AN INVESTIGATION INTO THE CAUSES OF VARIATION IN LABOUR PRODUCTIVITY ON CONSTRUCTION SITES.

By

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DECLARATION

I, JEDIDAH MUTHONI NYAGAH, hereby declare that this thesis is my original work and has not been presented in any other University for any degree.

Signed

With the supervision and approval of

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ABSTRACT

This study set out to investigate the major causes of variation in labour productivity on construction sites in Kenya. Labour productivity is one measure of the efficiency with which the human labour is assessed. Any variations in labour productivity will affect the construction project. A decline in productivity causes an increase in the time necessary to complete the project and the total cost of the project.

It has been established from literature that technical and human factors are among the factors that cause variation in labour productivity. These factors are within the control of the management of the construction firm. This is the main assumption of the study. The study investigated the extent to which the technical and human factors predominate. Linear multiple regression analysis was used, in which the labour productivity was the dependent variable and the technical and human factors on the site the independent variables.

The study has established that human factors are more important determinants of labour productivity than technical factors. This was found to be true for both the activities of walling and concreting that were studied from a number of sites under investigation. The most important human factors in the study were related to financial benefits

which shows the importance the construction labourer attaches to his wages. Other factors such as machinery and equipment did not show much variation because they tend to be the same in most sites. The study concluded that labour productivity in sites investigated can be improved through monetary based productivity improvement schemes, such as incentive payment.

The study is organized in five chapters. Chapter one introduces the problem and its setting, states the objectives of the study and the assumptions of the study. Chapter two of the study forms the literature review. The concept of productivity and productivity measurement are discussed. The technical and the human factors that affect labour productivity are reviewed. The same chapter makes references as to the relevance of these factors to the construction industry and the construction site.

Chapter three outlines the management organization of a construction site. The main aspects of the management that directly affect labour and its performance are discussed in relation to the case study.

In the fourth chapter, it is outlined how the data was collected and analysed. The analysis showed the factors that affect labour productivity and the degree of their effect.

The last chapter, draws the overall conclusions and recommendations of the study. In this chapter the implication of the final models is discussed in details and recommendations given. Bibliography and appendices appear at the end of the study while footnotes appear at the end of each chapter.

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DEDICATION

This work is dedicated to my father

Mr. Fredrick Nyaga

for taking me to school.

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CHAPTER ONE

INTRODUCTION

Statement of the Problem

Welfare of national economies as well as that of individual enterprises is widely regarded as being dependent on a country's natural resources and the ingenuity and productivity of its people. Labour productivity is one measure of the efficiency with which the human labour is used. With all the resources limited, productivity is important in any sector of the economy. The construction industry is one such sector where labour productivity is important. Any changes in construction industry's productivity affect the national product both directly and indirectly. The level of construction activity in a country is mainly a reflection of the needs of the population. Inadequate increases in productivity will mean sharper rises in construction costs with adverse social implications and declining work for the construction industry.

The construction industry is one of the indicators in the improvement of the economy. Construction activities generate demand for transportation of building materials such as stones, blocks, ballast, sand, timber, furniture, cement, paint etc. In turn the production of such materials require additional labour input which create demand for consumer goods. In Kenya over the last six years, there has been a decline in building and construction activities.[1] The decline is partly explained by increasing building costs and the credit squeeze by financial institutions in the country. The decline in building and construction activities is bound to affect other sectors of the economy.

As indicated in table 1, the combined building and construction cost index increased by 12.7 per cent in 1984 compared with 5.2 per cent in 1983. A break down of the cost index reveals that the large rise in 1984 was attributable to 43.5 per cent increase in labour costs. This rise in labour cost index was due to a change in using "basic income" as opposed to the "wage guideline" which was being used earlier. The former is a better measure since it includes annual increments, leave allowance and other fringe benefits on top of basic salary. The combined building and construction cost index increased by 6.8 per cent in 1986 when compared with an increase of 12.7 per cent in 1984. The slow rise was attributed to lower increases in 1986 for both materials and labour costs. Despite the slow rise in the combined index the increase in the cost of labour was more than that of materials. The changes in labour costs were mainly due to rises in monthly basic wages for unskilled, semi-skilled and skilled labour within the sector.

From the above information, increase in labour cost can be said to be the major factor pushing up the building and construction cost index in recent years. This clearly shows the importance of labour in the construction industry and the need to increase the efficiency of labour in the industry as a whole. Since site labour contributes about 40% of the output in a project,[2] there is the need to improve labour productivity in the construction site in order to check on the rising building

Table 1.1: Annual Percentage increase in Building and Construction Cost Indices in Kenya, 1982-86

	MATERIALS					LABOUR					TOTAL COST				
	1982	1983	1984	1985	1986	1982	1983	1984	1985	1986	1982	1983	1984	1985	1986
Residential Building	12.7	8.2	0.8	14.5	5.4	22.3	-	43.5	10.7	9.5	14.1	6.9	6.9	13.8	6.2
Non-Residential Building	11.7	5.1	0.7	10.8	7.1	22.3	-	43.5	10.7	9.5	13.7	4.1	8.9	10.8	7.7
All Buildings	12.2	6.7	0.8	12.9	6.2	22.3	-	43.5	10.7	9.5	13.9	5.6	7.8	12.4	6.9
Other Construction	17.0	6.8	11.6	7.6	5.2	22.3	-	43.5	10.7	9.5	18.7	4.7	21.2	8.7	6.7
Total Cost Index	14.6	6.8	4.2	11.0	5.8	22.3	-	43.5	10.7	9.5	15.6	5.2	12.7	10.7	6.8

Source: Economic Survey 1983 and 1987. Central Bureau of Statistics.

and construction cost index.

The planning and management of the total industry poses the greatest challenge to those concerned with increase in construction productivity. This is mainly as a result of the nature and organization of the construction industry. Organization in the construction industry exercises less control over the market than in any manufacturing industries. The construction industry unlike the manufacturing industry is less able to mould its market or to take advantage of market trends. Therefore organizations in the industry must be able to manage their affairs so that uncertainty is accommodated without incurring the cost of low utilization of resources. As a result of the uncertainty there is lack of commitment and an ever present threat that resources will have to be redeployed when completion of current tasks is frustrated. Taken together these depress utilization of resources, particularly those committed to fixed ends. In order to escape the consequences of low utilization, the industry has evolved a fragmented structure by specializing in tasks rather than by building types because this leads to greater continuity of work.

Subcontracting and specialization on the one hand, and a relatively slow rate of progress on the other hand which are responses to uncertainty, have the unfortunate consequences of reinforcing the uncertainty from which management seeks to escape. This is because sub-contracting, and the lack of commitment of resources to specific ends, makes it difficult for any organization to exercise effective control over progress and hence over the commitment of resources. Construction involves the co-operation of main and sub-contractors, many of the latter being nominated by the client and likely to look to the client rather than to the contractor for future work which must reduce contractor's ability to manage the work on the site.

As has been explained the building industry has resolved the problem of uncertainty by having few resources committed to specific ends, that is by having relatively high direct costs. But most measures to improve productivity run counter to this tendency by sharply increasing the proportion of indirect costs.[3] Any gain in site productivity can be easily eliminated by disruptions caused by incompetent management of the industry or the firm. However, this does not mean that there are no gains to be obtained from improvement of productivity at the site level.

There is no absolute definition of productivity related to the construction industry. Several definitions have been combined and adopted to construct working definitions of construction productivity. Fenskes, Ruch and Herchavers[4] have jointly provided a working definition of construction productivity thus:

> Productivity is the magnitude of productiveness; the amount of output produced by a unit of productive factor per unit of various inputs, with all other factors of production considered as variables, where one or more of these factors are held constant, it will be stated.[5]

This is a broad definition which can include all the construction process variables and the productive factors to make possible the establishment of a cause and effect relationship between them.

Accurate measurement and comparison of construction productivity between projects or firms is hampered by the absence of a generally accepted index. Productivity is not well defined at project, site and plant level. Most measurements have been concentrated on the partial productivity of labour, that is, output per man-hour and efforts to develop increasingly meaningful productivity measures in the construction industry seem to be unrecorded.[6]

Construction labour productivity has long been a topic of conversation among building clients.[7] It is still shrouded by confusion, misunderstanding and conflicting viewpoints of cause and remedies. Loss of labour productivity is not only a concern to the contractors for whom it means a decline in the net profit, it is also a concern to the client because a decline in productivity causes increase in the time necessary to complete the project and the cost. Construction activities are also slowed and the contractors overhead costs increase. Delay in completion lengthens the period of owner's withholding of contractors retention, thus increasing the contractor's cost of funding the work. Works capitalization period is also increased by the delay in completion.

In Kenya the problems associated with the loss of labour productivity are present. However no attempt has been made to investigate the major causes of variations and decline in labour productivity on construction site. Contractors are complaining about the low output from the labour force. When output is low, this results in the contractor spending a larger sum of money than anticipated, thus reducing his final profit.

Many building construction projects have been abandoned with the work half-way or nearly completed for various reasons. Other projects have been delayed beyond the date of completion, while others have overrun the estimated costs. Majority of the causes of the above problems are either the inability of the contractor to fund the works or poor planning and schedulling of the works. These can be traced back to the management of the construction firm involved. It is generally accepted that management activities play a significant role in influencing productivity and hence the need for management in the construction firm to improve labour productivity at site level.

If labour productivity at site level can be improved, this improvement will be reflected on the productivity of the construction industry as a whole. From research carried out in Britain, the results supported the need for productivity improvement in the construction industry particularly in house building.[8] Increased productivity can provide vital benefits that may be combined in a number of ways. For example, better quality materials for a building may be afforded from the same monetary investment; alternatively based on improved productivity a building may be produced with less money. Productivity in the construction industry tend to be poorly supported, though not due to a poor case for support to improved productivity, because infact the client has a lot to gain from improved productivity. The advantages of improved productivity must be communicated to the building client and the construction team alike. Productivity is infact given greater priority in other industries than in construction. This prevails for many reasons, but mainly due to the quality of our knowledge concerning the process of construction on the site and the important relationship between the construction process and design.[9]

This study sets out to investigate major causes of variation in labour productivity on building construction sites in Kenya. This study will try to identify what factors cause variation in labour productivity. Among some of the factors often cited in literature are technical factors and human factors, all of which are under the control of the management. This study will investigate to what extent these factors predominate.

Study Objectives

The primary objective of the study is to investigate the major causes of variation in labour productivity on building construction sites in Kenya. The study will attempt:

(i) to identify the technical factors which affect labour productivity on construction sites. It is recognised that some factors will increase labour productivity while others will cause loss in labour productivity.

(ii) to similarly identify the human factors, that cause variation in labour productivity on construction sites.

(iii) to draw conclusions,on the implications of these factors on labour productivity of a firm and the construction industry.

(iv) and to finally evaluate possible productivity improvement methods which the management of the construction firm can use with the aim of improving labour productivity on the construction sites.

The study hopes to shed some light on the major causes of loss in labour productivity on building construction sites which are within the control of the management. With the knowledge of these factors, the management of the construction firm will be able to determine the appropriate steps it can take to remove those factors which cause loss in labour productivity and implement the most effective approaches towards management of the construction labour in order to obtain higher productivity.

The need for productivity analysis cannot be overemphasized. Productivity measurement is a tool which yields a series of figures and ratios and without analysis they are meaningless. The analysis reveals what are the causes of productivity increase or decrease, and leads to action to improve productivity through better allocation of resources, improved working methods and more efficient utilization of inputs to produce more output of higher quality.

The productivity improvement should come from better utilization of available resources and fuller utilization of the prevalent working capacity. With proper analysis a manager should be able to increase output without necessarily increasing inputs or maintain the level of output with less inputs.

It is intended that the research will expose some of the inherent weaknesses in labour management practices in the Kenyan owned construction firms which have adverse effect on the labourer's output. Other inputs are lifeless, whereas labour consists of human beings capable of thinking, subject to emotional fluctuations and above all possessing the ability to innovate. Any attempt to raise productivity must take into account how individual human beings react and interact.

On construction sites, especially in operations which are labour intensive, labour productivity is more likely to be determined largely by what the workers do and their attitudes to work, than what the machines do. Sometimes an improvement in technology is more than offset by changes for the worse on the human side of productivity so that productivity which should go up actually goes down. Thus it is imperative that attention is paid to the human resource input even in times of innovative advances in technology.

The Study Hypothesis

The basic hypothesis of this study is that lack of proper management by a construction firm is the main cause of low labour productivity. That is to say, variations in labour productivity are caused by both technical and human factors within the control of the management of a construction firm. The technical factors on a construction site which affect the labour productivity include materials availability, tools availability, quality of raw materials, layout of the site, method and technique employed in performing the task, complexity of the building, amount of work available, the plant and equipment used i.e. capacity and percentage of capacity utilized, amount of necessary redo-work, and planning and scheduling of jobs.

Apart from technical factors the other factors which affect labour productivity are the human factors. Though human factors are difficult to quantify or to be expressed in monetary terms, they are never the less an important determinant of labour productivity. Labour, unlike other inputs in a construction project which are lifeless, consists of human beings capable of thinking, subject to emotions and possessing the ability to innovate. The human factors depend on the quality and the motivation of the labour force. Hence the contribution of the labour force to productivity results from the quality and motivation. It then follows that both quality and motivation are necessary and one cannot be a substitute to the other.

There are basically four labour variables that affect quality of labour, namely education/training, the physical condition of the worker, age-sex composition and the effort actually exerted by the worker. The level of education, experience, training and interest affect the knowledge of a labourer. A worker who has had a higher level of education and training in a particular craft of interest and also worked for a long period in the craft is more knowledgeable in the craft than another who has received little or no education, training, experience and has little or no interest in the craft. The aptitude and personality of a labourer affect his skill. Skill is not as a result of knowledge; it is in a person. A worker can exhibit great skill in a craft although his education level is lower. The physical condition of the worker is affected by his diet and prevalence of diseases of various sorts such as malaria, hookworms and other debilitating diseases. These diseases amongst others adversely affect the physical condition of the worker. Lack of adequate food or even unsuitable diet adversely affects the worker, resulting in a weak malnourished person. The sex-age composition affects labour productivity. Construction work is dominated by men because the task involved is usually strenuous manual work requiring physical strength. Thus the effort exerted by the worker in carrying out his duty depends on his physical condition and the sex and age.

Understanding productivity and the labourers attitude towards his work must begin with the basics of workers motivation. Motivation results from interaction of the forces in the physical conditions of the job, the social conditions and individual needs (Suitemeister 1969).[10] It is the interaction of all these factors present on a construction site that will cause high or low motivation.

The study however recognizes that labour productivity is not the same on all building construction sites because the technical and human factors may vary from site to site. This means that the needs and priorities of firms may require change from time to time in which case management practices should be sufficiently flexible and adaptive to the changing needs.

The Study Area

The study area comprised of five case studies. These were construction projects situated within Nairobi Province. The five projects selected were on-going projects, each managed by a different construction firm. This was to avoid duplication as taking two construction sites managed by the same firm might not have given any clue as to the cause of variation in labour productivity. The reason for this is because most likely the sites would be managed in a similar manner by the same team of management.

The firms from which the five on-going projects were selected comprised firms registered with the Ministry of Public Works in various categories. The ministry registers building contractors in various categories, ranging from A to F, according to the size and complexity of the project the firm can undertake. The size and complexity of the project which a contractor can undertake is measured in terms of the cost of the project. The main reason for choosing contractors firms of various sizes was that the technical and human factors present in their sites were likely to differ.

The five projects selected consisted of a variety of both small and large building projects. The reason for choosing a variety of projects was that the management of a small site will show some difference from that of a larger one, though size alone is not the cause of this difference. All the firms selected were owned by Kenyans. The reason for choosing Kenyan owned firms was that the study aimed at investigating local building construction firms and not multinational firms. Multinational and international firms usually have a different set up which is more related to the headquarters in the mother country than to the countries in which they operate.

Nairobi Province was chosen as the study area for the reason that, it is easily accessible and hence poses no transport problems. The modes of transport available included buses, "matatus" and taxis, to and from the sites throughout the whole day. The second reason was that there was more building construction work being carried out in this area as compared with other areas. Projects of all sizes and complexity can be identified in Nairobi as it is experiencing rapid urbanization.

There is demand for residential buildings to house the ever increasing rural immigrants and the increasing population.

This demand generates work for housing construction among others. Factory and office buildings are also in demand to accommodate the increasing labour force. This demand can only be met by constructing more new buildings or expanding the existing ones. This is despite the fact that since 1981 the amount of building construction work being carried out has been declining as indicated by the contribution of the construction industry to the Gross Domestic Product (GDP) in the (Economic Survey 1983). The industry is still comparatively busy especially in rapidly growing areas like the major towns in Kenya.

For each of the five sites chosen for investigation, only the two major activities of concreting and walling were observed. The activity of concreting consisted of a number of tasks. The concreting observed was that of the ground floor slab. Basically the tasks involved included feeding the raw materials into the mixer, mixing, transporting the concrete to the point of placing, placing and finally compacting. There were variations in the method and technique of concreting depending on where the placing is taking place and where special mixes are involved. The activity of walling observed consisted of the construction of external walls. The activity walling consisted of various tasks i.e. of transporting of the blocks to point of assembly, mixing the mortar and bedding the blocks. These two activities were the samples of activities chosen to be used to measure labour productivity on the construction site.

