usually isolated from construction process on the site. It often happens that even when the designer and the builder work in the same firm, a balance does not always result due to the different training and attitude of the two disciplines.

When the design information is inadequate or incomplete before the construction work starts, a considerable waste of resources could be incurred. This is a common situation which happens frequently in the construction industry.

The reduction of waste is one aspect of design that receives inadequate consideration by the architect and other members of the design team. A number of systems in designer/contractor relationships are now however used which create an awareness of the waste problem and induce positive thinking to develop methods of reducing its incidence. Some of these systems include:-

(a) *Industrialised Building Systems:*

This is mainly used by the Local Authorities to benefit from economies of scale for materials and components. Incidence of waste is generally less in industrialised buildings than it is in traditional buildings.

(b) Negotiated Contracts:

In this form of contract arrangement, the contractor is invited to negotiate on the contract sum. In so doing discussions on methods of construction are also discussed which may produce savings in time, labour and material.

(c) Design and Building System:

In this system, the developer or contractor can engage his own design team in producing the necessary drawings. Being both the designer and the builder, it is generally the interest of the contractor to alleviate or reduce waste.

Majority of contracts are still under the open or competitive tendering system in which the design is normally completed before a contractor is selected. The designer's interest in this situation is to design to the requirements of his client. In other words, the design team is interested in saving their client's money. Consequently, the design team is usually unwilling to commit itself to a more elaborate or comprehensive scheme for fear that the cost limit for the project may be exceeded.

Designers of building should consider their client's real needs and resources and ensure that they are correctly briefed. Every attempt should be made to avoid occurrence of variations at a later stage of the construction.

The designer can limit the incidence of waste by looking carefully into the type of material and component that he is specifying bearing in mind the amount of on-site labour content required.

Some ways in which the designer can influence the incidence of waste are set out below:-

1. Rationalisation of Materials and Components:

This method limits waste in labour, time and money in manufacturing process and fabrication of materials. It streamlines the use of materials and brings about the logical standardisation of sizes, so that interchange of say, timber windows into openings initially meant for metal windows, will not involve any alteration to the size of the openings.

2. Dimensional Co-Ordination:

It is a system using modular sizes for basic spaces provided into which components or elements will just fit, say 300mm,100mm, etc. Operations should be designed for materials used, using standard sizes and avoiding cutting where possible. The use of this system is slow. The designers do not want to specify these modular sizes because of the high price for short run-off and on the other hand, the manufacturers will not make these components until the market is available for such components.

3. Manufacturing to Design Tolerances:

The designer, in this system can state his fixing and joint tolerances that the manufacturing tolerances will meet. It will reduce the amount of on-site work in cutting and adapting of materials. For example, if timber joist are ordered to exact length plus bearing, then no further work will be required in cutting, thus reducing waste.

4. Package Materials:

It is common now to specify doors in sets. Other materials and components are kitchen fittings. They allow for easier site handling and trahsportation, consequently reducing incidence of damage. Greater care and protection of these units is however essential.

Avoidance of waste of all kinds should even be in the mind of designers from inception of the building through to the end of its life. Design should allow for the effective handling of materials and components during construction

and the subsequent maintenance period.

The ultimate aim of the designer should be directed towards achieving a balance between economic production, aesthetic and functional design.

3.1.2 Contract Planning.

Planning is an essential process of material control. In fact, for an efficient management of any contract, planning is an essential element. With good planning, incidence of material wastage will greatly be reduced. Inability to foresee the operating difficulties and to plan the company's activities accordingly is a primary factor for loss of resources on the building site. For example, insufficient planning for material delivery may result in earlier delivery of some materials leading to a long period of storage. Consequently, danger of damage, deterioration, and theft is increased. Furthermore, the materials may be stored in unsuitable places on the site involving later shifting to appropriate places. All these undoubtedly result in losses and wastes.

A plan may take a form of either graphs, charts, data sheets, diagrams, written words or oral. In any form of planning, the first consideration should be given to the desired objectives. The essence of a plan is that it should show the logical and practical ways of achieving its objectives. To this end, planning should be comprehensive, and should present a picture of the whole project by means of these effective communication forms (graphs, charts, etc).

The plan should be based on facts built up from known information i.e.

(i) materials and its quantity obtained from the bills of quantities.

(ii) length of time for labour to work on it - arrived at from work study records.

(iii) method of construction - from experience.

Three stages of planning would be necessary to produce a comprehensive build up of the requirements. Firstly, the pre-tender programme which concentrates on the labour content of the items of work to determine the time scale of the activities. Delivery times of materials of major importance and their availability are also determined at this stage.

Secondly, overall programme is prepared to ensure the correct use of all resources - men , machines and materials. This sets out in a practical and orderly sequence all of the operations necessary to complete the whole project. Inter-relationship of all events must be shown with clarity. Such careful phasing and sequencing of operations is necessary in order to avoid waste. One example of bad sequencing is where say, plasterowrk is completed before the wall chasing for electrical conduits has been started. This results in not only extra labour cutting through the plaster but also in bringing back plasterers to the site, mixing plaster and other works requiring labour.

These long-term planning involves such details as material schedule, plant and labour schedule and resources integration. Resources integration if well planned helps to ensure that a right activity is executed using the available resources with optimum efficiency.

Thirdly, short-term planning techniques are required. These are used to translate the overall programme into action. The short-term planning, generally of four to five weeks duration, can state the exact quantity of material to be used with its location pinpointed. It is therefore most used

by the site manager to indicate the quantity of materials required where and when it will be delivered. These programmes are generally used as short-term or long-term guides to indicate to the supervisors the relative cost importance of the various materials.

*In order to achieve waste reduction economically and derive maximum benefit from the resources employed, it is essential to deploy superiviion selectively. Timing and location of effort are critical, and the following factors are important in planning:-

(a) A knowledge of the proportion of the total cost of avoidable wastage which can be expected at each stage in the progress of a material from delivery to incorporation in the building.

Data for this purpose can be obtained by sampling during the progress of other projects carried out under similar conditions.

(b) The locations of those operations in the project where deployment of supervision will be most profitable. Recent case studies showed that percentage avoidable wastage during substructure work was at least twice similar work carried out on superstructures, and studies of concrete operations in substructures showed that avoidable inaccuracy in excavation accounted for over half the avoidable wastage of concrete.

(c) The influence of previous operations. Examples of this include inaccurate setting out, inaccurate or insecure fixing of formwork and incomplete filling or temporary works.

This is particularly evident in the case of inaccuracy in excavation work before concreting. Recent case studies by the author, of concreting 150mm

thick beds showed that avoidable wastage of ready mixed concrete arising during delivery, unloading, transporting on site and placing was about a quarter of that due to avoidable excess excavation. This indicates that, for the control of wastage alone, supervision of excavation would be more beneficial than supervision of the concreting work. For thickness exceeding 600mm this ceases to be so important, as the proportion of concrete wasted in excess of excavation reduces as the bed thickness increases.

(d) Utilisation of labourers for materials recovery. The expected saving in cost of avoidable wastage can indicate the amount of time which may be profitably expected on this work. It may be conveniently fitted in towards the end of the working day when craftsmen often require no further supplies of materials. Recent studies of bricklaying operations using average price facings, have shown that a period of 20 minutes per day spent on this work would have resulted in an overall saving in cost.*

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* "Reducing material wastage on Site" by W W. Abbott. Nov. 1970.

SECTION 2.

3.2: GENERAL MANAGEMENT.

3.2.1. - Ordering and supplying procedures.

3.2.2. - Attitude of Building Organisation and suppliers towards material waste.

3.2.3 - Labour only subcontracts.

3.2.1. Ordering and Supplying Procedures:

In most cases, orders for supply of building materials are placed by the main contractor, except in a few occasions where it is necessary for the architect or the client himself to do so.

Big firms may have a central purchasing department which deals with most aspects of the purchasing.

Like most factors, a considerable amount of waste may result from variations in orders already placed. They could interfere with the overall construction programme and interupt the normal flow of materials to the site. To avoid these happening on the site, it is necessary to have an accurate material schedule programmed to delivery dates which will just fit into the site layout and storage arrangements. This, in the majority of cases do not happen because the standard documentation used in the industry is based on the bills of quantities which is geared to the financial control rather than the construction process. Also, in many occasions documentations are not finalised before the contracts are being awarded. As a result, many variations occur in materials ordered.

Where the central purchasing department deals with orders, care should be taken to see that the same orders are nor repeated by the site management. Over-ordering of materials may cause a considerable loss to the contractor if some of the materials have to be returned to the supplier.

It is a common practice that a few items of materials or components extra, are

ordered to allow for any damages that might occur. There is no certainty as to the quantity that may be allowed for. This is a practice therefore, which may lead to having more than the quantity required in the final analysis.

The orders should specify quality, quantity, dates and times of delivery of each material to suit the available site handling, of resources, storage provisions and site security. Methods of delivery and packaging and the standard by which materials are to be judged and rejected must be stated in the procurement.

All those involved in the arrangements for material supplies should be well communicated with regarding transportation, eventual site location, order of delivery, labelling and packaging sizes. A good communication chain between the supplier and the receiver will be of great advantage to both parties, and consequently reduce unnecessary or late deliveries.

Prior to the selection of a supplier and the placing of any order, it is necessary to obtain competitive quotations from a number of suppliers for a particular item. In this way variations in price, delivery dates and general services could be compared for a suitable and economic selection.

Standard pre-printed forms are available for use by those ordering materials to ensure that the suppliers understand the nature of the work upon which their quotations will be based. A quotation with the most suited price and conditions is then considered.

If the suppliers comply with all the requirements i.e. quantity, quality, dates and times of delivery, and the purchaser keeps to his orders without constant variations, wastage of materials, loss of money and time, will greatly be reduced.

3.2.2. ATTITUDE OF BUILDING ORGANISATION AND SUPPLIERS TOWARDS MATERIAL WASTAGE.

Building Organisation:

Though the designers and clients may cause waste, much responsibility lies with the builders. The building companies and their subcontractors have not seen prevention of waste as a role of an individual or that of a department. Each person therefore leaves it to the other to take action.