The reason for choosing these two activities was that they are common in about all types of building projects carried out in the study area. These two activities also take up a large proportion of the direct work on the construction site and thus a large proportion of site labour, especially concreting. The most common form of construction to be found in the study area was traditional load bearing wall construction and framed construction. In both these forms of construction a large proportion of concreting and walling is carried out.

Another reason for choosing concreting and walling was that these two activities are labour intensive. They both and especially concreting require all categories of labourers whether unskilled, semi-skilled or skilled labour. Unskilled labour was readily available in Nairobi area so there was no problem of shortage or short supply. Skilled labour was still not readily available. Kenya's rate of unemployment has risen sharply in recent years and in its wake the country has been experiencing a disturbing trend whereby thousands of jobless "wananchi" (citizens) have been migrating from the rural areas into urban centres in search of employment.[11] The availability of casual employment on construction sites has therefore been a highly welcome opportunity of easing the unemployment situation in the urban areas.

Scope of The Study

The study of labour productivity can be applied to all human activities and at every level from a single operation to a whole industry. The levels at which productivity studies can be carried out in construction range from studies of, single operations, gangs, construction processes, sites, production shop or whole organizations. At other levels of greater generality productivity studies can be at the productivity of trades, professions, general processes or sector of the industry.

At each of the above levels, the studies can have different objectives or aims. Some of these may be to identify levels of productivity, to analyse working methods or to estimate the effect of sociological factors. Others may be concerned with technical issues such as the problems of observations, sampling or variability. For the results of any productivity study to be comprehensible to those not directly concerned with the study and be comparable with other studies, it is imperative that the study accurately defines the circumstances to which it applies.

This study sets out to investigate the technical factors and human factors which affect labour productivity on building construction site. The study will examine each case study to determine the technical factors and human factors present and will then attempt to find the relationship between labour productivity in the selected operations and those factors that are present.

The study however realises that with the amount of funds available and the time limit it is not possible to study all building operations involved in a construction project.

The study will concentrate on examining the effect of those technical factors and human factors under the control of the management of the firm. Their effect on labour productivity on each respective site is what is of importance to the study. The technical and human factors to be investigated have been identified through literature review and through preliminary site visits.

The study has been organized into five chapters. The first chapter forms the introduction to the study. This chapter includes the problem statement, the study objectives, the study hypothesis, the study area, the scope of study and lastly the research methodology. The literature reviewed is discussed in chapter two which forms the theoretical framework on which this study is based. This chapter considers literature related to the concept of labour productivity, technical factors and human factors. Towards the end of the chapter these factors are theoretically tied together through management.

Chapter three comprises an outline of management organization of a construction site as it relates to the case studies. In chapter four the analyses of the data collected is carried out and the results presented. This chapter contains the summary of the findings and their implications on the construction industry. Recommendations with respect to possible solutions applicable in the construction industry as well as recommendations of further areas of research form the last part of this chapter.

Footnotes appear at the end of each chapter following the order in which they appear. Selected bibliography appears after the last chapter.

The Research Methodology

The study was conducted through field study. This started with the preparation of questionnaires for use in subsequent field surveys. There were two sets of questionnaires; one set was used to interview the management of each of the selected firms and the other was used to interview the labourers involved in the activities studied. The aim of the questionnaires was to gather information on the management and organization of each of the construction firms by identifying line of authority in the firm, personnel policies and other company policies directly affecting the labour force. The questionnaires appear as appendix B(1) and B(2).

The second part of the study was field observations. The field observations were carried out on concreting operation in each site for five working days. The field observations were also carried out on walling operations in each project for five working days. A data collection form was developed for recording job characteristics, inputs, outputs, physical working conditions, equipment and tools used, technique and method employed in the activity, job layout and any delays or breaks.

The standard procedure on each site was as follows. Appointments were made through the contractor to go to the selected site. After the first visit to the site the contractor was interviewed using the relevant questionnaire previously prepared. On the first day on the site the observer was also introduced to the foreman and the supervisor of the activities to be studied. The foreman had been informed previously of the purpose of the observer. The observer was then taken round the site, after which she was shown the working drawings in the site office. The purpose of the drawings was to aid the observer in locating and sketching the job layout and the amount of work at hand.

At the earliest possible time the labourers involved in the activities to be observed were told that the observer was studying the method and technique of laying a concrete slab/ walling and also interested in interviewing them. The interview would be on their personal views about construction work; this was done so as to avoid hostility. The observer made all possible effort to prevent the labourers from thinking that she was supportive or related to any management function. She made sure that they understood she was only observing the techniques and the problem it poses. The labourers were further assured that the study was independent and that all the information would be confidential and not given or told to the employer. This made it possible for the labourers to air their views freely. With all the above assurance to the labour force the observer proceeded with the data collection.

For each of the five days the field work was to be carried out, the observer went about her work in the same manner, arriving some minutes before the work was scheduled to commence. The observer then noted the site conditions and the extent of work previously accomplished. The time the labourers started their work was recorded. The observer then noted the number of operatives carrying out each activity, recording the number of unskilled labourers and the number of skilled (masons) labourers.

The information on the number of skilled and unskilled labour involved in the activity was obtained from the foreman or supervisor. The observer then recorded the equipment and tools being used, their number and type, the materials being used and their quality i.e. whether dirty or clean, new or second hand. After doing this she then sketched the job layout. The observer also recorded the method by which the activity was carried out; this consisted of a brief discription giving the number of tasks each activity was divided into and the manner in which the labourers were divided up among these tasks. Any break in the working day was recorded and the duration of the break noted down.

At the completion of the days work after the work had stopped the observer noted the progress of the work over that of the previous day and measured the amount of work carried out. All the recordings were done in the data collection form. The observer then interviewed the labourers who may not have been interviewed over lunch hour. Where the same labourers were involved throughout the study period, then the interviews were only carried out on the first day alone.

The above daily procedure just outlined was carried out for both concreting operation and walling operations. The concreting operation selected was concreting of the ground floor slab, using concrete 1:2:4 mix. The walling operation selected was construction of solid concrete block walling. For this study care was taken to select model activities that can be clearly seen and qualified. Daily work accomplishments could be measured easily and accurately. Both the activities under observation could be broken down into a few definite tasks. This allowed an observer to track down the output.

The ease with which observations were carried out was further enhanced by minimal dispersion of the labourers on the construction site because the work proceeded in specific areas with all the men in the same area. This was the case in both the selected activities. With the collected data, the analyses consisted of determining the relationship between the technical and human factors found on each site to the labour productivity on that site. This was done using a multiple regression model.

The study however has realised that in both the activities under investigation, both skilled and unskilled labour was utilized. The ratio of skilled to unskilled labour in each of the activities varied, the same ratio also varied from site to site. For example on one site the ratio of skilled to unskilled labour was 1:2 and in another 1:3 in walling. For the purpose of working out the total number of hours spent on the activity i.e. the labour hours to be used in the calculation of the productivity index, it was found necessary to weight the skilled labour.

Since the skilled and unskilled labour received different levels of pay, the hours worked were weighted by relative value in terms of pay scales.[12] In the study the weighting factor was based on the hourly wage rate of an unskilled construction worker as 1, the wage rate used was the current minimum wage rate for Nairobi area published in the current issue of the Joint Building Council (JBC) price list. The wage rate per hour for unskilled labour as published in the above price list was taken to equal 1. The weighting factor of the skilled labour was then calculated. The weighting factor for a mason was calculated as follows:

$$\text{Weighting factor} = \frac{\text{Wage of mason/hr.}}{\text{Wage of unskilled labour/hr.}}$$

The weighted hours for the mason was then equal to number of hours worked multiplied by the weighting factors, and this was added to the unskilled labour hours worked to arrive at the total number of hours worked in the activity. This total was used in the calculation of the labour productivity index for each respective activity.

The reason for using the current wage rate in the calculation of the weighting factor was because it is a fair estimate of how much the contractor spent on each skilled labourer as compared to the unskilled and thus it was assumed it showed the contribution of the skilled labourer to the output as compared to that of the unskilled labourer.

The study also realised that weather could cause variation in labour productivity on a construction site. Depending on the weather conditions loss in labour productivity may be experienced. During extremely inclement weather such as flooding, construction work could all together grind to a halt. Weather was thus held constant by conducting the study within the same period when the weather was assumed to be constant, i.e. during the dry season.

Another factor which the study realized could cause variation in labour productivity on construction sites was their geographical dispersion. Geographical dispersion may cause variation in labour productivity on sites located in different regions due to such factors as infrastructure existing in the region, employment rate and materials availability among others.

The effect of geographical dispersion was held constant. This was possible by selecting all the projects from the same geographical region. Nairobi Province alone was chosen in an attempt to remove the effects of geographical dispersion of the sites from among the list of possible causes of variation in labour productivity on construction sites.

The data obtained from the field survey and the questionnaire was analysed using statistical methods.

The method which was used in this study is multiple regression. The conceptual productivity model in this study took the form of multiple regression function expressed as follows;

$$y = f(x_1, x_2, \ldots\ldots\ldots, x_n)$$

assuming a linear relationship exists between y and $x_1, x_2, \ldots\ldots\ldots, x_n$, then it can be expressed as

$$y = a + b_1x_1 + b_2x_2 + \ldots\ldots\ldots\ldots + b_nx_n$$

where, y = labour productivity per man hour

a = constant representing minimum productivity or the y intercept.

$b_1 \ldots b_n$ = partial regression coefficients

$x_1 \ldots x_n$ = independent variables assumed to affect labour productivity.

The x variables are those assumed to be the most relevant quantifiable independent variables affecting labour productivity.

Thus, if it can be established that a relationship exists between any of the independent variables and the labour productivity, a model can be developed. This model can be used to identify the variables which cause either an increase or decrease in labour productivity. The same model can rank these variables in the order of their importance, and can also tell us the magnitude of the effect on productivity of each variable.

In this study there will be four regression models. In the first model, labour productivity in concreting activity will be regressed against the technical factors affecting the productivity in concreting. In the second model, labour productivity in walling will be regressed against technical variables affecting productivity in walling. In the third model labour productivity in concreting will be regressed against human factors of productivity. The last model and the fourth one, labour productivity in walling will be regressed against human factors of productivity.

The relationship between the independent and the dependent variables in the above models will be tested at the 95% confidence level, allowing for 5% error. The null hypothesis states that there is no relationship between labour productivity and the technical or human factors as the case may be. On the other extreme the alternative hypothesis states that there is a causal relationship between labour productivity and technical/human factors. At the above confidence level the hypotheses will be accepted or rejected using the F statistic. A comparison will be made between the F-values obtained from the computer printout of the regression models, referred to as calculated F values, and the F value tabulated in Neave's statistics table at appropriate degrees of freedom.

FOOTNOTES

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CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter reviews the literature related to labour productivity and its measurement in general. It discusses factors that affect productivity, both technical and human, and makes references as to the relevance of these factors to the construction industry. For ease of reference, the chapter is divided into three sections namely; the concept of productivity, human factors of productivity and technical factors of productivity.

The Concept of Productivity

Few concepts can be subject to as many different definitions and interpretations as the term productivity. It is generally accepted that the concept of productivity involves the relationship between inputs and outputs, but this concept eludes precise definition. Dunlop, J. and Dratchenko, V.[1] noted that the term productivity even when modified by objectives, is still rather broad. Different measurements with the same name are possible, and a variety of figures are infact published. This makes it necessary for all who discuss productivity to make it as clear as possible what it is they are talking about and what the measurements mean.

Productivity in the sense of output compared with inputs relates to a whole family of concepts rather than to any specific member of that family. Almost any comparison of output with input is covered by it. Output may be defined in various ways, however, and input maybe measured by one factor or another or by several factors in combination. Further, productivity may be the relationship between output and the inputs of one factor, all other factors being kept constant as in an experiment under controlled conditions, or it may be output and the input of one factor with changes occuring in all other factors. Still further productivity may be the relationship between increment in output associated with the addition of one unit of a given factor of production, that is, it may be "average" or "marginal". Thus economists writing on the theory of marginal productivity use the term quite differently from statisticians who compute indices of productivity.

From the above, the use of the term productivity relates the volume of output to input where the output figure may be measured in physical units or value. Input is in most cases limited to labour, hence the use of the term labour productivity. This term is used when the production is considered in relation to the input factor labour.

The Organization for European Economic Co-operation

(1955)[2] came up with three clearly defined labour productivity concepts: specific productivity, total productivity and the net productivity of a factor. Productivity measurement is seen to fall under either of the above three concepts. Specific productivity is obtained if production is considered in relation to a given factor so that:

$$\text{Specific productivity of labour} = \frac{\text{Production}}{\text{Visible labour}}$$

Total productivity on the other hand may be defined as the relationship between the volume of production and the total volume of labour included in the production cycle so that:

$$\text{Total productivity labour} = \frac{\text{Production}}{\text{Total labour (Visible and incorporated)}}$$

Total productivity can be linked to the specific productivity of the various factors and represents their weighted average.

Net productivity of labour is defined as the ratio of net product which is produced, less external force to visible labour so that:

$$\text{Net productivity of labour} = \frac{\text{Net Product (Production - External Force)}}{\text{Visible labour}}$$

The foregoing productivity concepts relate to industry in general and not specifically to the construction industry. There is no absolute definition of productivity related to the construction industry. But following a similar pattern of definitions to those used in other industries it is possible to arrive at a working definition of construction productivity.

An attempt to arrive at working definition of construction productivity has been provided by Shaddad and Piltcher (1984)[3]:

> Productivity is the magnitude of productiveness; the amount of output produced by a unit of productive factor per unit of various inputs, with all other factors of production considered as variables, where one or more of these factors are held constant, it will be stated.

This is a broad definition which can include all the construction process variables and the productive factors to make possible the establishment of a cause - and effect relationship between them. However it provides an approximate definition of productivity related to the construction industry given the diverse nature of factor inputs required for a given unit of labour output.

In this study, it has been found necessary to adopt this as a working definition of construction productivity, and the unit of productive factor in this study is the labour. Labour productivity in this study therefore will be taken to mean the amount of output produced by a unit of labour per unit of various inputs with all other factors of production held constant. This definition will be sufficient since the study seeks to establish the relationship between labour productivity and human factors, or technical factors, and not the relationship between labour productivity and other factors of production.

Labour Productivity Measurement

The efforts to develop increasingly meaningful productivity measure in the construction industry seems to be unrecorded.[4] It is also found that productivity measurement is not well defined at both project, site and plant level. The most important thing to consider when selecting a productivity measurement is the relevance of the ratio obtained from the measurement to the needs of the study and whether it is the most meaningful for the purpose of the study.

Productivity measurement can be carried out at national, sectorial or firm level. At each level the methodology may be different to suit the situation. In this study productivity measurement will be of a technical nature at the firm level. The main problem in measuring productivity in this respect is the problem of choosing a measure of quantitative results of production. The measure may be a physical unit, a standard unit, total production expressed in comparable prices, commodity production (production earmarked for sale by the enterprise at comparable prices), net production at comparable prices, production expressed in terms of working time and production expressed in terms of constant wages.

"In many cases the application of only one measure is insufficient, and two, three or four measures have to be selected to throw light on the problem from different angles so that a comprehensive analysis of the dynamics of labour productivity can be made on that basis."[5] However for the purpose of this study the application of one measure will be sufficient. The measure applied will be the physical unit of production since the study aims at finding out the causes of the variation in labour productivity. The measure of output will be the physical output while that for labour will be the visible labour measured in terms of manhours worked.

The methods of measuring labour productivity have been found to differ greatly in detail according to the aim in view. The European Economic Community (1955)[2] has considered two main categories of productivity measurements. The first is the measurement of Economic character and the second is the measurement of a technical character. The principle aim of the second is to bring out differences in productivity as between individual firms. It is the second measure which is of relevance to this study.

But a general observation is that most methods of measurement actually seem to almost all fall within a common plan covering four successive stages. The four stages include; determining the scope of the study, measuring production and its contributory factors, collecting basic data and presenting it and finally interpreting the results. In determining the scope of the study, the time and space limits within which data is to be collected is fixed. The field of activity to be studied at plant level can be determined at this stage and the exact nature of the information required. In an investigation of the technical type it is essential to work on a representative sample because the aim is principally to bring out differences in productivity as between firms. Such studies are mostly limited to fewer than twenty firms.

Once the scope of the study is determined, the next stage follows, which involves measuring production. At this stage it is necessary to set the units in which production and its factors are to be expressed in. The physical labour unit is normally based on time (a year, a day, an hour or one minute) and is always assumed that the same period of time is equivalent for all classes of wage earners. Armed with the units of measurement the next stage is the collection of basic data. Basic data is obtained either from existing data or direct measurements through observation and special account kept by firms; the presentation and interpretation of results is a matter of choice depending on the objectives of the study. Results may be expressed in form of a fraction i.e. the inverse of the productivity of the factor. In a study of technical nature, an attempt is often made to explain the reasons for any divergencies revealed.

It is realized that the measurement of labour productivity in this study is direct and of a technical nature. The four stages outlined above refer to general characteristics of direct productivity measurement method as seen by European Economic Commission. This is in reference to the manufacturing industry, and hence for it to apply in the construction industry there is the need to modify the method to suit the condition in construction sites.

The Human Factors

In attempting to improve labour productivity most attempts have concentrated on technological improvements designed to reduce labour man hours. Certainly this emphasis on improving construction equipment, methods and materials have greatly assisted modern day construction. Unfortunately, complex technology has generated a feeling that management action produce a minimal and ill-definable effect on labour productivity. For this reason, the study of management strategies on labour productivity in the construction has understandably been largely neglected.[6]

It is worth noting that construction labour unlike other inputs has life and is capable of thinking and innovation. Management must then act on the human factors in order to influence labour towards the organizational goal of the company. For the management to act on the human factors, first and foremost it should be in a position to understand them and the factors on which they depend. This is necessary in order to devise a productivity improvement strategy which will be successful. It is generally assumed that the human factors result from the quality of labour and the motivation of labour.[7]

Measures of Quality of Labour

It is universally recognised that the quality of labour affects workers productive performance.[8] It has also been recognised that there are basically four labour variables that affect quality of labour, namely education/training, the physical condition of the worker, age-sex composition and finally the effort actually exerted by the worker. These four variables can be taken as the measures of the quality of labour. Though these apply to industry in general, there does not seem to be any reason why the same should not be applied to the construction industry and specifically to the construction site. This is because quality is a basic requirement in labour no matter where it is used.

Suitermeister (1969)[7] suggested that the ability of labour results from the knowledge and skill possessed. Knowledge , he further stressed is affected by education, training, experience and the interest of the worker in his job. Shen and Suitermeister have also emphasized the importance of education and training as ingredients for good quality labour. Through education and training, improved productivity of the workers can be achieved.

Since training and education are the main measures of the quality of labour in industry there does not appear any evidence that the same is not the case on the construction site. The other measures of quality of labour which are important in the construction industry are the physical conditions of the worker, and the sex-age composition. The effort exerted by the worker depends on the physical condition and the sex-age composition. Thus the effort exerted by the worker in itself should not be taken as one of the measures of the quality of labour.

Effects of Quality of Labour on Productivity

Training is proposed by many as a significant if not the most significant factor to successfully improving productivity. Much literature exists on training of workers at all levels. But this study will concentrate on the basic training of the construction labour as it affects the productivity of the construction worker directly involved in the production of the building and not management training. The literature reviewed here is therefore related to the training of the workers and the role of the management of the firms in training.

Training and development of manpower to provide the skill that will enable them to work more efficiently is an important part of productivity improvement. Training in this sense is taken to mean the acquisation of knowledge which was previously absent, and which is necessary to achieve the change requried in the worker. Training must have a purpose if it is to be of any use to the worker and the management. The training programme should be tailored to fit the training needs of the company, after an investigation into the training needs of the company has been carried out.

Training of workers can take place at three levels depending on the requirements of the company. This is training of the management staff, training of supervisory staff and training of the workers. The training of workers involves the following four main stages[9]:

(i) Appreciation for senior managers to enable them to direct and use the skills acquired by the subordinates.

(ii) Basic training generally in the classroom to give a clear understanding of the technique or skill at a theory level.

(iii) Practical training generally in the classroom to acquire the basic skill or use of technique and finally;

(iv) On the job training. This involves continuing guidance and instruction by supervisors and managers in the day to day use of the new skill.

From experience it would in many cases seem that the problem with training is not the course content, but rather how management perceives and provides for training needs. With a properly established training department which can carry out training needs survey and implement training programmes relevant to the needs, then improvements in the productivity of the workers can be expected. Relevant training will thus result in increased productivity in construction firms where training is provided for improvement of the quality of the labour.

The other factors which determine quality of labour are education, physical conditions of the worker and the sex-age composition. Education can not be over emphasized, since the higher the education level the better the quality of the labour force. It would then follow that with a well educated labour force increased productivity would be expected. The level of education a worker has usually determines the kind of employment which he can obtain. A person with ordinary level education will not find it very difficult to get employment in the manufacturing sector or the public service sector. This leaves all those persons with lower levels of education than the above and those who have not had any formal education to seek employment on the sites. This means that on the construction sites most of the labour force has got very little or no formal education at all, but this does not imply that such persons cannot be trained effectively to do various tasks on the site which do not require much formal education.

The physical condition of the worker depends on several factors. These factors are, diet, state of mind and the absence of diseases. The last two factors are not serious with the construction workers, and especially those working in Nairobi. The reason for this is that there are enough public medical services in Nairobi and so it is easy to get treatment for any ailment. The state of mind is important for any worker, but it can be assumed that once a person has set to do a certain job then his or her mind is on it.

The diet is a crucial factor determining the physical condition of any worker, be it a manual worker or a clerk in an office. A hungry man cannot work properly. The ILO report (1960)[10] said that inadequate diet, wrong diet and even lack of enough food was a concern in Africa, which really affect the productivity of the worker. Malnutrition can then be said to cause a decrease in the productivity of the workers.

It is therefore evident that a labour force with good physical conditions is expected to be more productive than one which is opposite. On the sex-age composition, this affects productivity because the human male and female are distinctively different in terms of the physical strength which each can exert. The male species is physically stronger and can handle manual work better than the female. Thus men workers on a construction site are more productive than their women counter-part. The age of the worker also affects the quality. Very old men above the age of fourty and very young boys are not as productive as those between the age of 20 and 40 years. One reason for this is the strength associated with each age. Very young persons are not strong enough for physically exerting work because they have not yet developed the endurance. Very old men on the other hand are too frail to handle such work.

<u>Motivation</u>

In order to understand the labourer's attitude towards his work, one must begin with the basics of workers motivation. The first step is to define what motivation is. Human motives are based on needs whether consciously or subcon-consciously felt. These needs vary in intensity and overtime, in different individuals. Human motivation can thus be best understood in terms of the needs experienced and the different means by which these needs are satisfied. When a need is aroused, an individual develops a drive towards a goal or incentive. This process by which behaviour is energized is called motivation.

Theories of Motivation

Many management theorists have come up with different theories on motivation. This stems from the fact that there are so many different ways to view human motivation. The different theorists and researchers often sound as though they are dealing with entirely unrelated subjects and exhibit a tendency to treat a single aspect of motivation as though it were the whole, or as though it were the only part that really matters.

In this section the various motivation theories will be reviewed. These will be the more fundamental theories. The reason for this is because many later theories are based on the earlier theories. In the review, its aimed to show that a number of different theories can all be valid since they lead to practical outcomes. It is realised that a knowledge of motivation theory provides a framework for drawing generalization, and for analysing novel motivation problems. After looking at these various theories, in the next section a motivational model for the construction worker will be built, based on these theories.

In 1960 McGregor [11] challenged traditional attitudes towards managing people by presenting two theories, Theory X and Theory Y as being representative of the perception held by management towards subordinate. The theory X hypothesis stated that the average man is by nature indolent, he lacks ambition, dislikes responsibility, prefers to be lead and is inherently self-centred, indifferent to the organization needs and resistant to change. According to this theory, the management must motivate these workers, control their actions and modify their behaviour to fit the organization.

On the other hand, Theory Y was the opposite of Theory X. It stated that men are not inherently negative and resistant to organizational goals but that they have become so as a result of their experiences. Depending upon controllable conditions, work may be a source of satisfaction or a source of punishment. External control and the threat of punishment are not the only means for bringing about the efforts towards organizational objectives. The acceptance of this theory would then imply that motivation is not readily attributable to the work force.

Other works have tended to support McGregory's hypothesis that motivation is an important ingredient of a productive workforce. The most notable works are the research efforts of Maslow [12] and Herzberg [13] that explored how to motivate workers. Maslow described motivation in terms of needs. In Maslow's theory, the needs were ranked in a hierarchy. In the need hierarchy, the hierarchy was viewed as applying to people in general. The hierarchy of needs gave needs in five ranks. The needs starting, from the lowest need were, physiological needs, safety needs, belonging or social needs, esteem needs and self-actualization these are presented diagramatically in figure 2.1.

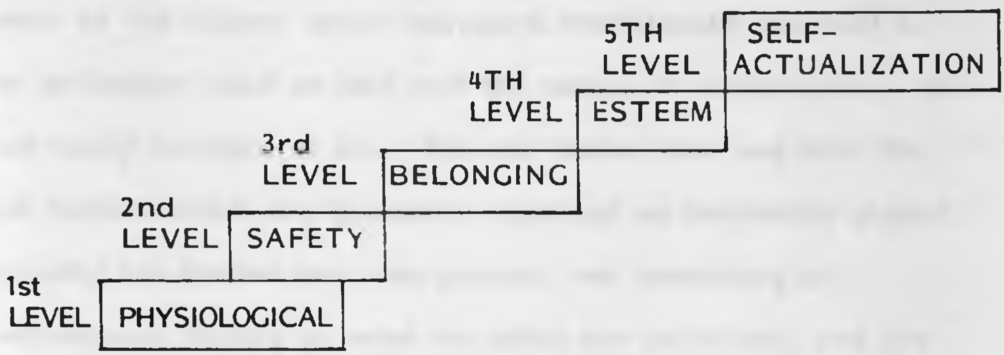

Fig. 2.1: Maslow's Hierarch of Human Needs

In Maslow's need hierarchy, a higher level need cannot be fulfilled until a lower level one has been satisfied. Modern management theory has accepted Maslow's hierarchy of needs as a reasonably good description of reality. However the theory contains some drawbacks. One, is the fact that it has never withstood experimental testing. Non the less the theory has some direct or indirect contributions towards the field of motivation. The theory called attention to three important points on human needs. These points are that satisfied needs do not motivate, a shift in employee need should be expected depending on the general economic conditions, and lastly the management level persons develop needs at the self-actualization level.

Another researcher, Herzberg in his two-factor theory suggested that the factors involved in producing job satisfaction are separate and distinct from the factors that lead to job dissatisfaction. From his studies he concluded that many of the factors which managers traditionally believed to be motivators such as pay and the nature of supervision, do not really motivate at all. The two factor idea was that the job factors which are generally regarded as motivators should actually be divided into two groups; one consisting of motivational factors or what he called the satisfiers, and the other consisting of maintenance factors as the dissatisfiers. According to the two-factor theory Maslow's lower level needs are dissatisfiers not motivators. Further more according to Herzeberg until the demotivators are removed, the improvement of job context would be largely ineffective. Table 2 gives the factors.

Hygiene Factors (Dissatisfiers)	Motivators (Satisfiers)
Company policy and administration	Achievement
Supervision	Recognition
Salary	Work itself
Interpersonal relations	Responsibility
Working conditions	Advancement

Table 2.1: Herzberg's Two-Factor Theory.

Suitermeister (1969)[14] in his descriptive model of management and productivity viewed motivation as resulting from interaction of forces in the physical conditions of the job, social conditions of the job and individual needs. Depending on the forces prevailing in the job, their interaction will result in either increased productivity or decreased productivity. He further noted that the relationship between need satisfaction, morale, employee's job performance, and productivity was much too complex for us to assume that satisfaction of individual needs would automatically lead to better job performance and increased productivity.

The above model has put together parts of the other theories which were reviewed earlier on. In the case of individual needs, the author has placed them in accordance with Maslow's Need Hierarchy. He sees the needs as following under three major types, these are physiological needs, social needs and egoistic needs. According to the descriptive model, physiological needs are the lowest level needs followed by social needs and the egoistic needs are the highest level needs. This seems to agree with Maslow's theory.

The physical conditions of the job and the social conditions of the job, in the descriptive model are infact, the hygiene factors in Herzberg's Two-factory theory. According to Herzberg these hygiene factors prevent dissatisfaction but they do not lead to motivation. But Suitermeister states that these conditions are necessary in order to motivate the worker, such that when these conditions are at their best assuming the needs are also met then the individual will be motivated.

But the author has also noted that the subjective feelings of the employee and the way they view the physical changes rather than the changes themselves seem to influence motivation. But this does not mean that the management should ignore physical working conditions and make no effort to have them pleasant and comfortable.

The foregoing review of the theories of motivation is by no means exhaustive. There are others but the ones which have been outlined are those that are felt to be relevant to the study. It should also be noted that all these theories were based on the industry and not the construction industry and, thus they apply to industry in general. In the next section the study will consider the construction worker and will attempt to find out or to arrive at a motivation model for the construction worker.

Motivation of the construction worker

Having reviewed the various motivational theories which are relevant to this work, the next step is to determine what motivates the construction worker. In order to do this so as to arrive at a motivation model for the construction worker based on the behavioural theories which have been advanced earlier, there is need to understand the characteristics of the construction industry in terms of behaviour.

There are several distinct characteristics of the construction industry which are not found in other industries.

These are high labour mobility, specialization by trade, high turnover rate, physical risk and that promotion is not guranteed High labour mobility results from the form of employment in this industry. Employment and especially that of labourers is based on the duration of the project, but in most cases it is based on the duration of a task. On completion of the project/ task the workers are laid-off and may be re-employed again later in the same project on yet another task. Continuous employment in the same company for long period is thus not common at the labourers level.

The fact that people are hired and fired or quit rather frequently when compared with other industries makes the construction workers highly mobile. Thus the tenure of employment in the construction industry affects the workers commitment to the organizational goals of the firm. The worker is not able to identify with the goals and aspiration of the company since he is preoccupied with maintaining his employment for as long as possible.

The characteristic of specialization by trade is perfection oriented. Workers specialize by trades such that workers have titles which recognize competence in a particular trade, such as mason, carpenter, etc. The fact that these men tend to stay within their narrow field of specialization contributes to the impermanence of the labour force. The reason is that projects are usually segmented into many different tasks so that a specialized task will not last for the whole duration of the project. Unskilled workers and masons may be employed to carry out concrete work and wall construction, and once these tasks have been exhausted, then no doubt these workers are laid-off and have to look for employment elsewhere.

Another characteristic of the construction industry is high turnover. The high turnover is due to continuous search for a more rewarding job.[15] But it is not clear whether these individuals probably know exactly what they are looking for. This situation is an indication of a basic lack of fulfilment of the individual needs on the various jobs which he has worked. Thus the worker will move from job to job until he meets a job where he feels most of his needs are met.

The physical risk which goes with employment in construction cannot be overlooked. Construction work involves many different tasks carried out at the same time at different parts of the site by different people. These people handle materials which are bulky and sometimes dangerous to the health. The construction worker is thus always exposed to danger from harmful materials and mechanical injuries. Examples of dangers he is exposed to are falling objects from construction work at higher levels.

Another peculiar characteristic in the construction industry is that promotion is not guranteed. Promotion is based on knowledge and ability rather than seniority. Some labourers may rise from the ranks to become supervisors and even form their own companies but only because they have proven their capacity for responsibility. In the absence of this, a worker may be employed as a labourer and stay the same for the rest of his life without any promotion. This means that in this industry only those who adapt most readily to changes can expect to advance.

These construction characteristics which have been discussed above play an important part in the motivational behaviour of the labourer. It follows from the above characteristics, that in order for the management of the construction site to motivate the worker then, first the element of physical risk should be removed or minimized. This can be done by changing the physical conditions of the job to the optimum. The most important physical conditions of the construction work are rest period, safety from injury and temperature. Construction work is unique in that it is carried out in the open with the worker exposed to all the environmental elements which the management cannot control.

The second step towards motivation of the construction worker is the provision of the individual needs. In order to motivate the worker the individual needs should be met. For the construction worker the needs are ranked according to Maslows Need Hierarchy. The lowest level needs, the physical needs should be met. The physical needs include food, clothing and shelter. The wages of the construction worker, that is the basic wages should be enough to meet these needs. Once these needs are met, the management should then make the working atmosphere such that the labourers will have a sense of belonging to the firm. The highest level needs, that is, the egoistic needs are beyond what an ordinary construction labourer can hope to achieve and so these are not important in the motivation of the worker.

The other characteristics of the construction industry which are undesirable and should be removed in order to motivate the worker are high mobility and high turnover. These two are as a result of the tenure of employment. There should also be a way in which the job should be made more rewarding such that the labourers can identify themselves with the firm. These can be done through improving social conditions of the job. The most important social conditions in the construction site are continuity of employment, incentive schemes, decreasing labour turnover, strikes and disputes, absenteeism, improving system of supervision and having a strong labour union to speak for the labourers.

The movitation of the construction work is represented diagramatically on the figure 2.2. This model shows the management variables and how they cause motivation of the worker and how motivation finally affects the end product that is the productivity. The diagram does not show how the management variable actually motivates, that is, the process of motivation. This is complex and will not form part of the work.