Undoubtedly the building industry is aware of the need for improvement in the control of wastage of materials. However, the industry has been slow to react to this need. This fact was confirmed by the result of my recent field survey. Up till now, many firms in the country do not even keep records of material wastage.

Traditionally, cheap raw materials - clay, sand, wood etc. are being used in the industry and it has often been thought to be more economical to waste these materials than to spend money in avoiding their wastage. This has been the old habit which has become difficult to alter despite the present day inflation and worldwide shortage of materials. It should however, be noted that materials which have traditionally been cheap can suddenly become expensive as costs of these materials are not static.

Truly, it may happen that there is a point at which avoiding waste can be more costly than would be saved. Unfortunately, this is often used as an excuse for doing nothing about it at all by the firms. However, waste is often caused by default. Management policy must therefore be to prevent rather than to cure.

Suppliers:

The suppliers of building materials and services are also not without fault. They need to have a considerable knowledge of building process and construction but often this is not the case. A builder ordering materials commonly deals with numerous suppliers with varying backgrounds and speciality. In the absence of specific details, suppliers deliver materials to their own advantage, giving little or no consideration to site conditions and requirements regarding packaging and other delivery methods. This results in damages to materials and components during transit to the site by the suppliers, so that such items have to be returned for replacement and causing further delays.

There are generally diverse demands on the suppliers from companies of different sizes, so the suppliers themselves find it difficult to decide on which demand they should concentrate. So it is not solely the fault of these suppliers.

3.2.3. Labour-Only Sub-Contractors:

The management of a firm may, in certain situations decide to sublet part of its construction works to a sub-contractor. The use of labour only sub-contracts practice is not uncommon in the building industry. In this situation the main contractor purchases all materials and the sub-contractor is only paid for his workmanship, usually on dayworks basis.

Where labour-only contracts exist,there will be no incentive on the sub-contractor to cut down the rate of material wastage as it is not his responsibility to purchase the required materials for his use. His interest is how to achieve a high rate of production, on which his pay is based. Little or no attention is paid to waste and quality control. It will therefore

be the responsibility of the site supervision to ensure a reduction in the wastage of materials.

In my recent survey, the majority of those interviewed agreed to the suggestion that this form of arrangement results in more waste than if the same works were carried out by the main contractor. The main contractor would however benefit from increased production with this arrangement.

Though used widely in the sixties and seventies, the use of labour-only sub-contract is on a general decline in the country.

SECTION 3.

3.3. SITE MANAGEMENT.

3.3.1. Site layout and organisation of Human Resources.

3.3.2 Material Deliveries.

3.3.3 Receipt of Deliveries

3.3.4 Material Storage and Protection on Site.

3.3.5 Site Safety.

3.3.6 Material Movement and Handling.

3.3.7 Attitude of Workmen Towards Material Handling

3.3.8 Site Security

3.4. SUMMARY.

3.3.1 SITE LAYOUT AND ORGANISATION OF HUMAN RESOURCES.

Site Layout:

On a building site, it is essential that site management should be in full control of the location and movement of the materials and components. Ideally, all materials and components on the site should be as close to the point of use as is practically and economically possible.

If materials are brought on site, off-loaded and re-handled over relatively long distance, then time is being wasted, risk, damage, loss and costs incurred are increased.

A good site layout plan, not only reduced the physical material waste but also increased the level of efficiency of the whole project. Also a good site layout produces a tidy working place for the workers, consequently increasing productivity and reduction in waste and losses.

Generally a site plan should be drawn up showing the relative locations of facilities, accommodation and plant, with the overall intention of providing the best conditions for optimum economy, continuity and safety during working operations.

Factors such as tidiness and accessibility should be related to traffic routes, material storage and handling, administration blocks, toilets, canteens etc. Also to be considered include the location of plant, workshops and

services, tall buildings, confined sites, staged completion and adjoining property.

Planning for ease of access and off-loading facilities for the suppliers' vehicles on the site is of primary importance. This need, however varies with the type and stage of the project. Access from main road should be duplicated where possible to facilitate the inwards and outwards movements of vehicles. Where permanent access to the site can be determined, the temporary access roads should be planned to utilise the permanent work as far as possible.

To facilitate off-loading, and on-loading all storage areas should be located adjacent to the access roads. The aim here is to minimise double handling and consequently reducing wastage and losses arising from careless handling. Sufficient space should be provided so that damage is not done to other materials or works on the site during the process of off-loading.

Administration blocks and other site facilities are best sited in places where viewing of works in progress is convenient and where the noise from operations will be minimum. Usually they are located as near as possible to the entrances for ease of checking incoming deliveries.

Plant, workshops for joiners and fitters, for example must be located to allow for easy access and short routes to point of construction to avoid congestion of the site which may cause material wastage.

Organisation of Human Resources:

After all the necessary locations on the site have been decided, the human organisation must also be planned.

Before we may discuss the physical aspect of waste and control, it should be

remembered that decisions or plans made by the top management must be carried out by the people on the site.

Lack of clear understanding of the responsibility of all concerned with the building operation, often lead to waste of time, material, labour and money. *The use of general labourers for unloading and handling materials for several different trades poses the problem of allocating responsibility. This can be obviated if each trade gang is made responsible for its own unloading and handling.*

Not only the categories and number of staff must be decided but their responsibilities and relationship should also be laid down. Each member should know from whom he should take instructions and to whom he may give instructions. Indication by way of diagrams showing the chain of command and chart listing the responsibilities and various duties of individuals will be essential. Since the attitude of the operatives are conditioned by those of the supervisors and the management, they should be told what and what not to do. They should be kept informed of the forward planning of work. The need for care in material handling should be emphasised to each operative with explanations of why this care should be taken by them.

Communication in writing, handed to operatives on joining the site, giving brief information about the whole project and the part in it, will help to increase the operatives interest in the work and further co-operation. Drawings of the job may also be displayed in the canteen.

Good communication systems are essential for effective control and should be planned. Frequently used on most sites are telephones, short wave radio, tho loud hailer etc.

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* Reducing Material Wastage on Site by W.W. Abbott, Nov. 1970.

Site layout and organisation, are in effect, plans from operational point of view and are checked against the overall and detailed programmes to confirm that the means and methods planned are properly and fully integrated.

3.3.2 Material Deliveries:

In response to orders placed by the purchaser, the manufacturers or suppliers will deliver the materials or components to site. The form and quality of these deliveries will vary depending on the material category, the vehicles being used and the method of off-loading.

Deliveries may be in loose form, bagged, located on pallets or banded. Due to the importance of the forms of material deliveries, materials are usually categorised to suit their convenience as follows:-

1. Bulk:

The material in this group is delivered in bulk and deposited on site into some form of container. Sand, aggregate and hardcore are a few examples of materials in this group. They are off-loaded directly from the vehicle by use of tipper. Materials in this group have a high rate of wastage and tend to be used indiscriminately.

2. Bagged:

A bulk of material are placed in bags for ease of handling and control. Other advantages are that they offer some protection against waste and deterioration e.g. cement and plaster.

3. Palleted:

Pallets are provided on transport vehicles onto which bagged material can be loaded. On arrival at the site, mechanical plant such as fork lift or crane could be used to off-load them. Generally manual handling is slow and generates wastage of materials. Examples of these materials are bagged cement, bricks or blocks, plasterboards and steel reinforcements.

4. Packaged:

An increasing number of materials are now packaged to prevent damage during transit and deterioration in storage. They can fully be banded together. When materials such as bricks arrive on site in packages, unloading time is reduced and they have an added advantage of being in convenience loads for most cranes to lift. Materials which can be packaged, e.g. nails, screws, have low rate of wastage on delivery until they are opened loose.

5. Loose:

Materials in this group are handled individually according to their weight, size and strength. Unloading is frequently carried out manually, thus increasing the risk of damage and waste.

Materials may however, be grouped in other ways. For example, according to their value, risk of theft or alternatively according to the method of handling or storage and the amount of care required on site.

Each form or category of material, however presents its own problems to the site from off-loading, handling and checking, to storage, distribution and subsequent risk of material loss or damage.

Whenever possible, a building organisation should obtain its materials palleted or packaged. These have the advantages of faster turn-round for vehicles on site, quicker and easier loading at the point of loading. Packaging of materials generally have the advantages of protection, easier handling and storaging. Materials can be packed in sets, stored in shelves or racks off the ground. These help to minimise the amount of wastage on transit and on site.

Most fragile or breakable materials such as glasses, sanitary wares, bricks or blocks are vulnerable to risk of damage or breakage during their

transportation to the site or within the site, causing a considerable amount of wastage.

Wastage which occurs within the site due to movement points of use, may be avoided by the storage of the materials as close as possible to their points of use in the first instance. The use of layout diagrams for such locations will be of great advantage.

Vehicles used for material transportation should also be suited for such materials and to the site conditions for ease of off-loading.

3.3.3. Receipt of Deliveries:

Before the deliveries get on the site, it is presumed that a good site layout and organisation, the planned orders and delivery methods are duly completed and fully understood by both the supplier and the receiver on site.

The first and the most important duty of the checker, is for him to keep a close check on the planned delivery dates. Goods arriving on site sooner than required can be as much embarrassing as goods arriving late.

On most sites, the receipt of material deliveries is the duty of a site clerk. Some firms still however, assign this responsibility to storemen, such as a storekeeper. Whoever is assigned with this duty, it becomes his responsibility to check all materials for quality, and quantity and to either accept or reject them.

The receipt and checking on site of each material delivery involves some administrative work in processing delivery notes, checking delivery descriptions and quantity for errors, omissions, damages and breakages.

The fact that a contract requirement for some materials, notably loose materials on larger sites, may involve several delivery loads, complicates the work for the checker. Many shortcomings may therefore result.

Some material facets cannot be checked readily on delivery. For example, ready mix concrete arriving on site. The contractor in this situation relies on the goodwill of the supplying firms. Some sites may be limited by the lack of time and or manpower to check deliveries. Sometimes, the intention of checking a delivery has to be abandoned because of other deliveries arriving or because the checker acts in another capacity. For example, it is a common practice for many site management to use a storeman for material checking thus duplicating his duties.