THE MOTIVATION OF THE CONSTRUCTION WORKER

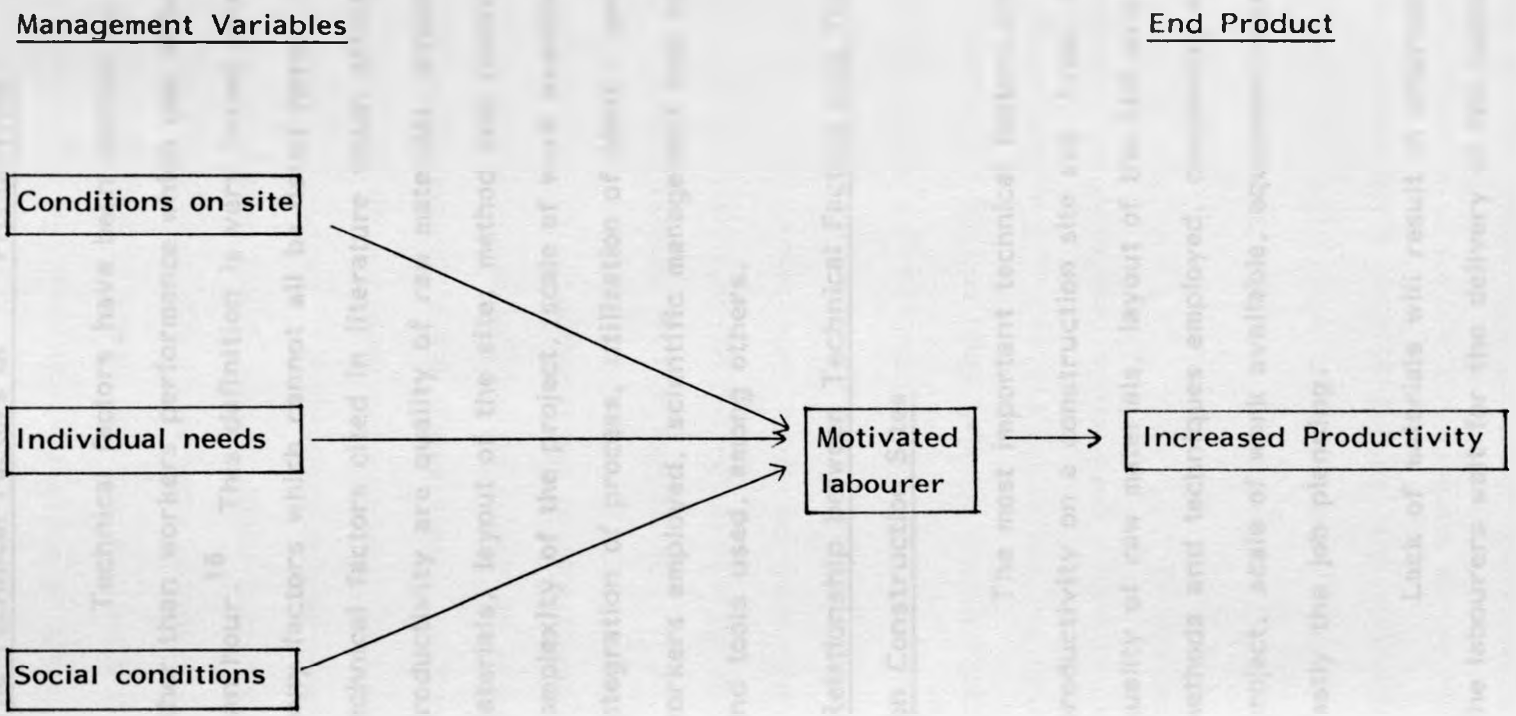

Figure 2.2

The Technical Factors of Productivity

Technical factors have been defined as all those factors other than workers performance which can affect output per man hour.[16] This definition is very broad and includes so many factors which cannot all be listed here. But among technical factors cited in literature which affect labour productivity are quality of raw materials, availability of raw materials, layout of the site, method and technique employed, complexity of the project, scale of work available, degree of integration of process, utilization of plant percentage of workers employed, scientific management and equipment, plant and tools used, among others.

Relationship between Technical Factors and Productivity on Construction Sites

The most important technical factors affecting labour productivity on a construction site are type, wastage and quality of raw materials, layout of the site and work place, methods and techniques employed, complexity of the building project, scale of work available, equipment and tools used and lastly the job planning.

Lack of materials will result in unproductive time while the labourers wait for the delivery of the materials. Insufficient material inventories result in both cancellation of scheduled activities and excessive delays when essential materials are not available. Insufficient or inefficient mode of movement of materials on a construction site will necessitate periods of waiting which result in unproductive time. Tools inavailability will also result in unproductive time and lost time for labour. Lack of enough tools will slow down the pace of work as a result of one group having to wait for the other to finish before commencing. Extensive requisitioning procedure for tools lead to work delays when tools are required on short notices. Tools which are of substandard quality which break easily or simply do not perform adequately will reduce the productivity of the labourer.

The quality of raw materials used is one of the factors that determine the method and techniques employed in performing the task. Low quality materials may necessitate double handling in most cases so as to render it more readily usable for the task. For example, sand collected from a contaminated pit may need seiving and washing before being used for preparing concrete. The seiving and washing is unnecessary work which results in low productivity in concreting.

The layout of the site in building construction is important. Poor layout, where the labourers have to transport materials over long distances, fetch water from far off points and where workers are subject to repetitive tiring movements in performing the work will reduce their productivity. The site layout should be so arranged as to make the performing of the different tasks as smooth as possible. The method and technique used is mainly determined by the quality of raw materials and the technology available to the construction firm. In the case of concreting, concrete can be hand mixed or mixed in a concrete mixer which is deisel or petrol operated.

The technology available to the contractor depends on the amount of plant and equipment he is able to own or hire for the task at hand. Technological improvement laying an emphasis on improving construction equipment will greatly assist construction by reducing labour man hours required to perform a task and thus increasing labour productivity. The amount of plant and equipment available to the contractor and the percentage of its capacity he utilizes will either increase or reduce productivity depending on the percentage of capacity utilized.

The complexity of the building project will affect labour productivity through site management. Problems of site management are determined largely by nature, number and inter-relatedness of tasks defined by the design. By determining the complexity of site operations, both technically and operationally, design impinges directly on the management of site as well as on the task performed. Technically and operationally complex operations arising from a complex building will determine the method and technique employed and also the material used, which in turn will determine the labour productivity.

The amount of work available will affect the rate of working of the labourers in that the more work they can see ahead the higher their rate of working will be because they are assured of continued employment but if the work available is little, then it would be expected that they will try to do less per day so that their time on the construction site is prolonged.

Redoing or reconstruction of work destroyed due to the work being defective or sub-standard in quality will demoralize the workers such that the productivity in redo-work would be expected to be lower than in new work. The demoralized workers will not put up the same performance as before. Poorly planned and scheduled jobs give workers negative attitudes which slow their performance. Conversely, jobs that are expertly planned and scheduled with little lost time actually stimulate workers to better performance. These technical factors that have been discussed are beyond the control of the workers and their immediate supervisors and are instead, the responsibility of the management.

The degree to which the technical factors given above affect labour productivity depends on several factors, such as the scale of mechanization of the tasks and also whether the task is labour intensive. In highly mechanized task it is expected that technical factors are more important than in another which is labour intensive. All the same, technical factors should not be ignored and the contractors should at least keep abreast with technological developments in the construction industry. This is important if they have to keep up in this competitive industry.

In his work, Thomas H.R.[17] (1984) classifies most of the above technical factors as demotivators. In his views unless these demotivators are removed then the workers cannot be motivated. Among the demotivators according to the above author are improper materials, inadequate material storage, improper installation, preventable clean up, planning error, design problems, materials availability, equipment breakdown, inadequate equipment and tools, scheduling conflicts, work sequence, insufficient manpower, work method, material waste, equipment damages and constructibility.

The author postulates that unless these demotivators are removed, then no matter what productivity improvement techniques are used, there will be no improvement. He further says that the origin of the inhibitors and demotivators is in planning. Construction projects require a lot of planning man hours to prevent existence of demotivators.

In this study, technical factors will not be considered as demotivators. They will be taken to be under the control of the management of the construction site. The management can only improve the labour productivity by removing those factors that cause a decrease in labour productivity and improving on those that cause an increase in labour productivity.

The study however realizes that technical factors and human factors are related. This is because some technical factors can affect the motivation of the workers. For the purpose of this study, the relationship between technical factors and the human factors will be ignored. This is to say that it will be assumed that technical factors are independent of human factors and vice versa. This study will thus look into how technical factors affect labour productivity and how human factors affect labour productivity on construction sites separately rather than jointly.

The table below lists the technical factors, and their possible effects on work and their assumed effects on labour productivity. This is the framework on which the effect of the technical factors on labour productivity on construction sites will be viewed in this study.

Table 2.2:

Technical factors, their effect on work and the assumed effect on labour productivity.

Technical Factor	Effect on Work	Effect on Productivity
Raw Materials		
Improper materials	redo	decreased productivity
Improper storage	delay	"
Wastage of material	delay	"
Quality of material	delay/redo	"
Layout of Site		
Crew interfacing	delay	"
Crowded work place	delay	"
Improper installation	delay	"
Planning		
Scheduling conflict	delay	"
Planning error	delay	"
Work sequence	delay	"
Methods and Techniques		
Poor methods	delay/redo	"
Improper technique	delay	"
Complexity of Building	delay	"
Scale of Work available		
Little	delay	"
Much	speed up	increased productivity
Equipment and Tools		
Improper	delay	decreased productivity
Damaged	delay	"

FOOTNOTES

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CHAPTER THREE

A SURVEY OF MANAGEMENT OF CONSTRUCTION SITES.

This chapter gives an overall picture of the management of a construction site as it relates to the study. In this chapter the main aspects of management organization on a construction site will be discussed, these include; organization of the firm, planning and programming of the work, site labour and training, safety on site and welfare on the site. These aspects will first be described and then discussed in relation to the case studies. Their possible effect on the productivity of the labour will also be considered.

Organization of the Firms

The organization of a construction firm can take various forms. The organization is influenced by the type of ownership and the size of the firm. The types of construction firms classified by ownership are as follows: sole proprietorship, partnership and limited company. These are the types of construction firms found in the Kenyan construction industry. Majority of the firms are sole proprietorships or partnerships. In sole proprietorship the firm is owned by one person and the same person is usually the general manager. In the partnership the firm is owned by several persons. These two types of firms have different legal personality.

The size of the firm is the other factor which influences the organization. Firms in the construction industry range from small, one man firms to medium sized firms and finally we have the large firms. Most of the small and medium sized firms are usually sole proprietorship. The size of the firm will determine whether the organizational structure is tall, broad or short. The form of ownership usually determines the distribution of the functions within the organization.

The organization and distribution of functions within the firms investigated and their various construction sites did not vary very much. All the firms investigated were sole proprietorship. Three out of the five firms were relatively small. The organizational structure of these firms was less clearly defined and division of responsibilities less formally established. The organization in the firms from the level of directors down to that of the chief supervisor in the site was largely based on personal relationships.

All the chief supervisors and most of the foremen, on all the sites were either relatives or had personal relationship with the directors of the firm. This made the organization of the firm look like a family affair. Both the technical and the administrative aspects of the firm in all the cases considered were controlled by the owner. Non of the sites was under the technical control of a qualified engineer as would be expected. The sites were mostly controlled by self-trained persons without formal college or technical institutional training. It was noted that the most qualified owner held a higher diploma in civil engineering. Despite these shortcomings in terms of qualified personnel, most of these firms seemed to be operating well in their environment and nothing can possibly be gained by advocating to them any greater formality of organization. The following diagrams show the organization types found in small and medium sized construction firms.

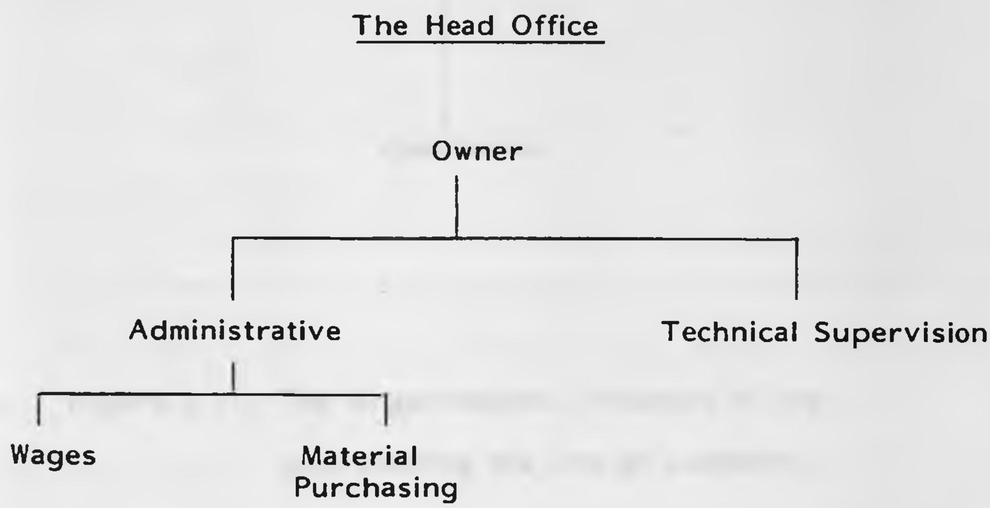

Figure 3.1: The Organization Structure of Head Office showing the line of authority.

The Site

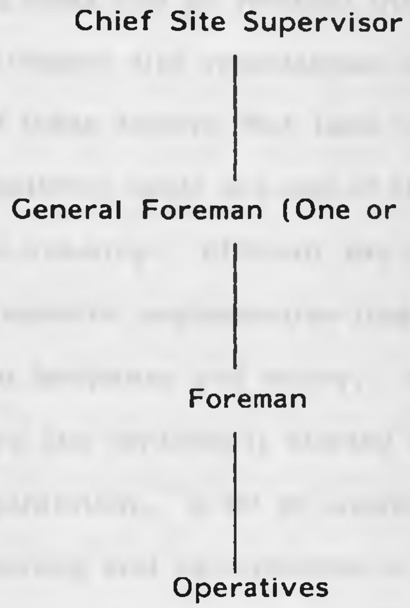

Figure 3.2: The Organizational Structure of the site showing the line of authority.

The organizational structure of the firm is important because it affects all the other aspects of the management organization on the construction site.

Planning and Programming of Work

Building costs can be reduced through efficient site organization. Efficient site organization should take into consideration all those factors that tend to increase building costs. Rising building costs are one of the major problems of the construction industry. Efficient site organization can reduce the amount of avoidable unproductive time. Unproductive time is a cost both in manpower and money. A detailed planning of production before the contract is started is an important factor in good site organization. A lot of unproductive time can arise from lack of planning and co-ordination of the work of the various trades involved.

The basis of any effective planning is a programme.[1] The programme should be a detailed schedule dealing graphically with every stage of the work. What most contractors call a programme is often merely target dates which they hope to realize and not a prediction of what they will actually achieve. A detailed and effective programme is devised to expose before the commencement of the work the problems and bottlenecks which are likely to arise in respect of the supply of both labour and critical materials at all stages of the work. Programming can be applied to any type or class of new construction.

Before a programme for the construction work is prepared its aim and the information it should provide should be defined. To be of maximum use the programme should:

(i) Show the most expeditious and economical method of carrying out the work, consistent with the available resources.

(ii) Provide continuous productive work for all the operatives employed and reduce unproductive time to a minimum.

(iii) Facilitate organization and control of the work by prior examination of all its aspects and, by the early consideration of possible difficulties ensure smooth and continuous progress on the site.

(iv) Provide accurate information relating to material delivery dates, the build-up of the labour force, the daily or weekly financial expenditure on labour and materials, and the quantity and capacity of plant required.

(v) Provide at any time during the course of the contract a simple and rapid method of measuring the progress that has been made for the builders' own information, and to check the architect's periodical certificate, or the valuation of work in progress for accounting purposes.

(vi) Contribute factual data for use in future estimating and planning.

Programming involves recognising the 'Key' operation. The operation taking the longest time is the key operation. In identifying the key operation allowance must of course, be made for any time required for drying, setting or curing in such operations as concreting and plastering. The key operations in traditional construction are normally blockwork in the superstructure and plastering in the finishings. In in-situ concrete construction the key operation in the superstructure is likely to be the curing time for the concrete in the suspended floors.

The most convenient stages in which to plan are the substructure, superstructure, finishings including services and equipment and finally external works. In each of the above stages there is a key operation which will control the speed of the work within that stage, and the longest of these four key operations will be the "master" operation. The manning and speed of this master operation will determine and control the speed of all other operations. When the building time and labour force for the master operation are fixed all the other operations should be brought into phase. It may be possible to complete some of the operations in less than the key operation time for the stage, but no advantage in overall building time will be gained ultimately and the site time for each gang should, wherever practicable, be made the same as that of the key operation by the adjustment of gang strength. The balancing of gangs is not possible with every trade because there are physical limits to the size of gangs in some operations. These operations should be dealt with intermitently. As this type of work is normally sub-contracted, periodic attendance can be arranged within the cycle of the key operation.

For the full benefits of the programme to be realised it is essential that tentative arrangements are made to compensate for any deviations within the stages themselves. For most operations gang sizes can be increased or overtime worked to compensate for delays. When implementing this programme, it is useful when the job is large enough to employ the same gang on the same section of work throughout the job. With smaller jobs and a restricted labour force for the key operations, the same gang or the same individual operatives should be, as far as possible employed repeatedly on the same group of operations.

The method of programming outlined above is logical and straight forward and can be used for any type of project which is relatively straight forward. But in very big contracts the programme can be varied to suit the circumstances. If the project is very large and the duration several years, a master programme for the whole project can be prepared. From the master programme smaller working programmes can be drawn for each section or phase.

The method of programming described in this section is one of the several which can be used. There are other methods of planning which have been applied in construction such as the critical path method. In all the five case studies investigated there was apparently no programming of the works. What there was in two of the sites was a chart showing the date of commencement of each operation and the expected date of completion for the same. On all the other sites there was no evidence of some form of programming. On those sites where there was a chart, the building work was divided into various stages. These stages included foundations, wall construction, roofing, finishes, plumbing and drainage and finally external works. As noted earlier the charts do not amount to a programme but are merely target dates which the contractor hopes to realize and not a prediction of what he will actually achieve.

To conclude the foregoing, it is important that the programme of work should be drawn before starting the site operations. The same applies to the planning of equipment and methods, selection of personnel and ordering of materials. It should also be borne in mind that the most important principles in planning for higher productivity are the reduction of double-handling and the establishment of balanced gangs working on repetitive work cycles.

In the next section, the two operations chosen for investigation will be discussed. These two operations are concreting and wall construction. In the discussion the operations will be described laying emphasis on the method, the materials and the planning of the operation area.

Concreting

The basic methods of producing in-situ concrete on construction sites are three. The first is mixing the ingredients at the point of use, the second is to mix at a point on the limit of the activity area and the third method involves the use of transported dry mix concrete from a base batching plant. The last method is usually referred to as ready mix concrete. The first method is the most common on construction sites. The method of production of concrete chosen on a site depends on many factors, such as the quality of concrete required, the cost outlay, the size of the site and whether a continuous supply is required.

The first method above which involves the production of concrete at the point of placing was the only method used on all the sites studied. The only variation was in the arrangement of the production area. One very important thing about planning of the production area is the fact that all concrete work is centred around the production area, and the steady movement of materials into the area and the product out of the area is of the greatest importance. In planning the production area, great care should be taken to ensure that there is a steady supply of the ingredients and a steady outflow of the mixed concrete. Excessive delay in transporting the mixed concrete may render it unsuitable as a result of partial set. It is therefore important to programme the work such that the mixed concrete is not produced at a higher rate than it is used or before the time it is required.

Materials and Storage: The main ingredients of concrete are cement, sand, aggregate, water in some cases additives to impact special qualities on the mixed concrete. It is important to ensure that these materials are not contaminated and are stored properly. Poor storage could result in contamination or spoilage. Each of the main ingredients will be discussed one at a time.

Cement is usually supplied in sealed paper sacks. These come in packs of 50 kilogrammes. The cement used is standard specification of the cement and any cement for use should not fall below this standard. The method of storage of cement on the construction site is crucial since poor storage or improper storage could result in partial setting. Cement which has partially set should not be used in construction. During storage, cement must be kept dry and thus cement should be stored in a shed protected from the elements of weather. The cement should not be stored on the ground but should be placed on an elevated platform to protect it from rising damp from the ground. The bags of cement should not be stacked more than four or five feet high to avoid "warehouse" set caused by compaction. It should also be used in the order in which it was received.

On all the sites in the study, cement was properly stored in dry sheds. The bags were stocked in many numbers ranging from 100 to 400 bags in one shed. The cement was only removed from the shed when required but not before then. The other method of supplying cement is in silos. The cement is supplied by a tanker from the manufacturers and at the site it is pumped into the storage silos. This method is usually used on very large sites where very large quantities are required continuously and the storage space on site is limited. The silo is expensive to purchase and generally this method is more costly and it is used only where the cost justify it.

The sand used in the construction work in and around Nairobi comes from Machakos District which is about 60 kilometres from Nairobi city. The sand is river bed sand and is harvested from dry river beds. It is delivered to the sites in lorries from the collection point. This sand is usually clean and free from contaminants such as vegetable matter. This sand is of good quality and usually does not require further treatment before use. It is at the point of storage on the site that the sand risks contamination. It is usually stock piled on the ground. The ground in most cases is not modified in any way. The sand is just tipped directly on the ground without first clearing the site off vegetation. At the time of use it is usual to scoop up some of the soil together with the sand thus contaminating it. Sand should thus be stored on a clean hard surface preferably on a screeded surface but not directly on the ground.

The course aggregate used, is usually broken stone, commonly referred to as ballast. Ballast can be purchased in one size or with different sizes of aggregate mixed together.

The quality of ballast depends on the parent rock. The ballast used in and around Nairobi is of similar quality since it is obtained from similar rock. The ballast is delivered to the site in trucks from the crushing plant. It is stock piled directly on the ground in the same manner as the sand, hence the problems of contamination similar to that of sand is present.

Both the aggregate and sand are batched by volume. In the sites studied, some of the contractors had boxes which were used to measure the volume of these two ingredients. The sand and aggregate were batched and then put into the mixer. The last ingredient of the concrete is water. Water is an important ingredient because it causes the mix to set. It is therefore imperative that the water is clean, and therefore reliable source of water for concrete is necessary.

The water for concreting should be clean and free from deliterious materials. On all the sites studied, the water for concreting came from the mains, but in most sites it was stored in large tanks near the point of mixing. The reason for this was to avoid delays while waiting for water from the pipe to fill the mixer and that way it was easier, to measure the amount of water added.

<u>The Activity Area</u>: The mixer is the nucleus of all concreting activity and at all times must be regarded as the controlling factor since all manning and movement in this connection will be

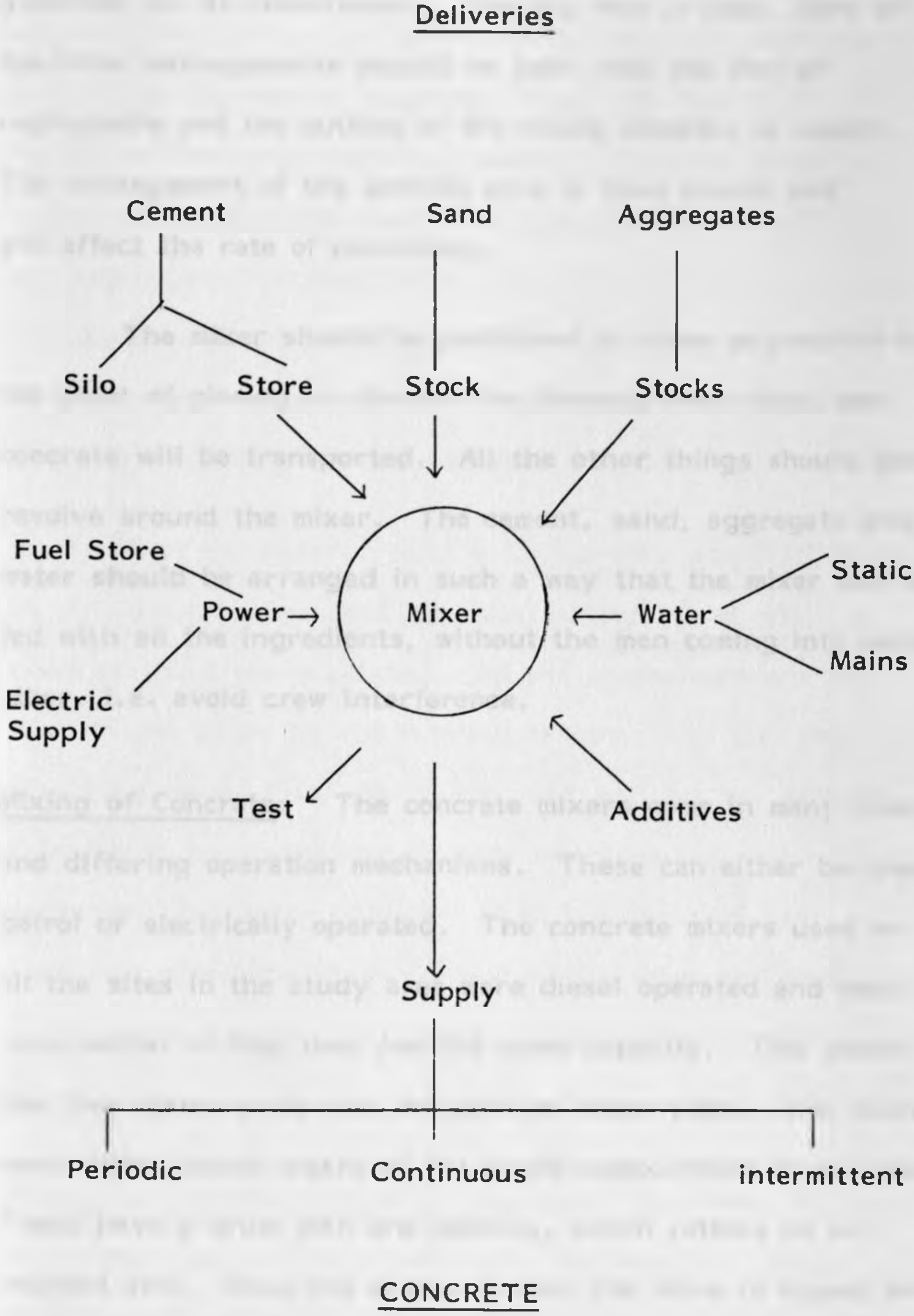

Figure: 3.3: The Activity Area, the mixer is the nucleus of the concreting activity.

Source: Edmeades, D.H., The Construction Site, London, 1972, p.39.

governed by its requirement. Bearing this in mind, then all the other arrangements should be such that the flow of ingredients and the outflow of the mixed concrete is smooth. The arrangement of the activity area is thus crucial and will affect the rate of concreting.

The mixer should be positioned as close as possible to the point of placing to shorten the distance over which the concrete will be transported. All the other things should then revolve around the mixer. The cement, sand, aggregate and water should be arranged in such a way that the mixer can be fed with all the ingredients, without the men coming into each other, i.e. avoid crew interference.

Mixing of Concrete: The concrete mixers come in many sizes and differing operation mechanisms. These can either be diesel, petrol or electrically operated. The concrete mixers used on all the sites in the study area were diesel operated and most were similar in that they had the same capacity. This meant that the mixing cycle was the same on these sites. The mixers were tilting batch mixers of the single-compartment drum type. These have a drum with one opening, which rotates on an inclined axis. Once the mixing is over the drum is tipped and the mixer is emptied.

The accurate batching of cement, sand and aggregate is important as mentioned earlier. This is a point where savings in cost can be realized. The method of batching employed on all the sites was volume batching, where the ingredients are batched by volume and not weight. Batching boxes or "Karai" or spades were used to measure out the quantity of each ingredient. Volume batching is not very accurate method since sand and cement are subject to bulking, especially in the presence of humid air. Also aggregates cannot be measured accurately by this method.

Once the cement, sand and aggregate are batched they are fed into the mixer and the water added. The water is added as the drum is rotated. All the ingredients are then mixed in the mixer by the rotating motion. The time required for mixing varied from site to site, but at least two minutes of mixing is necessary though some machines can mix thoroughly in shorter periods. When the concrete was completely mixed the whole content of the drum was discharged in one operation so as to prevent segregation of the larger stones.

<u>Storage and Transportation of Concrete</u>: There was no case among the sites studied where there was need for storage of the mixed concrete. The concrete was either discharged from the drum onto wheel-barrows or onto the ground and later shoveled into wheel-barrows, and transported to the point of placing. In the cases where the concrete was discharged onto the ground, the concrete became contaminated with soil and vegetable matter since the surface on which it was discharged was the direct ground without any

preparation.

The method of transporting the concrete from the mixer to the point of placing is important. The mode of transport should be such that the mix is not altered and the segregation does not take place. Where the wheel-barrow is used to transport the mixed concrete the run should be smooth so as to avoid excessive shaking of the mix. Where the terrain is rough then this can be facilitated by placing runways of planks on the ground. Where the mix is required a small distance from ground level, then a smooth lump should be erected using planks. At the point of placing the wheel-barrow should be emptied in one operation so as to avoid segregation. It should be tipped and the concrete shoveled level and vibrated as required.

Wall Construction

Walling or wall construction involves the use of small units, which are placed in position and mortar placed so as to bond together to form one continuous structure. The wall construction units vary in size from smaller units such as bricks to precast concrete units which are much larger and heavier and less easy to handle. The units of wall construction in this study are the precast solid concrete blocks bonded in cement and sand mortar. This mortar is prepared from one part cement, four parts sand and sufficient water.

The nature of the blocks is such that they can be precast on site or delivered factory precast. But whether precast on site or ready made, it does not affect the rate of wall construction. In most of the sites studied blocks were delivered on site ready made. There was only one exception where the blocks were precast on site. When the blocks are delivered on site ready made there are problems associated with delivery. But in all cases storage is important.

Delivery and Storage of Blocks: Delivery of blocks comes with its own problems. Most of these problems are concerned with handling especially at the point of unloading on the construction site. The blocks are delivered on the site on trucks. These blocks have to be off loaded one at a time and care should be taken to avoid damage. There is usually a temptation to tip the units from the vehicles because it is quicker, but this should never be allowed. In the general planning blocks should be as close as possible so as to avoid multiple handling. Care should also be taken to ensure that each delivery of blocks is directed to the corrected place to avoid scattered piles of blocks.

The speed of unloading depends largely on whether the process is manual or mechanically assisted. In all the sites studied where ready made blocks were used, the unloading was manual. Each block was handled separately which increased the time taken to unload. Whereas increasing the size of the gang unloading reduced the time taken to unload, this increased the cost of unloading. Mechanical unloading would not have been possible because the blocks were not pallated and came individually. Pallating can reduce the amount of time required to off-load and also facilitate the use of mechanical means to unload. Never the less, the handling of the building blocks should be kept at a minimum because it is both costly and time consuming.

The movement of the blocks should also be carefully considered. The form of movement should be such that the only person to handle the units individually should be the block layer. But this was not possible on any of the sites because mechanical means of movement were not available. The blocks for each part of the wall were transported in a wheel barrow to the point of placing. The blocks were loaded into the wheel-barrow manually and unloaded manually near the point of placing or the work place. The blocks were then arranged in neat stock piles adjacent to the wall under construction or near the blocklayer.

The blocks were stacked close to the block layer so that he did not have to travel to retrieve them. The proximity of the stacks to the block layer varied from site to site depending on the ground conditions. Where the stack was far from the block layer then there was the need for an extra labourer to pass the blocks to the mason. This extra hand would place the blocks very close to the mason so that the mason needed to turn only in order to pick a block. The size of the stack depended on the amount of walling within the reach of the mason and their spacing was such that once a stock is exhausted a new one was within reach of the mason.

Manufacture of Mortar for Bonding: The bonding media for solid concrete block walling is cement-sand mortar. The specification of the mortar varies depending on the type of blocks but for ordinary precast concrete blocks the mortar is manufactured by mixing one part cement and four parts sand. The quality of both cement and sand are as described under concreting. The mortar can be manufactured in two ways; it can be hand mixed on a hard surface or it can be prepared in a mixer. The second alternative is more economical where there is a large quantity of walling to be carried out. The materials, cement and sand are volume batched and placed in the mixer and water is then added as the mixer rotates. After mixing, the mortar is discharged in one operation either onto a hard surface or into a wheel-barrow. On the sites studied, the same mixer used for mixing concrete was used for the mixing of mortar when it was not mixing concrete.

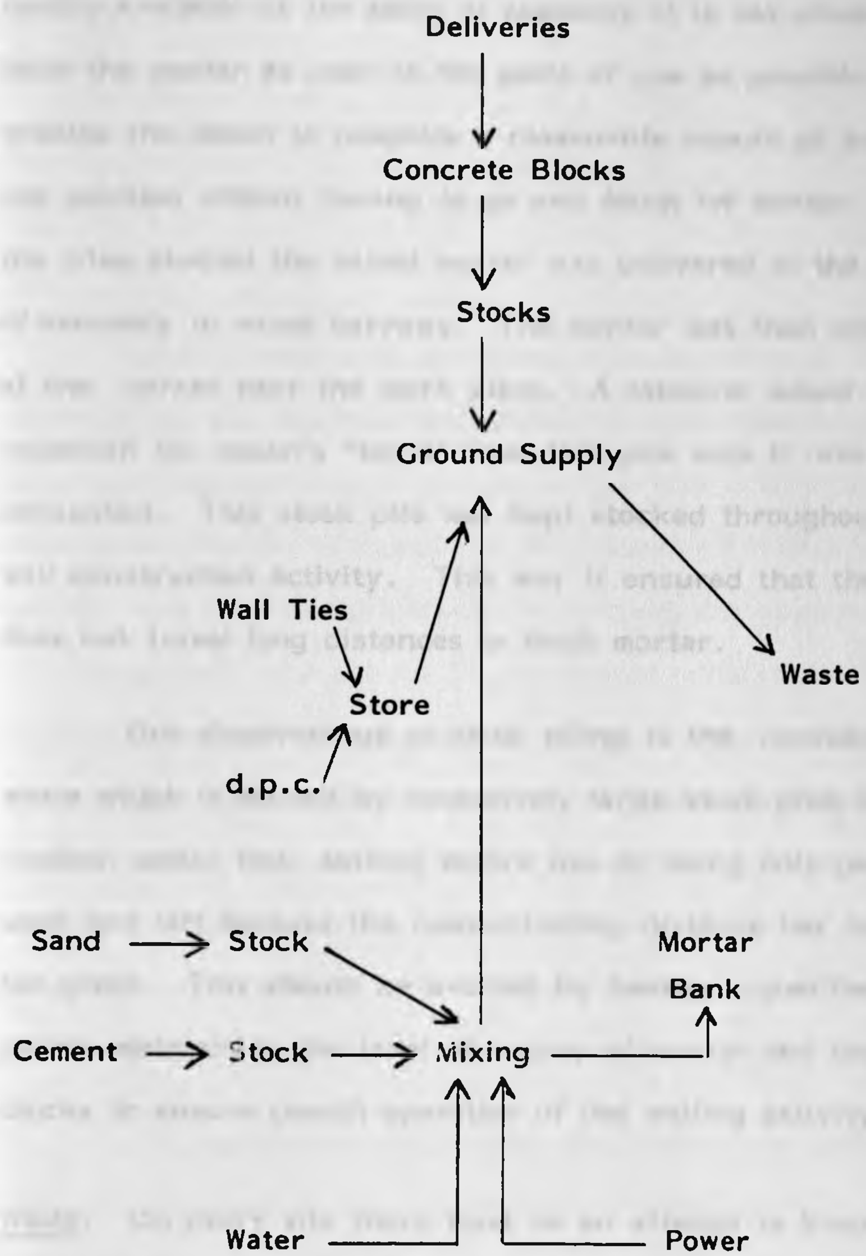

Figure 3.4: Flow Chart showing concrete block wall Construction materials and their needs.