Occasionally, a delivery driver, anxious to get away, delivery arriving towards the closing time or during rain, renders detail checking of such deliveries difficult. Also sometimes, those involved in checking may have little or no idea of quality or knowledge of delivery being made. Yet, it is the responsibility of such checker to determine the acceptance standard of material deliveries to site unless a firm has a quality controller.

In many occasions, errors may occur in loading up a vehicle or discrepancies occur in the accompanying delivery notes. Example, vehicle carrying materials of random sizes. Delivery notes should be thoroughly checked. There are instances, where descriptions or manufacturer's codes shown do not readily help the checker, or the units given are difficult to check without first converting them, e.g. boarding timbers delivered in cubic or square metres and not in metre run.

When delivery notes are signed, it should be ensured that the site copy is

legible and the signature appended is clear. It should be ensured that what is being signed for is what has been ordered and that the quality and quantity conform with the order. Any damages to materials or breakages should be clearly noted on the delivery note and the supplier notified in writing.

The checker should be aware of different deliveries, and after signing the lorry driver's delivery note, ensure that the same goods do not leave the site. It is not uncommon for lorry drivers to leave the site with a full load after the checker's signature on the delivery note.

Failure of the checker to observe all these strict checks when deliveries arrive on site may lead to deficiencies in both the quality and quantity of materials received on site resulting in ultimate wastage or loss.

3,3.4 Material Storage and Protection on Site:

Storage may simply be defined as the planned occupation of space by materials or goods, but storage has to be related to the sequence of construction to ensure minimum movement and handling, and to ensure security of the materials.

For example, the use of detailed method study to reduce marginally the allowance in preliminaries for the area and cost of accommodation, temporary roads, hardstandings and perimeter compound fencing, may easily result in a loss, due to the inability to store materials properly which arrive early as a result of changed production programmes.

Inadequate stacking and insufficient storage on site, is one of the principal

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* "Storage and Protection by W.W. Abbott.

reasons for material waste. Starting with the off-loading, stacking and placing of material on site, it is clear that there is much that can be done to reduce material losses and improve overall effectiveness of material use.

While materials may be off-loaded on the oversite slabs, or hardstandings, or into stores or compounds, the bulk of deliveries tend to be off-loaded alongside access routes or within the working area.

Also one of the most significant aspects of storage is that it is common for the goods to arrive on site inadequately packaged for the weight involved. Insufficient instructions about their handling, storage and stacking are provided with the goods or sent in advance to the site.

Material positioning on site should be given a careful consideration to avoid congestion. Where material congestion occurs and categories of different materials are involved it is almost certain that material wastage will occur. Decisions regarding the provision of storage facilities should be based on such factors as quantities of different materials, variety of materials, unit and value of different materials, timing and frequency of uses and the vulnerability of different materials to deterioration, damage, waste and theft.

Most building sites have wastage of materials such as timber, steel doors and windows resulting from bad stacking, cement and paints exposed badly stored. True economy will be achieved and future confusion avoided, if

FIGURE 1.

MATERIAL	METHODS OF STORAGE: OPEN SITE	HARDSTANDING OR DIVIDED BINS	LOCK UP GROUND OR COMPOUND	IN PARTIALLY COMPLETED BUILDING	IN WEATHER PROOF LOCK UP SHED	DELIVERED AS REQUIRED FOR USE	OPEN SITE WITH PROTECTION FROM RAIN	STORAGE AND PROTECTION OF MATERIALS: STACKING	REMARKS
CEMENT					X	X		Off ground- 5 bags high- maximum	Use in rotation F.I.F.O. Cement silo if large contract
AGGREGATES		X				X		Prevent detiorution & separation	Phase deliveries
CONCRETE BLOCKS							X	Near to point of use	Keep dry to preven shrinkage
CARCASSING TIMBER							X	Raise off ground, stack in sizes, support evenly	Seal ends
WINDOW & DOOR FRAMES			X				X	Stack in sizes off ground	Prevent damage
JOINERY			X	X				On bearers in bundles	Prevent damage keep dry
DRAINAGE GOODS	X		specials			X		Tie in ends of stacks	Valuable, liable to breakage
PLUMBING FITTINGS				X	X	all metals		Leave in packing cases	Ditto
JOINERY FITTINGS					X			In boxes	Keep in sets
GLASS				X	X	X		Upright on bearers in sizes and types	Keep dry
BRICKS	X		specials			X		Near to point of use	Check phased deliveries

from the very start, large stores properly floored and equipped with sufficient racks, shelves and benches are provided. With these, different types of fittings, equipment and other materials such as nails, screws can be kept in seperate apartments. Generally, it is important that similar type of materials are grouped together and laid out in such a manner that they can be found, checked or selected easily and quickly.

Appropriate protection and security of different categories of materials and goods during storage and stacking is essential. Methods to be adopted for material protection vary from one material to another depending on the sensitivity to climatic conditions, value, size of units and scarcity of an individual material.

Many methods of storage and protection for material on site are in operation. *Fig. 1 shows various storage and protection methods for some of the most commonly used materials.

The question of cost for each method of storage and protection to be used should always be borne in mind when considering what method should be used. Total cost of storage may appear to be expensive. However, if this cost is related to factors necessitating storage, such as the economic buying of materials, changing in production programmes, late deliveries, economic outputs, storages or particular materials limited period of availability and variations, the savings are quickly realised.

The following recommended steps if taken by the contractor, could lead to a considerable reduction in waste.

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* Elements of Administration for Building Students by John T. Butler.

1. The allocation and preparation of storage areas, marking on the site plan, the exact layout of all material storage area, giving each a code number or letter and then marking this area out on the site with pegs or similar, showing the equivalent code. Drivers delivering materials can then be told by reference to the plan where to place their load. Make sure that lorries can get to the area with as little interuption to the normal work as possible and that sufficient space is allocated so that other materials or work is not damaged in the process of unloading. Always ensure that materials are rehandled as little as possible and that they are placed to the final position in the structure as room allows.

2. Make sure that when materials are stored, they do not deteriorate. Fig.1 shows a material storage schedule that could be supplied to all site supervisors to ensure that this does not happen.

3. Collect waste e.g. half bricks, and use to prevent more cutting - a few by each bricklayer's spot will suffice.

4. Where small, and especially attractive items are on site, these should be kept under lock and key and only issued as and when required.

.3.3.5. Safety:

Safe stacking of materials on site should not be overlooked. Many accidents occur in site stores and stacking places due to falling materials. Care should be taken at the delivery stage to ensure that materials are safely stacked. Stacking of materials to heights that necessitate the use of ladders should be avoided wherever possible. Also metal to metal stacking should be avoided as slippage can easily occur. This can be avoided by using timber slats between metals.

Falling materials, not only endanger the lives of the workmen on the site

but materials are also often damaged or broken, giving rise to wastage.

Generally, site safety regulations should be adhered to in order to ensure the safety of men, plant and material on site.

3.3.6. Material Movement and Handling:

Materials when wrongly handled, even though well packed can be damaged. In practice, materials involve a great deal of movement and handling on site, thus giving rise to damage and waste.

Why such amount of movement? Primarily, movement of materials on site is necessitated by their wrong positioning at the point of delivery, resulting in the need for further shifting to the actual point of use. This repeated operation can be minimised or even avoided, if unloading points were carefully selected by the site layout planner before materials are delivered on site. This means planning the unloading positions for materials as close as possible to their point of use. The site roads should be prepared bearing in mind the handling equipment to be used.

Also the development of unit load systems by suppliers will expedite the development of mechanical handling techniques on the site and will facilitate material handling systems generally. Some suppliers, notably of bricks who have noticed the advantages of rapid loading and unloading, have been delivering materials in unit loads for many years now. Unit loads are particularly suited for materials that require processing before use. If unit loads contain the correct quantity of materials for a specific operation, then they can be unloaded directly at their point of use.

Different types of material handling will give varying waste levels. Traditionally manual handling of materials is a slow process and generates

more waste than the mechanical handling system. But construction being traditionally labour intensive industry, continues to use skilled and unskilled operatives to move and handle the majority of materials on the site. A great deal of manual handling is therefore involved in any building operation. Manual handling though more time consuming and expensive is inevitable in some cases. Fragile materials, for example are better manually handled as mechanical handling may result in more breakages and damage.

In most cases, material movement and handling involve the use of both labour and plant. Dumpers, hoists, and cranes are used for heavy lifting or shifting of material, yet manual operations are required for loading and unloading of these plants and in the preparation of crane loads.

As with the types of handling (manual or mechanical) different types of handling plant will give varying waste levels and the efficiency of any one type of plant will vary with the standards of the operators. Many mechanical plant or equipment are now available which can be used to handle a wide range of products. This range of machines include fork-lift trucks, excavators, loading shovels, dump trucks, jack-lifts etc. For efficiency and to reduce waste, drivers or operators who handle materials with specialised equipment require proper training. Too many builders allow unskilled people to use costly mechanical handling plant to move costly materials.

Machines should be well maintained so as to obtain the maximum usage from it. When a plant lies idle, it constitutes a waste of resource. Simularly, a breakdown of an important item of plant can cause not only delays in the overall programme but also material wastage. For example, if a crane breaks down during a concrete pour, the alternative modes of transport may be subject to spillage or in the worst case the mixed concrete may be entirely wasted. Faulty installation or misuse of plant can mean over-manning, damage or

reduction in output.

Handling and transportation around the site may involve vertical or horizontal movements and frequently in both directions at the same time. Handling plant selected should be suited to a particular situation, as well as to building areas and to height, site size, complexity and communication road.

3.3.7. Attitude of Workmen Towards Material Handling on Site:

One significant waste factor of building materials on site is the manner in which materials are being handled by the site workemn. This source of material wastage is particularly common with bulk or loose materials such as aggregates, sand etc. which careless operatives allow to spread during mixing operations, with the result that sand is trampled into the soil and rendered useless. Some finished works, such as fixed glass windows or doors are spilled with paint with subsequent cost of cleaning. An appreciable waste of bagged cement, lime and plaster, often occurs because operatives leave unused or partly used bags unprotected during rain or overnight.

As work progresses, there will inevitably be some materials left unused as surplus either due to miscalculation in the quantity of material required or due to inadequate storage area availalbe elsewhere at the time of off-loading. Wastage occurs due to non-transfer of these surplus materials from a completed operation in say one house to another or from one part of a large building to another part, where similar materials are used. Example of materials often left this way include bags of plaster, roofing sheets, cut-off sheets of plasterboards, cans of paints, nails, screws, etc.