Source: Edmeades, D.H., The Construction Site, London, 1972, p.52.

Since in wall construction it is important that mortar is readily available at the point of assembly it is not unusual to bank the mortar as near to the point of use as possible. This enables the mason to complete a reasonable amount of work in one position without having to go and fetch for mortar. In all the sites studied the mixed mortar was delivered to the point of assembly in wheel barrows. The mortar was then stock piled at one corner near the work place. A labourer would then replenish the mason's "karai" from this pile once it was exhausted. This stock pile was kept stocked throughout the wall construction activity. This way it ensured that the mason does not travel long distances to fetch mortar.

One disadvantage of stock piling is the considerable waste which is caused by excessively large stock piles being trodden under foot, setting before use or being only partially used and left because the communicating distance has become too great. This should be avoided by having a qualified person maintaining the level of supply of mortar and the blocks to ensure smooth operation of the walling activity.

Waste: On every site there must be an attempt to keep wastage down at a minimum. The loss of basic material in any wet construction process is unavoidable because of in-situ bonding and general site conditions.[2] In order to decide what is classified as waste, it is imperative to give the reasons for terming any item as waste. An item becomes classified as waste for any one of the following reasons: if it is broken or disintegrated in handling, if it has become mis-shapen or damaged, if lost or incorrectly cut or the shaping leads it to rejection or it falls through the scaffolding. All these reasons could apply to blocks.

Most of the waste on blocks and mortar in a construction site has the inherent cause in human failure. The only way waste may be minimised on the site is to attack the root cause and try to cure it at this point. But this is easier said than done, because it involves the appointment of a controller who should be conversant with all the causes of waste and who is in a position to remedy them. This calls for stringent measures to overcome this problem, which would lead to saving in material cost. The organized clearance of waste and the disciplined use of materials means a clean, efficient and safer site. A wasteful worker can be a menance to an efficient gang and this problem should be avoided.

To summarise, proper planning and programming of the the two operations is very important. Proper planning of these two activities will reduce wastage of materials, and the amount of unproductive time spent in the activity. It will also ensure the desired quality of the product, in our case the quality of concrete and that of the wall, is achieved. Thus efficient planning reduces wastage and unproductive time, this in turn raises the production and hence the productivity.

Site Labour and Training

The organization of the labour force on the construction site depends on the type of work in progress, the methods and rate of building and the particular division of operations amongst different trades. The labourers in concreting are usually organized in gangs working together, but activities such as wall construction are carried out by a small number of operatives usually two or three working together as a group. Successful organization of the site labour force depends on several factors namely: quality of supervision, quality of operatives and the working atmosphere present on the site.

Availability of labour especially the unskilled labour did not seem a problem on any of the sites investigated. The supply of either unskilled or skilled labour for the activities observed experienced no problems of shortage. The main reason for this situation is that there is plenty of unskilled labour in Nairobi and the relatively small number of skilled labour required in concreting and walling means that few are required. The principal effects of a shortage of skilled labour would be seen in a lower quality of works in buildings designed especially in concrete work, use of less skilled labour and more mechanical plant and semi and unskilled labour and in the need for more site supervision.

It was observed that the knowledge possessed by the site labour was very limited due to the level of education and training available. The site labourers did not seem to feel responsible and accountable for what they do. For any good quality work to come forth from these labourers there has to be very close and strict supervision which in most of the sites was scarce. The level of supervision is very important in such a situation. In most cases the supervisors would be selected from among those labourers showing superior qualities such as responsibility, skill, aptitude, hardworking, more intelligence and some leadership qualities. This method of selection in most cases does not yield the right candidate.

There seemed to be no conditions of service for the site labour on all the construction sites in the study. The majority of labour was employed on casual basis and paid on a daily rate. The situation was such that the labour could be dismissed any time and rehired immediately if necessary. None of the site labour was employed on monthly basis. The labourers were also employed on first come, first served basis.

The wages and allowances for special duty or overtime were negotiated between the management and the labourers, but there was not much room for bargaining from the labourer's side. The attitude of the management towards this was close to "take-it or leave-it", since they assumed that there are many labourers willing to accept the wages offered. The lack of bargaining power was made worse by the absence of a strong labour union to speak on behalf of the labourers. It was also clear that there were no guidelines being followed in paying the skilled labour. On all the different sites the skilled labour was paid differing wages. There were no allowances for insurance, holiday etc, added to the wages of these skilled labourers. But one point of distinction between these and the unskilled labour was that they tended to be employed on monthly basis and not on daily basis. The mode of payment of wages was fourtnightly on three of the sites and weekly on the remaining sites.

On training of site labour, there was no internal or external training of the labourers in any of the construction sites. One reason for this is that most ot these firms are small and prefer to pay training levy to the Government rather than train the workers. Most of the site labour had no formal training at all in any construction process. What they know had been picked up from the construction sites over a long period of time.

The construction industry in Kenya does not offer any initiative to the firms to train labourers. This is reflected in the lack of interest in training shown by the contractors. The construction firms studied did not offer any form of apprenticenship training or on-job training;they also did not sponsor any labourers for any training at government training institutions. The contractors felt that they stand to loose if they provided the training to the labourers because they are of the opinion that once trained, these labourers will demand higher wages or will just leave for better prospects in other firms. This discourages the contractors from making any attempts to train their labour force. Another aspect which affects the performance of the labour force is incentive payments. Of all the firms studied only one firm offered some form of incentive payment. Incentive payment can be defined as monetary incentive which has the specific intention of encouraging and rewarding higher productivity than normal. If any incentives existed in any of the other sites, then these were not clearly defined.

Safety on Site

Building construction is a more harzardous occupation than those that take place under more sheltered and static conditions like factories. The moment a person walks on to a building site he is potentially in danger of injury, which in some instances may be fatal. There are many sources and several reasons for this danger and, whilst it cannot be completely eliminated, all personnel must seek to maintain a level of safety in keeping with the normal harzards. Too much acceptance of accidents as "Acts of God" or fate should be avoided, by creating a measure of confidence in each labourer on the construction site.

To succeed in creating a measure of confidence implies a system of training which shows each man the correct approach and the sequence of operations he will be required to carry out. Emphasis must be placed on the correctness of training procedure, increasing the worker's awareness of the dangers in mishandling the equipment, and stressing the importance of the timing of his activities in relation to others working with him. There must be a measure of co-ordination and his over-confidence should not be allowed to diminish his concentration.

The main purpose of safety measures on a construction site is to remove the fear of injury from the employees during productive operations. Many methods would be sufficient but each must be assessed individually, in light of the operations and the dangers associated with it. The highest reported incidences of serious and fatal accidents are by falling from a height, crushing by falling walls, by objects dropping from above, by lorries or by collapsing excavations. Safety training is thus an important part of the construction site. Safety measures within each trade or activity must be clear, and operate under all conditions.

It was interesting to note that the safety consciousness amongst firms investigated hardly differed. In all cases no more than a general reminder to site supervisors that any safety regulations should be complied with was taken. There seemed to be no organized safety training policy on all the sites. An assumption was made that all the labourers are aware of all the dangers lurking in the site and that they are able to avoid them.

The other aspect of the construction site which is related to safety is the provision of protective clothing such as rubber boots for those involved in wet operations and leather gloves in operations where these are required. On all the sites under investigation the labourers were not provided with any of the protective clothing mentioned above. These people had to handle the wet concrete with their bare hands which can result in injuries or irritation of the skin. The labourers were also not provided with rubber boots or crash helmets. Crash helmets should be provided especially to those operatives working above the ground floor.

A lot has been written on the subject of safety measures in the building construction site and many regulations governing the subject are legally enforceable. But safety should be seen as an attitude of mind which enables a man in any given situation to rationalize on the probabilities and evaluate the safety level. Some people seem gifted in their ability to recognize danger and take evasive action, others, especially the older men, have less awareness, and probably less stamina to enable them to take avoiding action.

A construction firm can employ a safety officer depending on its size and needs, whose duty is to visit sites and institute a level of safety in each as long as it is necessary. The main duties of the safety officer is to carry out the safety training of the workers on a site. The aim of the safety training is to instill safety consciousness on the site and acquire a sense of correctness about their actions. The safety officer has a big task in implementing safety within the trades or skills because he must be aware of the method of the operations, the skills required and the minimum time in which the operation can be safely completed. The safety officer is usually trained on the general approach to safety.

First aid is another aspect of the construction site which cannot be left out in the subject of safety. With the present day highly mechanized construction methods and the consequent lowering of the labour - plant ratio, it is becoming more important for the employer to provide an efficient first-aid service on the site to deal with electric shock, resuscitation, external bleeding etc. This will mean that the firm must employ a person who is qualified to give first aid. First aid can be defined as that which is rendered subject to a secondary medical treatment and any subsequent re-dressings. To what extent a wound or condition becomes a medical matter will depend upon the decision of the man himself or the employer concerned. A man may not regard a wound as being so serious to bother about while another will insist on treatment.

Non of the sites under investigation provided a qualified person to attend to first aid. Only extremely limited services in the form of a first aid box was found on one of the sites while in the remaining sites no first aid was offered. The laxity in the provision of first aid on the construction site can result in a worker suffering injury to the extent that he sues for compensation while such injury could have been mitigated if prompt first aid was offered. Since it is the contractor who stands to lose, he should take it upon himself to provide this essential service. How the first aid operates will mainly depend upon the resources of the contractor. But the pre-requisites are ample medical supplies and a person capable of administering first aid. A place, especially in the site office could be reserved for administration of first aid.

To conclude the foregoing, safety on the site is important in order to remove the fear of injury from the workers during productive operations. This removal of fear will raise the production of labour. This is because the workers will feel secure and can thus work at ease. Provision of first aid on the sites makes the workers feel they are well cared for and raises their morale. The knowledge that if an accident occurs, quick action can be taken immediately on the site, is important to the construction workers because of the harzards they are exposed to.

Welfare

The "Oxford English Dictionary" defines welfare as "the state or condition of doing or being well, the happiness or well-being of a person or a community". In its application to the modern construction site, the contractor not only should, but frequently must provide reasonable welfare facilities. Like any other employer he is expected to provide amenities on a scale comparable, with other industrial concerns, bearing in mind the relatively short time on the site and the size and complexity of the contract. Today all workers have a social right to decent and up-to-date welfare amenities.

Chapter 514 of the Laws of Kenya, which is the Factories Act stipulates the level and quality of welfare which, should be provided by the employer in the factory or the working place. Welfare covers a broad field of services which should be provided in the work place. Taking the construction site as the work place or "factory", there are many welfare services that are essential for the well being of the construction site labour. These essential services include, the following: sanitary facilities, canteen and protective clothing. Sanitary facilities include, water closets, washing facilities and urinals. The welfare services or facilities are discussed in the following sections.

Sanitary Facilities

(i) Washing Facilities

On every construction site the contractor is required to provide some washing up facilities for the workers to wash and clean up at the end of the working day. This facility can in many cases be in the form of a wash room. But on all the sites investigated the only facility provided was a tap outside, at one point on the site. This tap was not enclosed in any structure. There was also no facility for changing of clothes or somewhere secure to store personal effects such as clothes, shoes and hats after changing into the working clothes. The labourers came in their clothes and simply slipped their working clothes over these. Other items of clothing which they could not work in like shirts, hats and jackets were usually kept in a bundle on the ground or floor close to where each labourer was working so as to keep an eye on them.

(ii) Water closet and Urinals.

The provision of lavatory facilities on any construction site is mandatory. The workers should be provided with some reasonable lavatory facilities for use during the working day. The types of this facility range from very crude to sophsisticated types such as the flush-down toilet. The types of facilities include the simple trench with chloride of lime in the bottom and a surrounding screen. This is very crude, minimal and is objectionable on both the sanitary and social ground. The second type is the latrine bucket which is also crude but at least the bucket is provided with a self closing lid. These buckets are placed in cubicles and one advantage is that the buckets can be tipped into the soil drain once full. Both the above methods are fairly crude; they are also unclean, unhygienic and generally demoralising.

Greater sophistication can be obtained by using the flush down water closet. This can be kept clean and tidy at all times and is also hygienic. But one important point that should be noted is that it is expensive and requires a reliable supply of water and a soil drain manhole for discharging into. All the construction sites under investigation did not provide a water closet for the labourers. The only water closet provided was for the consultants during the site meetings and site visits. Another point is that proper toilet paper should be provided and a weekly inspection should be instituted to ensure the maintenance of a high standard of cleanliness.

At least one urinal should be provided on the site. If the site is extensive, then several urinals should be provided close to the work places. The urinal should be enclosed, kept clean and of reasonable construction. The urinal can be separate or can be grouped together with the water closet. It should not be open to the elements of weather as this encourages the breeding of flies especially in the hot tropical climate.

Having looked at what is required in connection with water closets and urinals the next thing is to describe what was actually provided on the construction sites under investigation. The sanitary facilities provided were abhorently crude, inadequate, unclean and an eye sore. Although these facilities are subject to official regulation and liable to inspection, no step was taken to ensure their improvement. It would seem that the machinery involved in enforcing the regulation is either absent or very understaffed to deal with all the problems. Some colussion between the contractors and the health inspectors to pass the facilities as adequate when they are not cannot be overruled.

The toilet facility provided on all five sites consisted of a shallow pit latrine with planks placed over the pit and a screen all around. The material of construction was old form-work boards. The latrine was open to the sky and this provided easy access to flies. The principle of the construction of the latrines was the same on all the sites. There was only one latrine on each site irrespective of the size and the number of workers. The urinals on all the sites consisted of an open trench with hessian screen on all sides, but open to the sky. The trench was frequently sprinkled with soil.

A part from the sprinkling of earth on the urinal trench no other treatment was given to it. The pit latrine was not treated with lime or any disinfectant. The whole facility was therefore smelling badly. Infact it was very embarrassing to the workers when asked about these sanitary facilities. Nobody on the site wanted to discuss this topic. They preferred to let it stay closed. It was also noted that on two of the sites which were extensive and were bushy, the workers preferred to go and relieve themselves in the bush rather than face the stench of the pit latrine and the urinal. The path ways approaching the site and especially at shady corners, were used as urinals. This clearly shows that the sanitary facilities provided are grossly inadequate and require urgent improvement.

Canteen

The canteen should be a place where the labourers can rest over the break period and eat their food seated and protected from the elements of the weather. The basic provision of a canteen is a large clean wooden hut provided with sufficient tables, chairs or benches for taking meals and some means of warming the food. Such a provision is infact not a luxury but a necessity. On the five sites under investigation no canteen or any form of shelter from inclement weather was provided. For this reason the labourers did not carry food for lunch. But a form of "outside catering" was evident on all these sites.

The form of "outside catering" mentioned above consisted of a woman or group of women, who after negotiations with the contractor or the chief supervisor were allowed to erect a makeshift kiosk on the construction site from where they cooked and served hot food to the labourers. The type of kiosk varied on all the sites; on one site the kiosk was fairly large and was covered on all sides and roofed with polythene sheets. Some crude form of seats were also provided. This consisted of broken stones or blocks placed on the ground and hard brown paper placed on top for cushioning. On all the other sites the kiosk was operated under the shade of a tree in the open air. The "outside cateresses" had no other obligation to the contractor other than to sell their food to the workers and clear the rubbish generated. The price of the food was in no way subsidised by the contractors.

The type of food sold included "Uji" (porridge) and "Githeri" (a mixture of dry maize and dry beans boiled together). These were the only dishes available to the labourers. The "Uji" was sold in tin-cans and the "Githeri" was sold in 1/4-kg brown paper bags. These were reasonably priced and were served hot. The operatives purchased their food and either ate it standing or sitting on the ground where seating was not provided.

Protective Clothing

Although this was mentioned under safety on construction sites,some more will be said under this subheading. As was mentioned, protective clothing is required where the workers are exposed to harzardous substances during the process of carrying out their work. In most construction work, harzardous substances are not the main concern, since where these are encountered adequate allowances are made for the provision of protective clothing.