Attitude of workmen towards material handling can lead to a very untidy site.

The more untidy the site, the more will be the amount of wastage of material. Even though, a material may still serve a useful purpose, it may because of its position within an area of waste be classified as a waste.

Wastage of small fittings by scaffolders when dismantling a scaffold coupling, connecting and fittings on props which often drop and get covered by other materials or rubbish is common. This amount of waste can be avoided by keeping the site tidy, so that such fittings, nails etc. dropping, can easily be found and picked up. Site managers should ensure that someone is appointed to keep particular check on the operatives for their attitude towards material handling.

3.3.8 Site Security :

All the while, my discussions have been centred on ensuring that materials get to the site and handled efficiently. If after this is done and no care is given to retaining them, then all the previous time, money and effort will have been wasted. It is important therefore that what is on the site should be protected.

Loss of materials on building sites due to lack of security arise from two principal sources - the criminal activities and vandalism.

Criminal activities which include stealing and pilfering of some items of materials and small tools is largely connected with the site labour force and new tenants in the case of occupation of partially completed housing estates.

Site security is very difficult because of continually changing personnel as one trade succeeds another and as various specialised sub-contractors

arrive at site to perform their part of the contract. Pilfering by employees is prevalent on building sites. A means of preventing workers from stealing materials for their own private use needs more thorough investigation.

*The aim of store security should be to remove temptation and make matters difficult for a potential thief.

The following check list is a guide to the action required :-

(a) Access should be limited to one or two gates.

(b) Frequent checks must be seen to be made on materials, windows, doors as the potential thief will be deterred if he knowns a theft will be quickly discovered and investigated.

(c) The internal layout of enclosed stores should be arranged to provide an issue counter segregated from the main storage areas.

(d) Responsibility for the custody of keys should be clearly defined. There should be a minimum number of duplicate keys and if one is lost the lock should be changed.

(e) Security patrols should be employed in particularly difficult areas where there is high probability of loss.

(f) Materials or equipment which are attractive for domestic use and easily transportable should be marked, if possible, with the company name or colour.

(g) In some areas stealing from open building sites is regarded by the local residents as normal practice, rather than as a crime. Some new tenants on partially completed housing estates will remove paving slabs, bricks, cement, timber, rainwater goods etc. during their do-it-yourself weekend activities to complete gardens, sheds and extensions. One or two tours by a security guard should have some effect and a single prosecution in the courts, well publicised, is an excellent deterrant to other potential pilferers who live on the estate*

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* Storage on Site by W.W. Abbot.

Building industry, though not a major sufferer of vandalism, experiences a range of attacks. This is considerable on urban sites. Building materials suffer damages or are being disfigured to some extent by vandals. Most wilful damages on the site are caused by children coming into the site after working hours. Finished works are often rendered unacceptable by spilling paints or smearing external walls etc. result in extra cost of repainting or cleaning.

It is noticed that watchmen (mostly elderly people) employed are often unreliable or ineffective. Police assistance is virtually impossible to obtain due to shortage of police personnel. Fencing of large sites is often uneconomical. A vandal will most likely commit damage to property if it is made vulnerable and if the chances of being apprehended is negligible. Thus unprotected sites are often open to vandalism.

Deterrent measures are therefore of vital importance. The effectiveness of deterrent measures is difficult to evaluate and compare against cost outlay but it is generally recognised to be more economical to the contractor to provide some form of security measures.

The following are some of the widely recommended measures

(a) Fencing and Hoarding:

A good perimeter fencing of the site will keep out intruders. It should however be ensured that the fencing is made of strong materials and constructed to a reasonable height. Fencing may also act as a check to prevent unintentional trespass on to the site. Where chain link fencing is used, it should be embedded into the ground to a reasonable depth to discourage tunelling.

(b) Security Lighting:

Most of the site vandalism occurs at night. Security lighting of the site serves as a deterrent to intruders.

(c) Warning Notices:

Often a notice warning potential intruders that they will face serious penalties if caught trespassing or causing damages on site is sufficient to deter the less ardent offenders. Such warning signs should be clearly written, be simple and large enough to be noticed.

(d) Watchmen and Security Patrol:

This is a common feature in the industry but it is realised that watchmen are often unreliable or ineffective. With the development of security firms employing professional security men, the building industry has began to rely more on their services for safety of the site. Static and patrol guarding are most commonly used. Static guards are particularly beneficial where vandalism problems or site security are of primary importance (e.g. isolated site).

(e) Alarm Systems:

Alarm systems are new technological developments used by contractors for site security. These are comparatively less costly to other forms of security. Generally, a builder will enter into a contract with an alarm company who will offer advice on suitable systems for the site, install and maintain the equipment, and on completion of contract remove the system and resite it.

3.4 Summary:

Material wastage results from many influences or causes often outside the control of the building firm and beyond its influence. It would be optimistic to expect that material control could therefore be the responsibility of one discipline. It should be recognised as a continuing function at successive stages of construction. As wastage occurs throughout the construction stages, material control to avoid waste should start at the design stage and proceed on to the completion of the construction works and even to the maintenance period.

Material control can be defined as ideal design, specification and documentation, packaging, transportation, reception, handling, storage and protection, co-ordination and general good management and supervision. Steps taken in this manner will greatly reduce the incidence of material waste in building.

CHAPTER 4.

"COMMON BUILDING MATERIALS AND THEIR DEGREE OF WASTE"

4.1. Introduction

4.2 Concrete

4.3 Bricks/Blocks

4.4 Timber

4.5 Building Research Establishment Survey.

4.6 Summary.

COMMON BUILDING MATERIALS AND THEIR DEGREE OF WASTE.

4.1: Introduction:

While numerous materials are used for building purposes, their degree of vulnerability to waste resulting from damage, lack of security, methods of handling, storage and protection etc, differ considerably. For example, fragile materials such as glass doors have higher risk or damage compared to similar doors made of timber.

From the response to questionnaires (See Chapter 6) in my recent survey, a popular opinion indicates that waste occurs most in walling materials (bricks/blocks etc.) Other materials with significant waste include concrete, timber, plasterborads and plumbing goods.

Due to the limited time for research and the restriction on the length of this thesis, only a few of these will be discussed here. I would however like to include at a later stage in the chapter, the results of studies carried out by the British Research Establishment of 114 sites as summarised in Fig. 2. Though the research was carried out ten years ago, it is one of the most comprehensive surveys conducted and the record of which is available for reference.

4.2. Concrete:

Different categories of concrete are used for construction works. They include site mix or ready mix in-situ concrete and precast concrete. The general level of waste varies depending on which category is being used and it may be appropriate to deal with these categories separately.

Site Mix in-situ Concrete:

The component materials to be considered here are cement, sand, aggregates, reinforcing bars and timber formwork. As described in Chapter 3, planned delivery for all materials is very essential. Adequate storage and protection should also be provided to avoid deterioration and contamination of sand and aggregates.

During the mixing operation, particular attention should be paid to batch weights and the handling of cement, sand and aggregates. Most of the waste that occurs during the mixing operation is caused by the failure of the mixing operator to ensure that correct measures are used. This results in using less or more of the component materials than the required amount e.g. over-watering of concrete.

Because cement is often delivered in bags, half or some fraction of cement is frequently left unused after a day's job. Care should be taken to ensure that the surplus is returned to the store and well protected against moisture. All cement bags should not be unduly exposed to dampness. A large quantity of cement may be lost through operatives carelessly leaving behind some quantity of cement in the bags in an attempt to emply them. Though insignificant amount when a bag is considered, a considerable waste may result in an operation which involves the use of many bags. This cumulative waste should be avoided by completely emptying cement bags.

The sand and aggregates brought on site should be unloaded as near as possible to their points of use. Aggregates of different sizes should be kept separately and free from muddy areas.

At the end of each concrete pour the mixer should be hosed and cleaned to

ensure that the concrete remaining in the plant does not weaken the fresh mix. Spillages often occur due to selection of cheap equipment for concrete transportation. It should be ensured that such plant are suitable and well maintained.

Ready Mix Concrete:

The above factors also hold for ready mix concrete during the mixing operation. There are however, a number of factors which may be peculiar to ready mix concrete. Normally, when ordering for ready mix concrete, the exact quantity for an operation should be ordered. Ordering procedures often present a problem. In most cases, concrete is ordered a little more in quantity than would be required to allow for wastage. This allowance may be over-estimated resulting in surplus at the end of the operation. This leaves the contractor with the problem of disposing the excess at the end of each pour. If sundry works do not exist at this stage for which this excess could be used, then this surplus becomes a waste.

Checking at the point of delivery for quantity and quality of ready mix concrete is normally very difficult and contractors in most cases rely on the goodwill of the supplying firms. Concrete of lower strength than required for a particular operation, may be used for works for which it was not intended, resulting in monetary loss.

Selection of cheap delivery vehicles may result in spillage. Also, delivery routes for ready mix concrete vehicles should be carefully planned to ensure safe delivery and to ensure that delivery times as planned are met. The use of imperial size skip with metric ready mix trucks will lead to waste by overfilling. It should be ensured that metric skips are used with the corresponding metric ready mix trucks.

Wastage Stemming from Construction and Concrete Usage:

In a significant number of cases, concrete usage which otherwise can be avoided, may be attributed to one or more of the following:-

(a) Incorrect setting out

(b) Over-digging of excavation

(c) Width of trench excavation

(d) Peg depth for concrete pour

(e) Levelling accuracy

(f) Placing of concrete.

In correct setting out of foundation trenches and over-digging will necessitate trench fill. In practice these often happen due to lack of efficient supervision.

The width of a trench determines the size of bucket to be used. Designers should be aware of the readily available bucket sizes and relate these to the width of trenches they specify on the drawings. The use of the nearest available size, as it often happens in practice, will give rise to additional usage of concrete.

Peg depths for concrete pour need to be accurate. On building sites, it often happens that peg depths are either carelessly set up or completely ignored resulting in increased slab thickness. Consequently more concrete than expected will be used.