The protection required on all the sites under investigations was protective clothing when carrying out wet work such as concreting. During concreting there was the need to provide the workers with water proof rubber boots and leather gloves. This regulation was not observed on any of these sites. The few labourers who had these items, the items were personal, otherwise the rest handled wet concrete with their bare hands and stepped on the same with inadequately covered feet. It seemed that most of the labourers were so used to wet concrete on their feet and hands that it hardly had any effect on them. No water proof clothing was provided to the workers by the contractors so that during the rains the work would be adjourned until it stopped raining.

As a conclusion to the foregoing, the provision of welfare on the site is important to the workers. Lack of welfare on the site can demoralize the workers. A demoralized worker cannot be as productive as one who is not demoralized. Thus the productivity of the demoralized worker is lowered.

FOOTNOTES

1. Broughton, H.F., Economic Site Organization and Building Supervision, Spon, London. 1965, p.5.

2. Edmeades, D.H., The Construction Site, 1972. The Estates Gazette Ltd. London, p.50.

3. Samson, R.C. Organization of Building Sites, 1959. HMSO. Great Britain, p,

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

Data Collection Procedure

The main aim of this study is to investigate the causes of variation in labour productivity on construction sites. In order to carry out the investigation, sites had to be made available. In all there were five sites and on each site questionnaires were used to interview the contractors as well as the employees. The questionnaire administered to contractors is Appendix B(1) and that administered to site labour is Appendix B(2).

The questionnaire to the contractor asked questions ranging from those that tried to find out the type of firm to those that tried to find out about the management of the site. In the questionnaires to be administered to labourers there were questions which tried to find out the most serious problems facing the labour on the site. The questionnaire used to interview the contractor was used only once for each case study, but that used to interview the labourers was used on all the labourers involved in the activities which were under investigation.

Although only five case studies were investigated, a choice of fifteen contractors had been made from a random sample of some one hundred and fifty (150) contractors registered with the Ministry of Works. A letter of introduction in appendix A was sent to each of these fifteen contractors, however only five of these firms had some work involving the activities under investigation being executed in the study area. Despite the fact that only five firms were available it is still possible to obtain adequate results because of the depth of the investigation and the size of each case study.

For each of the firms only one site which provided the activities under investigation was selected. The number of labourers interviewed on each of the five sites varied, depending on the number of persons carrying out the operation. The sites were numbered as Project A to E. On project A, a total of 22 employees were interviewed, in B a total of 23, in C a total of 21, in D a total of 21 and in E a total of 23 employees were interviewed. The number interviewed in each project is presented in table 4.1 and table 4.2.

Apart from the interviews using the questionnaires a field observation was carried out to collect information on the activities of walling and concreting under investigation. The data was collected on a special data collection form in Appendix C. The data recorded on this form included among

Table 4.1: Skilled and Unskilled labour interviewed.

Project	Skilled	Unskilled	Total
A	1	21	22
B	0	23	23
C	3	18	21
D	6	15	21
E	2	21	23

Source: Own field survey.

Table 4.2: Skilled and Unskilled labour Percentage of the total interviewed.

Project	% Skilled	% Unskilled	Total %
A	4	96	100
B	0	100	100
C	14	86	100
D	28	72	100
E	8	92	100

Source: Own field survey

(NB. Skilled - refers to those who have been trained in an institution).

other things the ground conditions on site, number of operatives carrying out the activity, plant and equipment used, materials and tools used, method and technique used in carrying out the work and a sketch of the layout of the work place was also made.

The main aim of the field survey was to record the output in the activities under investigation and also to record the technical factors present on the site. The output recorded and the number of hours worked were used to calculate the productivity index on each of the five sites. Apart from the primary data obtained from the questionnaire and the field observations, other important information was obtained from informal interviews and discussions with the various personnel on the site. Such personnel included the supervisors and foremen. Also, while walking around the site a lot was observed which otherwise would not have been recorded.

Following now is a summarised description of the work involved in each of the five case studies labled A to E. This information was obtained from either the bills of quantities or from the architectural drawings where bills of quantities were not part of the contract documents.

Project A

This project consisted of twelve number three storey flats, a single storey reporting office and a single storey canteen building. The approximate total area of all the units was 1500 square metres. The work to be executed under the contract comprised the erection and completion of the above mentioned work and all related external works including access road, foul drainage and landscaping. The landscaping comprised of planting trees and grass. The flats were on going at the time the field survey was carried out and the data was collected from the flats. The form of construction used for the flats was traditional load bearing wall with two columns, ring beam and suspended slabs. The walls were in solid concrete blocks, plastered externally and internally. The walls were carried on a strip foundation. The roof was timber trussed covered with concrete roofing tiles. The internal finishes were as follows; floors were in granolithic in all wet areas, and pvc tiles in all other areas, wall and ceilings were generally lime plastered and painted with white glazed wall tiles fixed to walls in the bathrooms. The doors were in timber and the windows louvred.

The site on which this project was situated was very sloppy which necessitated alot of cut and fill so as to obtain the correct level. The soil was red volcanic and the rock sub-strata was not very deep below the ground level, it was an average of 1 metre deep. The site being difficult due to the topography presented a number of problems especially where it concerned the transportation of the building materials and general movement about the site. Another problem experienced on this particular site was shortage of building materials and especially that of solid concrete blocks such that at one time the wall construction was suspended for about a week. There was also the problem of shortage of cement where by it was not possible for concreting to be done on a few days. These shortages in building materials, especially building blocks culminated in data for wall construction being recorded on only two days in this project. It had also been intended to collect the data on a daily basis and this was also not possible on this particular project. The data was thus collected only on those days when work was in progress. The contract sum was 29 million shillings.

Project B

This project consisted of an office block. The work to be executed under the contract comprised the erection and completion of a four storey office block with all the related external works, including access road, foul drainage, fencing, gates, gate house and the land scaping. The form of construction used was reinforced concrete frame, comprising columns, beams and slabs with a flat roof finished with water proof membranes. Externally the wall, beams and columns were either vertically broad-marked or fair face concrete. The internal finishes were as follows: floors were generally finished in carpet tiles and terrazzo in the wet areas, walls had lime plastered and painted with ceramic tiles in wet areas. The ceilings were lime plastered and painted.

The doors were aluminium sliding doors and windows were also in aluminium with tinted glass. Fittings and fixtures were generally hardwood framed and painted blockboard. The building measured over external walls was approximately 2670 square metres. The site on which the building stood was level with black cotton soil and murram sub-soil. The contract sum was 9 million shillings.

Project C

This project consisted of a three storey control Building and Generator House. The work to be executed under the contract included the erection and completion of the above works, and all external works and the drainage system. The form of construction of the building was reinforced concrete frame comprising of columns, beams and suspended slabs. The roof was a flat roof finished with built-up-asphalt and covered with pitched asbestos sheet on timber trusses. The external and internal walls were in solid concrete blocks. There was a parapet wall which was in reinforced concrete and there were sunbreakers which were in precast concrete.

The finishes were as follows: external wall finishes comprised of mosaic tiles and rendering which was painted. Internal walls were lime plastered and painted, floor finishes comprised of wood parquet, terrazzo in wet areas and special computer floor in the computer room. The ceiling finishes in the offices comprised of suspended aluminium ceiling strips and accoustic tiles, all the other areas had a plastered and painted ceiling. The work to be executed also included plumbing and drainage, electrical, mechanical and fire fighting installations. The approximate floor area measured over external walls was 1000 square meters. The site on which the building stood was fairly level with a small layer of black cotton soil and murram sub-soil. The contract sum for this project was eleven million shillings.

Project D

This project comprised of a study centre two storey high. The work to be executed under the contract comprised the construction and completion of a two storey building with all the related external works including foul drainage, fencing, gates, gate house and the land scaping. The form of construction used in this building was load-bearing wall construction with ring beam and suspended slab. The external and internal walls were in solid concrete blocks. The roof was pitched timber trussed with concrete tiles covering.

The finishes were as follows: the external wall finishes comprised of cement rendering and paint, with stone facing at the quoins. The internal wall finishes comprised of lime plaster and paint, with white glazed wall tiles fixed in the wet areas. The floor finish was parquet in all other areas apart from the wet areas which were in terrazzo. The doors were framed panelled hardwood doors and others were steel casement. Fittings and fixtures were generally in hardwood and block-board. The approximate floor area of the ground floor was 560 square metres measured from the external face of the walls.

The site on which the building stood was fairly level with red soil. The contract sum was four million shillings.

Project E

The last project comprised of institutional hostels. The total number of the hostels was four. The work to be executed under the contract comprised of the erection and completion of the above single storey blocks, with a plinth area of approximately 230 square meters each. The associated work such as external work was also part of the contract. The form of construction used for this project was load-bearing wall construction. The external walls were in solid concrete blocks on strip foundation with concrete floor slab. The roof was pitched timber trussed with galvanized corrugated iron sheets covering.

The doors were matchboard timber framed for external doors and solid core flush doors for internal doors. Windows were metal louvred and glazed. The finishes were as follows: floor finishes were cement and sand screed in all areas, the walls were plastered and painted externally and lime plastered and painted internally. The ceiling was in celotex soft board on timber brandering and then painted. The external works comprised of foul drainage, fencing and land scaping. The site on which the project stood was level with a small layer of black cotton soil and a murram sub-soil. The contract sum was three million shillings.

Data Presentation

Using the information collected in the data collection form the labour productivity index was calculated. The productivity figure for each day was calculated, and from these the average labour productivity index for the five days during which the observations were carried out was calculated. But it will be noted that in project B, the data for concreting was available on only three days. The reason for this is, that after the three days there was no more concreting as the operation was suspended. In wall construction, the data for project A was taken only twice, the reason for this is because the operation was suspended due to non availability of blocks on the site.

The calculation of the productivity index was done as described in the next section. The amount of concrete poured was calculated from the area of concreting recorded in the data collection form multiplied by the thickness of the slab. This gave the amount of concrete poured in cubic meters. The amount of wall constructed was recorded in the data collection form in square meters. The number of labourers involved in the activities on each respective day was also recorded in the data collection form. The total hours worked by the whole gang was also recorded in the data collection form. Using the above data, the labour productivity for each day was calculated. The formular used in the calculation is as follows:

$$\text{Productivity per/man hour} = \frac{\text{Output (cm/sm)}}{\text{man hours (worked)}}$$

The man hours used as the denominator represented the hours worked by the unskilled labour plus the weighted hours worked by the skilled labour. The reason for weighting the total hours worked was given in the first chapter of the study. The man hours were calculated from the total hours worked recorded on the data collection form. They were calculated as follows:

Man hours = Total hours worked (unskilled) + weighted total hours worked (skilled labour)

The figures obtained from the calculations are presented in table 4.3 and 4.4.

Project	Day 1	Day 2	Day 3	Day 4	Day 5
A	0.060	0.084	0.090	0.086	0.172
B	0.094	0.078	0.094	-	-
C	0.072	0.068	0.105	0.090	0.059
D	0.104	0.142	0.095	0.095	0.095
E	0.080	0.070	0.094	0.078	0.079

Table 4.3: Labour Productivity in concreting measured in cm/manhour.

Source: Own field work.

Project	Day 1	Day 2	Day 3	Day 4	Day 5
A	0.488	0.557	-	-	-
B	0.338	0.330	0.420	0.354	0.354
C	0.248	0.277	0.180	0.175	0.211
D	0.388	0.388	0.388	0.388	0.388
E	0.256	0.380	0.213	0.410	0.315

Table 4.4: Labour Productivity in walling measured in sm/manhour.

Source: Own field survey.

From the two tables, table 4.3 and 4.4, it is evident that productivity varied during the five days when observations were carried out. This shows that apart from the variation of productivity from site to site, there was also variability within each site. For each site the average productivity index was obtained from the daily productivity by averaging the later. This is shown in tables 4.5 and 4.6.

Table 4.5: Average Productivity index in concreting in cm/manhour.

Project	Concreting in cm/mahours	Ranking
A	0.098	2
B	0.088	3
C	0.079	5
D	0.106	1
E	0.080	4

Source: Own field survey

Table 4.6: Average Productivity index in walling in sm/manhour.

Project	Walling in sm/manhours	Ranking
A	0.523	1
B	0.359	3
C	0.211	5
D	0.388	2
E	0.315	4

Source: Own field survey.

Out of the five case studies project A had the highest productivity in wall construction which was 0.523 sm/manhour, the lowest was in project C which had a productivity of 0.211 sm/manhour. In concreting the highest productivity was in project D and the lowest in project C. Project C had the lowest productivity in both the two activities observed. How can this variation in productivity on the various sites be explained? In the first and second chapters of this work, it was hypothesised that variation in productivity is caused by technical and human factors encountered on the construction site. These factors which cause the variation in labour productivity were assumed to be under the control of the management of the firm. This issue will be discussed in the succeeding sections.

Causes of Variation in Labour Productivity

Earlier on in chapter one, the use of a multiple regression model for labour productivity was suggested. Possible independent variables are those technical and human factors which are assumed to affect labour productivity, these were discussed in the first and second chapters. These factors were all investigated, and some were excluded during the field observation as they were found not to be relevant on the construction sites studied.

From all the literature reviewed, a number of factors both technical and human were identified which were thought to affect labour productivity. After the field survey a good number of these factors were found to be, either absent or not to vary among the sites. These factors which were either absent or did not vary were eventually left out of the regression model. An example of one technical variable which was found not to vary among the sites was quality of raw materials. These are the raw materials in both concreting and wall construction. These materials were found to be of similar quality giving the impression that they were all obtained from the same suppliers. The section which follows explains the selection of the independent variables for the regression model.

Selection of Independent Variables

(i) Technical Factors

At the onset of the study there were many independent variables to be investigated. These are the variables which are thought to generally affect labour productivity, but after the field survey and the preliminary data analysis only the following variables remained; technical factors of productivity in concreting that remained were nine, and were numbered x_1 to x_9. These are shown in table 4.7. The technical factors of productivity in walling that remained were eight and were numbered k_1 to k_8 to differentiate them from the above. They are shown in table 4.8.

Table 4.7: Technical factors of labour productivity in concreting

			Variable	Projects A	B	C	D	E
Y_1	-	Labour productivity in concreting measured in cm/man hour	Y_1	0.098	0.088	0.079	0.106	0.080
X_1	=	Materials wastage on site	X_1	1	0	0	0	0
X_2	=	Distance of mixer from point of placing in linear meters	X_2	30	5	10	5	10
X_3	=	Number of labourers involved	X_3	21	25	14	18	17
X_4	=	Capacity of mixer in cubic meters	X_4	0.14	0.20	0.14	0.14	0.14
X_5	=	Number of pocker vibrators used	X_5	1	1	1	1	1
X_6	=	Number of wheel barrows used	X_6	5	7	4	4	3
X_7	=	Complexity of building	X_7	1	0	0	2	2
X_8	=	Scale of work available in million shillings	X_8	23	9	11	4	3
X_9	=	Condition of mixer	X_9	0	0	1	0	0

Value lables.

X_1	(0)	No wastage (1) wastage present
X_7	(0)	Framed construction (1) Load bearing wall with columns
	(2)	Load bearing wall construction without columns
X_9	(1)	Not efficient (0) Efficient.

Table 4.8: Technical factors of labour productivity in walling

			Variable	Projects A	B	C	D	E
Y_2	=	Labour productivity in walling measured in sm/man hours	Y_2	0.523	0.359	0.211	0.388	0.315
K_1	=	Materials wastage on site	K_1	1	0	0	0	0
K_2	=	Distance of blocks from wall in linear metres	K_2	3	2	1	1	1.5
K_3	=	Complexity of building	K_3	1	0	0	2	2
K_4	=	Scale of work available in million shillings	K_4	23	9	11	4	3
K_5	=	Condition of mixer	K_5	0	0	1	0	0
K_6	=	Number of labourers involved	K_6	2	2	6	3	3
K_7	=	Number of trowels used	K_7	2	1	3	1	1
K_8	=	Number of levels used	K_8	1	1	3	1	1

Value lables.

K_1	(a)	No wastage (1) wastage present
K_3	(0)	Framed construction (1) Load bearing wall with columns
	(2)	Load bearing wall without columns
K_5	(1)	Not efficient (0) Efficient

Among the selected variables were some dummy variables. The inclusion of dummy variables in a regression model is fully described by Lewis-Beck[1]. This technique has been devised for the purpose of establishing relationship between variables that can take two or more distinct levels. In the case of a complex study such as a building form, dummy variable can take three levels; the building can either be reinforced concrete frame, load-bearing wall construction with columns or load-bearing wall construction. Another example is the condition of the concrete mixer, which may take two levels; the mixer can be either efficient or not efficient.

The dummy variables do not cause regresion estimates to lose any of their desirable properties as may be feared. The dummy variables have one main weakness in that the change is not continuous and therefore a graph cannot be drawn to illustrate the gradient for the change, from say framed construction to load bearing wall construction with a few columns.

The independent variables which were included in the regression models were selected for various reasons. Materials wastage on site is represented by a dummy variable. Materials wastage on a construction site can be measured. But measurement is generally applicable to those materials which can be enumerated by numbers such as building concrete blocks, windows etc. But for materials such as cement, sand or ballast, the amount of waste cannot be accurately measured, it can only be estimated. Material wastage was thus allocated a dummy variable. The alternative would have been to estimate the percentage of wastage based on approximate quantities.