Access to foundation area for placement of concrete is sometimes a problem, particularly where spoil heaps have not been moved. This may lead to concrete being wasted, even before the placement. The best option in such a situation should be, placing by pumping.

Before concrete is poured into trenches, the bottom of the trenches should

be well levelled and rammed. Undulating bottom of trenches will not give a uniform thickness to the concrete placed. Additional use of concrete will therefore be inevitable.

Formwork to Concrete:

The amount of concrete used when concrete is poured against faces of excavation will often be greater than when earthwork supports are used for the same concrete work. The formwork too, costs money. Therefore, true economy can only be achieved if these formworks are properly cared for. A great deal of these are frequently left wasting on building sites.

A careful consideration should be given to their selection, and striking rules observed. By so doing, the timber formworks may be re-used a number of times. Early striking off has adverse effects on formwork. Where steel props are used, they should be well maintained.

Reinforcing Bars:

Orders for reinforcing bars should take into consideration the delivery dates and appropriate bar lengths. These will minimise storage periods and the labour required for cutting and bending of bars. Bars of different sizes should be stacked separately and duly marked. They should be stored in sufficient space to allow sorting. They should always be stacked on timbers, off the ground and away from oil or diesel to avoid rust.

Skilled benders should be used in the bending and cutting operations. Dropping and hammering of bars should as far as possible be avoided. It should be ensured that the correct sizes and quantity of bar reinforcements are used. Incorrect use will result in waste.

Precast Concrete:

Though factory made where much prevention of waste must have been exercised, their delivery methods and transportation to the site, handling and storage should be carefully planned.

The delivery dates for panels should be agreed, which will fit into the overall programme in order to avoid long storage periods or disruption of works in case of late deliveries.

Suitable vehicles should be used for their transportation to the site. Nothing that will constitute danger or liable to damage the panels should be left in the vehicles. For example, stones left in the vehicle can damage the units.

On site, attention should be paid to access requirements for vehicles, provision of lifting devices and other special arrangements for off-loading.

Those involved with moving of concrete units must be aware of the following:-

(a) Correct sliding methods

(b) Correct location for each unit.

(c) Markings for various types and handlings.

(d) Correct storage requirements (e.g. bearer spacing).

4.3. Brickwork and Blockwork:

Among the materials commonly used in building, the greatest amount of waste probably occurs with brickwork/blockwork. About 80% of the persons interviewed recently on building sites held this view.

Wastage of bricks or blocks generally can be seen to occur from three principal sources:

(a) Method of Ordering

(b) Delivery, stacking and storage

(c) Handling on Site.

Though when quantities are estimated for ordering purposes, attempts are often made to provide some allowances to take care of the amount of wastage of bricks envisaged. These allowances are often either under-estimated or over-estimated. Furthermore, bricks may arrive too early on site resulting in long periods of storage. Undoubtedly, the more the bricks are kept on the site, the more is the risk of damage. A planned delivery times when orders are placed is therefore essential to avoid wastage. It often happens that, a number of different types of bricks may be ordered to be delivered on the same date. This creates a great deal of difficulties in ensuring that the right types are delivered and at the time they are required on the site. To minimise waste, delivery of bricks and ready mix mortar should be carefully planned and so detailed in the orders placed.

Delivery or transportation methods to be used may be any of those described in Chapter 3 i.e. palleted, packaged or loose. It is however, preferable that bricks are loaded into lorries packaged and on pallets. When in loose form they may be more liable to breakages or been chipped due to excessive

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handling. When packaged their handling becomes easier, unloading time is shortened and stacking becomes easier and safer.

Before bricks arrive on site, it should be ensured that site roads and hardstandings are well prepared to facilitate their off-lodaing and stacking Bricks should not be unloaded onto unprepared muddy surfaces. Photographs taken on site recently (see Chapter 6) show that in practice, bricks or blocks are unloaded onto such muddy surfaces with the result that, some are burried into the mud. A means of preventing them from excessive moisture should be used. Polythene covering to bricks will prevent them from rain or snow.

Bricks are often tipped into heaps from a tipper. This practice leads to a high level of breakages and should therefore be avoided. Bricks either in bands or loose form should not be stacked too high or on sloping grounds. Always stack bricks on edges rather than on faces and on timber pallets. Blocks are particularly vulnerable to damages when stacked on faces.

To avoid waste, common bricks should be kept separate from facing bricks and blocks of different strength also kept separately.

During walling operations, scaffolds are often over-loaded with bricks or blocks resulting in sudden collapse breaking or damaging them. Over-loading of scaffolds should therefore be avoided.

On site where it is likely that rain water would come in contact with bricks or blocks, the flow should be diverted. All high block walls should be supported against wind damage.

On completion of a job, all surplus bricks or blocks should be transferred to new jobs and all broken bricks or blocks collected and used as hardcore or in other operations for which they may be useful.

4.4 Timber:

Like most other materials, ordering procedures, careful planning for storage, stacking and handling of timbers, play very important role in reducing incidence of timber waste on sites.

Orders for supply of timbers should as far as possible specify the acceptance grade including such details as extent of twist, knots etc. Though, the quality of timber is not easily identifiable when deliveries are received on site, such specification helps to indicate to the suppliers the standard qualities of timber expected of them.

Sometimes checking is made almost impossible when a lorry is loaded with random sizes of timber. A further difficulty is that timber quantities are usually derived from measured items of bill of quantities descriptions (i.e. cross section) while orders and delivery notes may bear trade description and presented as an aggregate, in cubic quantity. Moreover an invoice may sometimes contain details of timber deliveries for more than one site. When received on site, a special care should be taken in checking and some means provided for identifying what timber has been delivered and for what job. A carefully phased deliveries to suit the building programme and where possible bundled into house/dwelling sets will reduce incidence of timber waste.

Timber must be stored off the ground and in a dry place. Air circulation should be ensured especially for pressure impregnated timber. They should be stored in covered areas and free from mud and oil or diesel. In smaller sites, tarpaulin cover may be adequate. Some expensive timber components such as roof trusses should be correctly stored to avoid damage.

During construction process, it will be necessary to ensure that timber is used for the purpose for which it was ordered. Regular collection of off-cuts from around the site should be organised for re-use which otherwise will become waste.

FIG:2 *Direct waste of common building materials*
Results to July 1975 based on 114 sites

Material	No of sites	Range of results from indiv. sites	Overall wastage	Normal allowance for wastage	Comments
		%	%	%	
Concrete					1. Further studies of only part of the concrete operations were undertaken on 20 other sites. These studies showed a range of between 5-10 % with a mean of 7 % for foundations and sundry concreting works with no formwork and from 3-5 % for concreting operations using formwork. 2. Waste in foundations may be due to 'overdug' trenches, ie negligence and production waste which has not been segregated in these results.
In foundations	12 (1)	3-18	8 (2)	2.5	
In formwork	3	—	2	2.5/5	
Steel reinforcement	1	—	5	2,5	
Pre-cast concrete (small units)	1	—	5	1	
Bricks					1. One site had a result of over 27 %. This was considered to be exceptional and has been omitted from calculations. 2. Covers wide range of specifications including both hard and soft bricks. 3. Results based on contracts using large quantities. 4. Overall waste by size — 3 in. 9 % (excluding one small site with 30 %) 4 in. 11 %; 6 in. 8 %.
Common	68	1-20	8	4	
Facings	62	1-22 (1) (2)	12	5	
Engineering 'blues'	2	—	5 (3)	2.5	
'reds'	3	9-11	10 (3)	2.5	
Blocks					
Breeze	4	8-11	10 (4)	5	
Lightweight	22	1-22	9	5	
Concrete	1	—	7	5	
Walling materials overall	97	1-22	10	5	
Roofing					1. Results based on one very large housing site.
Tiles (roof and ridge)	1 (1)	—	10	2.5	
Felt	1	—	8	2.5	
Softwood					1. Only housing studied on very large sites. 2. One site had a result of 33 %: this has been omitted from calculations. * *Includes results of general studies.*
First fixings	23 *	5-16	10	5	
Boarding	3	12-22 (2)	15	5	
Plywood	2 (1)	—	15	5	
Second fixings	5	8-17	9	5	
Ironmongery	2	—	3	2.5	1. Norm for lathing appears high; sample was small.
Metal lathing	3	—	3	10 (1)	
Metal *trim*	2	—	4	—	
Plaster					1. Overall results for plaster may be slightly on the high side because of waste possibly being caused by uneven walls *requiring more plaster.*
Walls	4	2-7	5 (1)	5	
Ceilings	4	1-4	3 (1)	5	
Plasterboard	3	—	4	5	
Dry lining (plasterboard)	11	4-22	15	5	
Tiling					1. Study on school swimming baths including bath, shower and dressing areas (edge tiles 2 % wastage).
Wall	1 (1)	—	3	2.5	
Floor-ceramic	1	—	3	2.5	
Floor-thermoplastic	1	—	7	5	
Lead					
Flashings	1	—	7	2.5	
Pipes					(1) Based on external rainwater goods.
Copper	9	—	7	2.5	
Plastic	1 (1)	—	3	2.5	
Copper fittings	7	—	3	—	
Glass					1. Preglazed metal windows from two different suppliers.
Sheet	3	—	9	5	
Preglazed	2 (1)	—	16	—	
Drain goods					1. Does not include fittings to manholes.
Pipes	1	—	4 (1)	2.5	
Fittings	1	—	5	2.5	
External works					1. Norm for carcassing timber which is ususally quoted.
Paving slabs	1	—	5	2.5	
Fencing posts	2	—	5	5 (1)	
Fencing slats	2	—	12	5 (1)	

NB: Observations on a limited number of sites for sanitary appliances, electrical goods and painting materials showed waste was insignificant

4.6. Summary:

Though the degree of waste varies with different materials, some common factors exist between them. These are notably; ordering and delivery procedures, storage and protection, and site stacking and handling.

For all materials, the building organisation or firms should ensure that the orders for supply of material include such details as quantity, quality, specific delivery dates. Their delivery schedule should fit into the overall building programme to avoid long storage periods or disruption of works. Suitable vehicles should be used for material transportation to avoid damage, breakages or spillage. Careful checking should be conducted before materials are accepted on site.

On site, materials should be carefully off-loaded, well stacked or stored in carefully planned areas to minimise movement. There should be a provision for adequate security to deter vandalism and other criminal activities.

A great deal of waste occurs as a result of mishandling of materials by workmen. Material wastage will be greatly reduced if all concerned with material handling should receive training in all aspects of material control.

CHAPTER 5.

"MEASUREMENT OF WASTE "

5.1. Direct and Indirect Waste

5.2 Sequence of work necessary for measurement of waste.

5.3 Recording material deliveries to site.

5.4 Measuring stock of materials on site.

5.5 Measurement of work in progress.

5.6 Waste and the estimator

5.7 Summary.

5.1. Direct and Indirect Waste:

From my previous discussions, it can be seen that waste of materials on building sites is considerable and that the incidence of waste varies under different circumstances. In order to establish an accurate assessment of the extent of losses, a site accounting for each material is essential.

In its broadest form, a measure of waste is the difference between the quantity of material delivered to the site and that used as specified. This has been proved by many studies to over-estimate the true loss because materials ordered for one purpose may be used for another in practice. For example, facing bricks may be used as common bricks or even become expensive hardcore. This mis-use results in substitution waste because the material used is of higher quality than necessary. The waste here is not a total loss of material (direct waste) but a monetary loss related to the material (indirect waste).

To facilitate accurate measurement waste is classified into direct and indirect waste as detailed in Chapter 2. The principal information that can be obtained when measuring waste is usually the incidence of complete loss of material. In order to calculate the complete loss however, it is necessary to identify and calculate the indirect waste. For example, if a door frame is damaged beyond repairs and subsequent use, then it is necessary to replace it. This replacement will involve not only the cost of the door frame but cost indirectly connected with the replacement such as cost of re-ordering, cost of returning it to the

supplier, cost of delivering the new one back to the site etc.

5.2 Sequence of Work Necessary for Measurement of Waste:

The calculation of waste on site consists of three stages. For each material being measured, all the three stages should be carried out at the same time especially if the work is done by more than one person.* These three stages include:-

(a) A statement of the total delivery of material to site at a given point in the progress of work, less any material transferred or credited.

(b) A statement of the stock of material which is being examined and which is held on the site (or elsewhere for the site if it has been recoreded in the deliveries), together with any adjustments for materials stored on site pending their use later in the contract.

(c) A measure of work completed giving the materials which have been placed in position, suitably adjusted for any material classified as indirect waste*

These three stages required for waste measurement are each now described in more details below.

5.3. Recording Material Delivered to Site:

The first step to be taken towards ensuring accurate measurement of waste is to be able to record accurately all materials delivered to the site. All the necessary particulars of the material being examined including

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* Site Accounting for Waste of Materials by E.R. Skoyles.

sizes, quantity etc., should be listed.

In practice, different methods of recording are used by different firms. Many firms keep record of each material on separate cards noting every delivery, transfer or credit in columns provided on the card. Some firms undertake their recording on printed forms often supplied in duplicate or triplicate.

Whichever method is being used, it should be ensured that the approach to recording is not open to risk of error. The recording should show the adjustment for transfers and credit for each material being examined and the data collected are then assembled ready for reconciliation.

5.4. Measuring Stock of Material on Site:

The aim here is to ensure that all materials in stock are duly noted and included in the reconciliation of waste calculation. If stacking positions for all materials are planned and made known to all concerned, the possibility of omission of any stock may be remote. Such plan could be a rough sketch of the site displayed prominently so that an inspection for counting of materials is made easy. Marking of relevant storage areas relating to each block of construction, could be helpful for easy identification of materials. The common mistake in reconciliation of material waste often occurs due to the fact that some of the materials, even though in stock are being overlooked.

Regular stacking of materials on site provides easy counting but accurate counting of numbers of units become much more difficult. It is found best to round-off numbers in such cases. It is also advisable to count

than to measure in volume terms and later to convert to material measures by constant because it is noted that in so doing, voids that may exist are often being overlooked.

Often problems may arise as to define whether an item of material is a stock or is a measured work. Generally, if materials are at the work place and are not being used they should be regarded as stock. If however, materials are at the work place but there is a continuous use by drawing material from the stock, then they should be regarded as measured work.

Materials can be regarded as waste if they have been dropped, broken and trodden into the ground or stained. Even if materials are in good condition but have been left behind after men have been moved elsewhere, then the materials can be regarded as waste unless there is a policy of collecting such materials and returning them for subsequent re-use.

In certain circumstances, stock not for immediate use are received and stored on the site (i.e. frozen stock). It is a good practice to place such materials in special positions on the site and suitably marked for identification. The number of these frozen stock is deducted from the total number delivered. During the reconciliation exercise, they can be carried forward from waste check to waste check until such time that they are required for use. At this stage they then become re-calssified as stock.

The total stock of materials is therefore arrived at by deducting the frozen stock from the number of materials delivered to the site.

5.5. Measurement of Work in Progress:

Quantity Surveyor's interim valuation may in certain circumstances not reflect the true value of materials being used. The valuations are based on the bills of quantities, which in turn were taken from project drawings. It is possible that these drawings might have undergone considerable modifications during the construction process. Moreover the measuring conventions adopted may not be sufficiently detailed for waste accounting. For example, no account is made of production waste in the bills of quantities. Extra concrete may be required in an excavation trench because the designer's specification for trench width does not coincide with any size of bucket available for use by the mechanical plant. Wastes which occur this way cannot be measured based on the bills of quantities.

For an accurate measurement of material waste, any measures should be in the unit of their purchase e.g. number of bricks. Though counting of materials may take a little longer, it is found to be the most reliable method of measurement on site.

Principally, measurement of work in progress involves the carrying out of the measurement of work executed, the calculation and adjustment for indirect waste which might have been encountered.

The measure of work executed needs a high degree of accuracy in order to achieve a corresponding measurement of waste which might have occurred during the construction process. To this end therefore, it has been recommended by the Building Research Establishment that the method of more measurement for ascertaining bonus payments represents a more realistic account of work actually done and should be used for calculation of the amount of work executed.

In practice, indirect wastes result from substitution of one material for that specified, waste due to negligence and waste occurring out of production process (see details in Chapter 2). These indirect wastes are measured individually and adjustments made from the measure of work executed. From these the value of material placed are measured and the result assembled. It will be a good practice to prepare a statement of indirect waste.

From all the assembled data collected from the material delivery recording, stock measurement and the measurement of work in progress, direct waste can then be recorded in the direct waste calculation record form shown in Fig. 3.* (overleaf)

Amount of material waste is then calculated from the formula:

Waste (H) = C - G as percentage of C.

Where H = percentage waste

C = total material available (i.e. total material delivered less transfer from site)

G = Material accountable for on site.

The measurement of waste can be carried out at any stage of the building works but it is recommended that the reconciliation should be undertaken monthly. In cases of where regular low waste is recorded, reconciliation every 3 months may be sufficient. A final reconciliation of waste will be necessary at practical completion to enable a feed-back of the waste for the whole project.

5.6. Waste and the Estimator:

The traditional approach to waste by the estimators, is to include allowances

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* Fig. 3 extracted from a paper titled "Site Accounting for Waste of Materials" by E.R. Skoyles.

DIRECT WASTE CALCULATION RECORD

SITE: _____ DATE _____

MATERIAL: _____ RECONCILIATION NO: _____

_____ No/m² /m³

A Total delivered .....

B Total transferred (from site) .....

C Total available [ ]

D Total measured (as specified) ....

E Allowances for Indirect Waste

	%	No/m² /m³	No/m² /m³
i Substitution	....	.....	.....
ii Negligence waste	....		.....
iii Production usage	....		.....
Adjustment for Indirect waste	_____		.....

[ ]

F Total in stock on site ....

i Less frozen stock (if present) ....

ii Stock available for use .....

G Materials accountable for on site [ ]

H = _____ % Waste (H) = C – G as % of C

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FIG. 3

for material waste in the estimates. These allowances are generally assumed to cover all possible losses of money related to the material concerned. Studies have however proved that the actual wastes experienced on the site are normally double the allowances usually provided by the estimator. This under-estimation of waste therefore results in a reduction of the contractor's expected profit. For overall viability of a project therefore, the estimator's approach to the problem of waste is of vital importance.

The estimator should have a good knowledge of all types of waste. Up till now, it is cutting wastes that is generally considered by the estimator. In Chapter 2, it can be seen that apart from cutting waste, there are numerous other types of wastes arising from different causes discussed in Chapter 3, notably design, planning, delivery and handling of materials etc.

The estimator should be sensitive to all types of waste, especially those related to material delivery and handling and identify design waste. If all these wastes are spotted at the estimating stage, account can be taken of their losses by the quantity surveyor.

Feedback of waste performance on site to the estimator will be of great value to the estimator. This feedback will facilitate a comparison to be made between the waste allowance provided and the actual waste experienced on site. In some cases, the contract documentation fails to give exact or rather vague descriptions leading to variations in later stages. For example, quantity surveyors in their bill descriptions use such phrases as "deemed to be included" , "best of its respective kind". These terms make it difficult to control materials efficiently in

order to prevent waste. The estimator in his pricing of tender should bear in mind the possibility of waste resulting from lack of concise documentation.

The subcontractors and suppliers' activities may result in delays and consequently some waste. When inviting bids from subcontractors or suppliers the estimator must consider their wastes. Hence, feedback from subcontractors of their waste performance is essential information to the estimator.

Generally, the estimator needs to improve his estimating techniques regarding the problem of waste. Due to the shortcomings from the present form of contract documentation, he is however handicapped. The conventional bills of quantities do not reflect the actual building process. Moreover, materials are presented in measures of their fixing which become gloom when the quantity surveyor collates their dimensions.

Though the estimator may be able to assess some possibility of waste, he works under some considerable pressure, to meet limited time. Basically, for the estimator to be able to improve his estimating techniques, it is important that the form of contract documentations are more concise and that materials are kept spearately from labour in the bills of quantities.

5.7. Summary:

To be able to control material wastage effectively, it is essential to know how much waste is experienced. Site waste accounting is therefore necessary. The measurement of waste involves three basic stages:-

recording of all material delivered to site, measuring stock of materials, on site and measurement of work in progress. It is found best to measure waste monthly possibly at the same time as the interim valuations are being conducted.

The idea of waste accounting brings about a change of attitude of the estimator to his approach to the waste problem. Traditionally, he only simply includes waste allowances in his estimates assuming that waste is being covered by these allowances. With waste measurement, more accurate assessment are arrived at and the feedback of these waste performances on site helps the estimator to compare the waste allowances with the actual wastes on building sites.

C H A P T E R 6

"FIELD RESEARCH ANALYSIS "

6.1. Analysis of the Field Work

Site Photographs

6.2 Comparison of Waste in Ireland with Nigeria.

6. FIELD RESEARCH ANALYSIS.

Within the limited time of 4 months given for the completion of the thesis 1½ months of my time was devoted for a field research work. The main aim of the research was to ascertain some basic understanding of some points as they exist regarding building material wastage in Ireland.

The research took the forms of questionnaires, personal interviews with site managers of reputable construction firms in the country and presently carrying out the construction of traditional buildings (domestic and commercial buildings). Industrialised form of construction was not covered by the research due to lack of adequate time given for the thesis.

In all, 11 sites were visited, 6 successful interviews were conducted and out of 40 questionnaires sent out to individual firms, 21 of them were returned.

Due to lack of co-operation from many sites, not many photographs were taken but a few taken are included here to indicate the various ways in which material handling, stacking and storage could frequently lead to wastage of materials on sites. The results of the field survey are summarised under the following headings.

1. Degree of Waste:

The level of material wastage on building sites is significantly recognised by the industry and is vast in nature. Unfortunately the building industry is not giving this aspect of site problem an adequate consideration and effort towards its reduction, not less of its elimination. Wastage of materials on the site cannot totally be eliminated as unavoidable waste occurs even under perfect conditions of design and production. Effort can only be made to reduce its magnitude.

Though most sites do not keep records of material wastage, the popular opinion is that, the amount of material waste ranges generally between 5 to 10% of the total value of material needed for a project. The lack of recording and accounting systems in most firms makes it difficult to ascertain the value of loss in money terms resulting from waste. A few firms that try to keep these records seldom achieve results with any degree of accuracy as this responsibility is usually given to site clerks or foremen. These persons not only lack skill in carrying out this accounting responsibility but have little time to devote to it.

If material controller is assigned to a large site, or in the case of a small site an efficient material clerk is specifically assigned, a considerable level of accuracy may be obtained and appropriate steps taken to reduce waste.

2. Areas with Largest Quantity of Waste:

Waste occurs throughout the industry irrespective of size of the building organisation, the value, type and duration of a contract but some form of buildings and areas of construction process attract more waste.

Due to the amount of cutting, joinery works, material handling etc., involved in traditional form of construction, it is evident that waste occurs more in traditional buildings than in industrialised buildings where most components are factory manufactured. Care should however be taken during their transportation to the site and within the site. Within the traditionally constructed buildings, it is the opinion of many that waste is usually more experienced in construction of domestic buildings (housing) than in commercial buildings (e.g. offices). Obviously housing with more sanitary fittings, numerous partitions, decoration etc. will conceal more waste.

During construction, it is important to have a knowledge of the stage at which more care should be taken to avoid waste. From response to my questionnaires regarding this aspect, it is noted that waste is more experienced in superstructural work. However, the amount of waste resulting from substructural work such as over-digging of trenches and the subsequent concrete blinding work should not be undermined. Brick/blockwork ranks high in the rate of waste, especially breakages that occur with the facing bricks.

One of the responses to the questionnaires regarding this aspect of waste gives the following figures:-

Statistics from a Contractor's One Year Turnover.

Material	Total Quantity Used	Percentage Waste.
Concrete blinding	$3,000m^3$	30%
Structural Concrete	$42,000m^3$	5.8%
Concrete Blocks	300,000 no.	10.51%
Facing Bricks	600,000 no.	10.90%
Hardcore	20,000 tonne	12.84%

The foregoing has briefly indicated some areas with large quantity of waste. This aspect of the waste problem is dealt with in more details in Chapter 4.

3. Responsibility for Waste:

It will not be right or justified to lay the blame for material waste on one particular person or group of persons involved in the erection of a building. The responsibility for waste concerns all members of the design team, material manufacturers and suppliers and even the building owner.

Very often inadequate briefs are given to the architect by the client at the

planning stage. At this stage he may only have a broad idea of what he actually wants. The design team are then left with a wide range of imagination to suit his requirements. This leads to numerous variations at a later stage causing disruption of overall programme, the flow of materials and changes in material requirements. Time, labour and materials are wasted and lost as a result.

Designers in most cases lack the idea of design /production interaction. In the construction industry, the design process is entirely separated from the construction process. Sometimes specified material sizes, length etc. have to be changed due to site conditions and methods of construction which ultimately result in material waste. There should be co-ordination of activities between all parties to the contract to avoid excessive overall wastage.

Though waste is not only a site problem,excessive wastage occurs during the building process due to lack of good site management and supervision. The result of my recent survey indicates that more than ½ of the amount of waste occurs on the site.

4. Forms of Contract and Contract Arrangements.

Amount of waste will vary with the form of contract and contract arrangements entered into. In negotiated contracts for example, methods of construction may be discussed in the course of negotiating the contract price, producing saving in time, labour and materials.

Design/build system encourages the contractor who is also the designer to try to alleviate waste. He becomes easily aware of the importance of his duties and responsibilities towards reducing waste, which otherwise would reduce

his overall profit.

On the other hand, competitive tendering systems attracts a high rate of waste. Naturally all drawings, the bills of quantities would be completed before tendering. Any variations in material requirements after the contract has commenced will be welcomed by the contractor as extra costs of doing so can be claimed.

Where labour only sub-contracts exist such as in brick/blockwork, there is no incentive on the contractors to cut down waste as it is not their responsibility to purchase the materials. The level of waste however also depends on supervision and site management.

In my survey, majority of the people agree to the suggestion that this form of arrangement results in more waste than in normal contracts. Generally the use of labour only sub-contracts is fast diminishing in the country.

5. Waste Allowances used in Estimating:

In theory, the material management performance of a site should be fed back to the estimator in order that a company's estimates reflect the same performance in the field.

In practice, this seldom takes place. Many estimators simply use the historic material waste allowance values, usually 2.5%, 5%, 7%, 10% or even 12.5% in certain cases. These allowances are referred to as 'norms' and are applied arbitrarily to each material irrespective of its usage, variety form of package or method of delivery to the site.

As a result it is found that these figures allowed for waste by the estimator under-estimate the actual value of waste of that material in most cases. In practice less than 50% of the waste allowances used in pricing tenders,

provide inadequate value for the actual amount of waste experienced on the site.

6. Material Control on Site:

On the site, the main material control systems may include:

(i) checking schedules, drawings and contract documentation.

(ii) checking materials on site for quality and damages.

(iii) directing off-loading, placing and storage of materials.

(iv) measurement of work in progress and stock on site.

(v) certification of invoices for correctness.

(vii) chasing up queries, delays or material shortages.

Presently in this country the attitude to waste control systems needs an improvement. This responsibility is left to the hands of less influential and efficient persons in the organisation, such as the material clerks or foremen who spend less than 1/5th of their normal working time on matters relating to material wastage control.

7. Site Security and Vandalism:

The security of materials on the site should not be overlooked. Majority of building materials are damaged or disfigured either accidentally or wilfully by children coming into the site after the working hours. Some materials and small hand tools are often stolen by these outsiders or lost through pilfering by the operatives. Fencing of the entire site and provision of locks help to reduce waste through this source.

The building industry fortunately, is not a major suffered of vandalism. The survey indicates that less than 1% of the waste is caused by lack of security and by vandalism.



1. Concrete Blocks badly stacked.



2. Scaffolding Components at Risk.



3. Waste Resulting from Operations.



4. Materials Left wasting on muddy area of the Site.



5. Damages Bricks and Chipped Conc. Blocks.



6. Timber Wastes Resulting from Cutting.



7. Bad stacking of Scaffolding Components.



8. Materials Left Unprotected.

Q U E S T I O N N A I R E

RE: MATERIAL WASTE AND ITS CONTROL.

(1) Do you keep record of the amount of material wastage on your building sites; if you do what percentage of materials is generally been wasted?

1 - 5%, ☐ 5 - 10% ☐ 10 - 20% ☐

(2) What type of building has higher rate of waste (a) Domestic, ☐

(b) Industrial ☐ or (c) Other ☐ Buildings?

(3) In what stage of construction process is wastage most experienced?

(Substructures ☐ Superstructures ☐ or finishings ☐)

(4) In what trade (Brickwork, Carpentry, Concrete Work etc. do wastes occur most: _____

(5) Who to your opinion is most responsible for waste of material in building:-

(a) Managers in building organisation ☐

(b) Manufacturers and suppliers ☐

(c) Designers of buildings ☐

(6) How much waste is caused by vandalism and lack of security?

1 - 5% ☐ 5 - 10% ☐ or above 10% ☐

(7) Labour only Subcontracts are believed to result in more rate of waste than in normal contracts, Is this true? Yes ☐ No. ☐

_____

_____

_____

(8) In practice a normal percentage allowance is provided in the estimate for material wastage. In what percentage of these contracts is waste allowance adequate?

Above 50% ☐ 40 - 50% ☐ 30 - 40% ☐ Less than 30% ☐

(9) Do you have specific persons assigned with the responsibilities for material control? _____

(10) If this is the responsibility of the site supervisors, how much of their normal working time is generally spent on activities concerned with material control?

(½, ☐ 1/3, ☐, ¼ ☐ 1/5 ☐ or less ☐

(11) What material control systems do you recommend? Is coding system recommendable?

Yes ☐ No. ☐

(12) In general do you favour and believe that further research into the problem of material waste in building will be beneficial to both client, the Contractor and to all of the building design team? Yes. ☐ No. ☐

RESULT TABLE OF THE QUESTIONNAIRES.

	Questionnaire.	No. in Support (Yes)	No. Opposing (No)	Percentage. 1-5%	5-10%	10-20%	20-30%	Above 30%
1.	Do you keep records of the amount of material wastage on your site; if you do what percentage of material is generally been wasted.	12	9	5	16	-	-	-
2.	What type of building has higher rate of waste?							
	(a) deomestic	14	-	-	-	-	-	-
	(b) industrial	5	-	-	-	-	-	-
	(c) other buildings	2	-	-	-	-	-	-
3.	In what stage of the construction process is percentage most experienced?							
	(a) substructures	6	-	-	-	-	-	-
	(b) superstructures	11	-	-	-	-	-	-
	(c) finishings	4	-	-	-	-	-	-
4.	In what trade do wastes occur most							
	(a) Brockwork/blockwork	12	-	-	-	-	-	-
	(b) Carpentry	-	-	-	-	-	-	-
	(c) Concrete work	9	-	-	-	-	-	-
	(d) Others	-	-	-	-	-	-	-
5.	Who to your opinion is most responsible for waste of material in building							
	(a) Managers in building organisation	10	-	-	-	-	-	-
	(b) Manufacturers & Suppliers	3	-	-	-	-	-	-
	(c) Deisgners of buildings	8	-	-	-	-	-	-
6.	How much waste is caused by vandalism and lack of security	-	-	18	3	-	-	-
7.	Labour only sub-contractors are believed to result in more rate of waste than in normal contracts. Is this true?	20	1	-	-	-	-	-
8.	In practice, a normal percentage allowance is provided in the estimate for material waste In what percentage of these contracts is waste allowance adequate?						16	5
		86						

Contd...

	Questionnaire	No. in Support (Yes)	No. Opposing. (No)	Percentage. 1-5%	5-10%	10-20%	20-30%	Above 30%
9.	Do you have specific persons assigned with the responsibilities for material control?	7	14	-	-	-	-	-
10.	If this is the responsibility of the site supervisors, how much of their normal working time is generally spent on activities concerned with material control.	-	-	-	-	13	8	-
11.	What material control systems do you recommend. Is coding system recommendable?	8	13	-	-	-	-	-
12.	In general, do you favour and believe that further research into the problem of material waste in building will be beneficial to both the client, the contractor and to all of the building design team?	21	-	-	-	-	-	-

Summary:

Total number of sites visited:	=	11
Number of interviews conducted	=	6
Number of Questionnaires sent out	=	40
Number of Questionnaires returned duly answered	=	21

All photographs included are taken on the residential buildings sites visited in Dublin to indicate the likely situations that would frequently give rise to material wastage on building sites.

A BRIEF COMPARISON OF GENERAL MATERIAL WASTAGE IN IRELAND WITH THAT EXPERIENCED IN NIGERIA.

While the general principles of material waste holds for the industry in any country, there are, in my opinion some differences in the magnitude of waste in some areas worth identifying.

Due to the limitation in the length of this thesis, I would like only to briefly summarise these differences under the following headings:-

(i) Types of material and methods of construction used.

(ii) Effect of weather and ground conditions.

(iii) Material delivery and material handling.

(iv) Site management/site supervision.

(v) Site security and vandalism.

Types of Material and Method of Construction:

Some materials attract more waste than others. Materials used in Ireland differ to some extent from those used in Nigeria. Take for example, the roof covering materials - in Ireland the use of roof tiles as roof covering for pitched roofs is common. In Nigeria, however, roofing sheets are more commonly used. Considering the amount of waste of these two materials, I would say that tiles have more risk of damages during transport-ation, storage and site handling than say aluminium or asbestos roofing sheets.

Concrete blocks are more commonly used than bricks in Nigeria. In general assessment, the magnitude of waste is more in brickwork, especially the facing

bricks commonly used in Europe.

On the other hand, ready mixed concrete is rarely used in Nigeria. Most concrete is site-mix Historically, site mixed concrete operations cause more wastage than the ready-mix just delivered to the site, despite the amount of care required to avoid any incidence of concrete getting hardened before being used.

If other materials are compared in a similar manner, it can be proved that the amount of waste differs from one country to another depending on the type of materials and method of construction being used.

Effect of Weather and Ground Conditions:

Generally, the effect of weather contributes a great deal to the level of waste on the site. With a very high temperature (say average of $27^{o}C$) great care should be taken, with concrete to prevent it from getting hardened within a very short time. If concrete is left in Nigeria unused for the same time as it would suffice in Ireland, it may become a waste.

However, bagged cement, timbers and a few other materials deteriorate more quickly in this country due to the damp weather than they would in Nigeria. Also the sites being too muddy here most materials such as bricks, falling nails etc. are easily buried into the ground adding to the amount of waste.

Material Delivery and Material Handling:

Shortage of materials could be a worldwide affair but this problem is much more acute in some parts of the world. Nigeria is major suffer of material shortage. As a result, delivery of materials to target dates is usually a failure despite all planning. Materials are therefore in most cases

delivered at odd times resulting in long period storage, change in sequence of building operations etc. A considerable amount of materials are often lost or wasted as a result. This factor of waste though existing is very minimal presently in Ireland as over 60% of local building materials are being used by the construction industry.

Apart from irregular deliveries, the method of deliveries and means of transportating materials in Nigeria create more risk of damages. For example, most materials are delivered to the sites in loose form. Packaging and kitting of materials is rarely done by the suppliers. Rough roads add to the damages of materials in transit (e.g. fragile materials such as glass).

Handling of materials on site like off-loading is mainly carried out manually by unskilled operatives. Majority of the firms are small scale businesses with no mechanical plant for such operations. One can imagine the amount of breakages that would be recorded if bricklayers have to climb up ladders onto scaffolds in the first and second floors with concrete blocks - which often happen on majority of sites in Nigeria.

These factors result in higher rate of waste of materials in Nigeria than can be found in Ireland with comparatively regular deliveries and with mechanical material handling methods on building sites.

Site Management/Supervision:

While there are some very competent management personnel, and site supervisors in Nigeria, majority of the site are being manned by inexperienced and unqualified managers and foremen. In majority of cases, unskilled workmen are assigned the works requiring skill and experience. For example, inexperienced bricklayers or carpenters could be used for very important jobs.

This misuse of workers leads to rough handling of materials resulting in careless waste than it would have been under normal circumstances.

Security/Vandalism:

In this respect, the level of waste is comparatively the same. More attention however needs to be given to the provision of site fencing as a means of deterring vandalism in Nigeria. This is presently not happening on most sites.

Generally, it is likely that the greater amount of waste that may be experienced in Ireland due to effect of weather will off-set the differences in waste resulting from type of materials used and from vandalism. But due to poor material delivery and handling and due to inefficient site management and supervision, it is my view that the general level of material wastage is higher in Nigeria (no statistical evidence of material wastage is now yet in record in Nigeria).

CONCLUSION.

The extent or scope of waste in the building industry is vast in nature. Material wastage results from many causes right from inception of a project to its completion and even during its maintenance period. Waste should not be seen only as a physical loss of a material (direct waste) as it is always thought to be but also be seen from the monetary point of view. Waste can be an indirect waste, which normally only represents a monetary loss. For example, a production waste as described in Chapter 2.

Unavoidable waste occurs even under ideal conditions of design and production. Cutting of timber to regular dimensional shapes for example, is unavoidable as trees do not grow with regular shapes to form such requirements as timber boardings or joists. Attempts however, can be made to reduce the cost of doing so, i.e. reduction in the cost of labour, plant and time used in obtaining the required shape.

Avoidable waste on the other hand can be prevented as it is caused by default. Though not only a site problem, most of the avoidable waste occurs on building sites. Control of avoidable waste is therefore within the powers and influence of the building contractor.

Material control can be defined as ideal design, specification and documentation, packaging, transportation, reception, handling, storage and protection, and co-ordination, so that waste is minimised while other resources employed in the construction process are used efficiently. It is therefore necessary to control material wastage right from the design stage.

Design should be economical and should meet both the aesthetic and functional requirements. It should take into consideration the ease of construction process and material handling. All specifications for materials should aim at avoiding variations in requirements in later stages of construction.

At the planning stage, material control should be delegated to a responsible person. Calculation for the principal materials required should be carried out and orders for their supply with all the necessary specifications placed. Storage and stacking positions for materials, plant and equipments should be determined before materials are actually delivered to the site.

When goods arrive on site, they should be checked to ensure that their quality and quantities conform with the orders placed. It should be ensured that the goods are unloaded at the correct places and as close to their points of use as possible. Stacking should be made safe. Materials should not be stacked too high and not on sloping grounds. Stock should be protected against effect of weather and from children and other trespassers.

While moving materials on site to their points of use, they should be handled with care. Vehicles or plant used should be suitable and not be overloaded. It should be ensured that issuing of goods are not in excess of the required amount for the tasks to be performed.

At the working place, care should be taken especially by the operatives to avoid damage to materials. Material aids, such as nail boxes should be used by each carpenter. Arrangements should be made for regular collection of all large pieces of materials left behind after say, cutting works and

returned to the store or stockyard.

At the completion of a job, it should be ensured that records are kept of any materials transferred to another site or credited to the site. All surplus materials should be collected and returned to the store or stockyard.

Unless the extent of material waste encountered on the site is known, it may be difficult to effect full material control measures. So material accounting has an important role in the application of material control. It is now recognised that the traditional allowances used by estimators are generally far less than the amount of waste normally experienced on sites. Reconciliation of waste at regular intervals and at the practical completion enables a feedback of waste calculation for the whole project. This therefore provides the estimator with the means of comparing the waste allowances with the actual waste for the project.

The first and most important step to be taken towards reducing waste on site is a change of attitude of all personnel involved. The general management of a firm should identify, recruit, train, motivate and encourage those performing material control function. All necessary responsibilities and authorities should be given to all concerned with material control. Site security and supervision of operatives and sub-contractors should be arranged to guard against vandalism, theft and pilfering of materials. The use of labour-only subcontract arrangements where possible, should be avoided as it is generally believed that these increase the amount of material wastage.

Effective material control reduces incidence of waste and consequently increases the contractor's overall profit. To the client, the use of

material control to avoid variations in material requirements and their subsequent payments, reduces the overall project cost.

The problem of waste is therefore worth tackling. In addition to educating and training personnel to appreciate the significance of material wastage on building sites, there is need to co-ordinate and encourage more research activity in the fields of material control and waste.

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