Some aspects such as layout of site are difficult to express in mathematical terms other than by using the surrogate. The surrogate which was thought to suffice as a representative of the layout of site was the distance of the mixer from the point of placing the concrete in concreting activity. In chapter three it was shown that the concrete mixer is the nerve centre or the nucleus of the concreting activity. This would imply that the distance of the mixer from the point of placing is an important factor affecting rate of concreting. Thus the distance of the mixer in metres was used to represent the layout of site. In the case of wall construction, the distance of the blocks from the point of placing them on the wall under construction was also found to be important in affecting wall construction, thus this distance was taken as the surrogate for the layout of site in walling.

Another aspect which is very difficult to express in mathematical terms is the technique of carrying out the work. The technique is the way of achieving the aim skillfully. The technique of concreting a ground floor slab varies but is generally carried out in the manner described in the third chapter. But this cannot be expressed mathematically. The technique had to be expressed using surrogates. The surrogates used, (in this case more than one surrogate had to be used) were; number of labourers involved, capacity of the mixer used, number of pocker vibrators used and the number of wheel barrows used,the reason for choosing the above variables as surrogates stemed from the fact that it is the combination of all the above variables that determines the technique of concreting in each case. The technique of walling experienced the same problem of not being expressed mathematically and so in this case the number of labourers involved and the number of trowels and levels used were used to represent the technique of wall construction.

The complexity of the building in each case was assigned a dummy variable. The reason for this is because it is not continuous. It is discrete and can only be measured at a given point. The complexity of the building was thus measured at three levels. This was either reinforced concrete frame, load bearing wall construction with few columns or load bearing wall construction. The most complex was the framed construction and the least complex the load-bearing wall construction.

The scale of the work available is in itself not measurable perse but can be represented by the value of the works,in this case the contract sum. The contract sum is arrived at by estimating how much work is involved in a project and then pricing the same. This would then imply that the contract sum is a good representative of the scale of work involved in a project. For example, a project with a contract sum of Ksh.20 million will obviously involve more work than another which has a contract sum of only Ksh.5 million. There are other reasons for a high contract sum which do not necessarily reflect the scale of work available. One reason is where the cost of materials used is much more as a percentage of total cost, especially in a case where special materials are used. This did not happen in any of the five projects in the study. All the same, it may be reasonable to assume that about 40% of the total cost of a project is labour cost.

The last independent variable is equipment and tools. The equipment used can be measured in terms of numbers, or horse power depending on the equipment in question and the function it carries out. In this study the only plant used was the concrete mixer. On each of the sites only one mixer was used. What was of interest here is the operating conditions of the mixer. The condition of the mixer is represented by a dummy variable. This variable takes two levels. The mixer can either be efficient or inefficient. This is because the condition of the mixer affects its efficiency. By inefficient it implies that the mixer is either damaged or keeps breaking down thus necessitating frequent stoppages in the progress of concreting to allow it to cool due to over-heating or for attention.

(ii) Human Factors

In the first two chapters of this work, the human factors affecting labour productivity were discussed. It was established that human factors depend on quality and motivation of labour. Quality of labour is an aspect which is difficult to express in mathematical terms so is motivation. Quality of labour is determined by the education/training, the physical conditions of the worker, age-sex composition and finally the effort exerted. These factors which have just been outlined have been used as the surrogates representing quality of labour. The quality of labour was determined through questionnaire administered to the labourers. Questions one, two, three, twelve, thirteen and fourteen were used to try to find out about the quality of labour.

The motivation of the construction worker depends on several factors including; conditions on site, individual needs and social conditions on the job. The aim of the study is to find which of these factors cause increase in labour productivity and those that cause a decrease in labour productivity. In the field survey some of those factors listed in chapter two were found not to vary and these were excluded from the regression models. Only those factors that were found to be relevant were included in the regression model.

The human factors which constitute the independent variables that are included in the regression model are shown in table 4.90. Initially there were thirty two independent variables under investigation. After the field survey they were reduced to 18 variables. Some variables were also found to be related to each other and so to avoid problems of multi-collinearity, one of the variables was selected and the other excluded.

The independent variables excluded include physical condition of the workers. The reason is because all the labourers did not appear to have debilitating diseases which affect their working capacity. This information was obtained from the interviews using the questionnaire. Another reason for excluding the above mentioned variable is that on all the sites investigated at least every worker had two or more meals per day, particularly lunch and supper. For the above two reasons the variable was thus excluded

The temperature on site which was also one of the variables was excluded because the weather did not vary during the period the field survey was carried out and also because it was one of the factors which was held constant during the study period. Another variable which was excluded was training. The reason was that in all the projects investigated non of those firms offered any type of training to the labourers. The informal organization on the construction site which is one of the social needs in the job was minimal. The reason for this was the fact that almost all the labourers met for the first

Table 4.9: Human factors of labour productivity in concreting and walling

			Variables	Projects A	B	C	D	E
Y_1	=	Labour productivity in concreting measured in cm/man hours	Y_1	0.106	0.088	0.079	0.098	0.080
Y_2	=	Labour productivity in walling measured in sm/man hours	Y_2	0.388	0.359	0.211	0.523	0.315
Q_1	=	Unskilled labour with primary level of education in percentage	Q_1	64	92	62	29	70
Q_2	=	Unskilled labour with secondary level of education in percentage	Q_2	32	8.7	19	29	20
Q_3	=	Skilled labour in percentage	Q_3	29	0	14	5	8
Q_4	=	Labour with over 3 years of experience in percentage	Q_4	72	57	38	58	51
Q_5	=	Labour in age bracket 20 to 40 years.	Q_5	100	83	67	64	65
Q_6	=	Labour interested in construction work	Q_6	71	74	67	64	65
Q_7	=	Safety training	Q_7	1	0	0	0	0
Q_8	=	First aid	Q_8	0	0	0	1	0
Q_9	=	Protective clothing	Q_9	1	0	0	0	0
Q_{10}	=	Rest period on site per work day in hours	Q_{10}	1	½	½	1	1
Q_{11}	=	Mode of selection of labour	Q_{11}	0	0	1	0	0
Q_{12}	=	Incentives	Q_{12}	1	0	0	1	1
Q_{13}	=	Supervision	Q_{13}	2	0	1	1	1
Q_{14}	=	Labour union	Q_{14}	0	1	0	1	0
Q_{15}	=	Labour turnover	Q_{15}	0	1	1	1	0

Table 4.9: (Contd...)

Q_{16}	=	Frequency of payment of wages in Ksh. per day
Q_{17}	=	Company transport
Q_{18}	=	Wages in Ksh. per day

Value labels

Q_{17}	(0)	No training (1) Training offered
Q_{18}	(0)	No First aid (1) First aid provided
Q_{9}	(0)	No protective clothing (1) Protective clothing provided.
Q_{11}	(0)	1st come 1st served (1) Merit.
Q_{12}	(0)	No incentives (1) Incentives present.
Q_{13}	(0)	Below average (1) Average (2) Above average
Q_{14}	(0)	Ununionised (1) Unionised.
Q_{15}	(0)	Low (1) Average
Q_{17}	(0)	No transport (1) Transport provided.

Q_{16}	7	14	14	7	14
Q_{17}	1	1	1	0	1
Q_{18}	30	34	25	39	30

time on the site. And since the projects were all at the early stages of the contract, informal groups had not began to form or even if formed had not gained enough strength as yet to affect productivity.

The social conditions on site were represented by among other variables the strikes and disputes on site, continuity of employment, provision of welfare facilities such as a canteen, and the provision of social activities. All the above mentioned variables were excluded because they were not present on any of the five sites under investigation.

The individual needs of the labourers fell under three levels, namely: physiological needs, safety needs and social needs. The physiological needs were represented by four variables, these were food, clothing, shelter and the wages paid to the labourers. Of the four variables only wages were found to vary. The other variables did not vary. The type of food consumed by the labourers was more or less the same and consisted of the staple foods of maize and beans or maizemeal. The form of clothing of all the labourers could be described as shabby. The kind of shelter these people live in was to be found in the slum areas and other low income quarters. This was indicated by the areas in which they said they lived in and the amount paid for rent. Save for two workers, all the rest of the workers interviewed on all the five sites paid a rent of less than sh. 250/= per month.

Safety from injury which is a safety need according to the classification of needs in the study, is tied to safety training. Since the variable safety training was included, then it was found that there was no need of including safety from injury as an independent variable. The two are more or less very related. The social needs on the construction site were all excluded from the list of the independent variables. The main reason for this was, that these are the highest individual needs, and according to the literature review these higher needs are out of reach for the construction worker. Another reason for the exclusion is that they are difficult to express mathematically and no easily identifiable surrogates are to be found. For the above two reasons and from the analysis of the questionnaire it was found necessary to exclude them.

Although the social needs were excluded from the list of the independent variables, a few questions in the questionnaire used to interview the construction labour were aimed at trying to establish the general social conditions of the site. From the analysis of the questionnaire it was found that friendship, contact with others on site and a sense of belonging were present on the site but did not vary and thus are not important factors affecting productivity. It was also found that there were no cases or reports of hostilities and fights among the construction labourers. And to put it in one labourers words "we are all friends on the site because we have a common goal, to earn a living".

Use of Regression Analysis for Labour Productivity Model

The use of multiple regression model to analyse the effect of human factors on productivity has been suggested by George C. Shen[2]. The author's suggestion is general and does not necessarily refer to the construction industry. The approach for doing this first entails a monitoring system to be established to gather feed-back information on certain management aspects which are related to productivity. Examples of these are, the labour turn-over rate which may reflect workers satisfaction or dissatisfaction with the management style, salary or wages scales or certain specific incentives or disciplinary measure.

There are many ways suggested for the gathering of the data and the choice of the variables. Though there are doubtless many difficulties and even pitfalls in this approach, somehow it is possible to express peoples reaction and work attitude in quantitative terms. With the data available it is then possible to relate the rate of productivity change through a multiple regression model, taking the following form:

$$P = a + b_1x_1 + b_2x_2 + \dots\dots\dots\dots\dots + b_nx_n$$

Where,

P is productivity,

a_1 b_1 b_2 b_3,.....,b_n are the constants to be determined and

$x_1, x_2, x_3, \dots\dots\dots x_n$ are the independent variables.

The number of independent variables to be included in the analysis may vary and may be expanded or contracted depending on the kind of data. Once it is theoretically established that the independent variables are positively related to change in productivity, a correlation coefficient matrix may be worked out to help analyse their effect on productivity. The regression model in this study follows more or less this principle. But in the study Step-wise Regression Analysis is used.

Step-wise Regression Analysis

The data collected in the field survey was analysed using "Stepwise" multiple linear regression analysis, with the aid of statistical package for social sciences (SPSS) version 5.01 on ICL 1900 computer. The use of step-wise multiple linear regression analysis is important in that it is an automatic process that enables one to know how powerful an explanation the regression equation accounts for variation in the independent variables.

The objective of the study is to find out which of the independent variables cause an increase in labour productivity and which cause a decrease in the labour productivity. The important coefficient for the purposes of this study is the coefficient of multiple determination R^2. This measure is important when one wants to know how well the regression equation accounts for variation in the independent variables in the multiple regression. For a multiple regression, R^2

includes the proportion of variation in Y explained by all the independent variables. This means that R^2 is given by:

$$\frac{\text{regression (explained) sum of squares}}{\text{Total sum of squares}}$$

The value of R^2 ranges from "1" to "0". When $R^2 = 1$, the independent variables completely account for variation in the dependent variables, so that knowledge of x values allows the prediction of y values without error. At the other extreme when $R^2 = 0$, the independent variables account for no variation in the dependent variables, so that knowledge of x values would be of no help in predicting y-values, because the variables are totally independent of each other.

The fact that R^2 is closer to 1 merely shows how complete the phenomenon under the study would be. But the explanation is more of a mathematical necessity rather than a causal explanation for the dependent variable. This necessitates that one must take into account the theoretical consideration or assumption as to how the independent and the dependent variables could be related.

Using the step-wise regression analysis for the variables shown in tables 4.7, 4.8 and 4.9, a print out was obtained for each of the first two tables and two print outs were obtained for the last table, which contains two sets of data. For each of the set of data a summary table and a plot of residuals were printed. The summary table shows the variables which affect the productivity and the plot of residuals shows the line of best fit of the final regression equation.

All the variables that did not appear in the summary table are those that do not affect productivity. The results obtained from the printouts are discussed under the following four separate headings, namely:

(i) Technical factors affecting labour productivity in concreting.

(ii) Technical factors affecting labour productivity in walling.

(iii) Human factors affecting labour productivity in concreting.

(iv) Human factors affecting labour productivity in walling.

(i) <u>Technical factors affecting labour productivity in concreting.</u>

The printout showed that only three factors out of the nine indepedent variables x_1 to x_9 affect labour productivity in concreting on construction sites. The three variables are the only ones that appear in the summary table shown in table 4.10. The three significant variables are x_9-condition of the mixer, x_4-capacity of the mixer and x_3-the number of labourers. The three variables had a value of $R^2 = 0.4778$, which means that the three variables accounted for only 47.78% of the change in productivity in concreting. The three variables thus accounted for less than 50% of the change in productivity, which is indeed low. The explanation of why these factors account for less than 50% of the change is given

FILE JEDIDAH (CREATION DATE = 13/05/88)

* MULTIPLE REGRESSION * * * * * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. Y1 LABOR PROD.IN CONCRET.MEASURED IN CM\4.H

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
X9	CONDITION OF THE MIXER	0.53648	0.28781	0.28781	-0.53648	-0.00233	[illegible]
X4	CAPACITY OF MIXER "CM"	0.59076	0.34900	0.06119	-0.10538	-0.41154	-0.94621
X3	NO.OF LABOURERS INVOLVED	0.69127	0.47786	0.12886	0.32261	0.00285	1.02021
(CONSTANT)						0.09915	

FILE JEDIDAH (CREATION DATE = 13/05/88)

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE: Y1 FROM VARIABLE LIST 1
REGRESSION LIST 1

SEQNUM	OBSERVED Y1	PREDICTED Y1	RESIDUAL
1	0.7900000E-01	0.7900000E-01	-0.4500436E-11
2	0.8000000E-01	0.8992308E-01	-0.9923077E-02
3	0.8800000E-01	0.8800000E-01	-0.1485993E-12
4	0.9800000E-01	0.1013077	-0.3307692E-02
5	0.1060000	0.9276923E-01	0.1323077E-01

```
PLOT OF STANDARDIZED RESIDUAL
-2.0      -1.0      0.0      1.0      2.0
                     *
           *         I
                     *
                 *   I
                     I        *
```

DURBIN-WATSON TEST OF RESIDUAL DIFFERENCES COMPARED BY CASE ORDER (SEQNUM).

VARIABLE LIST 1, REGRESSION LIST 1. DURBIN-WATSON TEST 1.69231

Table 4.10: Final Model for Technical Factors in Concreting.

in the next chapter. A suggestion of what should be done to improve the results is given in the same chapter.

The condition of the mixer accounted for 28.78% of the change in productivity. The RSQ change in the print out shows how much each of the variables account for. The capacity of the mixer - x_4 accounted for 6.11% of the change in labour productivity and the last variable, x_3 - number of labourers accounts for 12.88% of the change. All the other 6 variables shown in table 4.7 with the exception of x_1 which was excluded after the first run did not appear in the summary table. X_1 - materials wastage on the construction site was excluded because it was found to have a very high correlation to x_2 - Distance of mixer from point of placing. x_1 was excluded and x_2 left because of their high correlation and because it could have been measured as a percentage or as an approximate quantity. It also did not vary much from one site to the other.

The reason why all the other variables were not included in the final model shown in the summary table is because they were found not to affect labour investigated. It had been assumed in chapter one that they affect labour productivity on the site, but due to the circumstances present on these sites they were found not to. These factors are not significant in our sites but may be significant in other countries.

(ii) Technical factors affecting labour productivity in walling.

The print out showed that only three variables were contained in the summary table, as opposed to all the eight variables, k_1 to k_8 which were inputed into the computer. The three variables appearing in the summary table shown in table 4.11 were, k_6-No of labours involved, k_1-materials wastage on site, and k_2-distance of blocks from wall. The three variables had a value of $R^2 = 0.9882$ which means that the three variables account for 98.82% of the variation in productivity in walling. A value of $R^2 = 0.9882$ is very high and this shows how complete the phenomenon under study is. This should not be taken literally, what is important is the causal explanation of the relationship between the dependent variable and the three independent variables. This makes it necessary that one must take into account the theoretical considerations before drawing a conclusion.

Variable k_6-number of labourers involved accounted for 66.40% of the change in labour productivity, k_1-materials wastage on site accounted for 26.97% of the change and finally k_2-distance of the blocks from wall accounted for 5.49% of the change. All the other five variables appearing in table 4.8 which were inputed into the computer did not appear in the summary table because they were found not to affect productivity. The possible reasons for this will be discussed in the last chapter.

FILE \ JEDIDAH (CREATION DATE = 13/05/83)

* MULTIPLE REGRESSION * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. Y2 LABOR PROD.IN WALLING MEASURED IN SM/Y.H

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
K5	NO.OF LABOURERS INVOLVED	0.81491	0.66407	0.66407	-0.81491	-0.05724	-0.83693
K1	MATERIALS WASTAGE ON SITE	0.96610	0.93334	0.26927	0.80639	0.26476	1.04377
K2	DISTANCE OF BLOCKS FROM WALL "L.METERS"	0.99411	0.98826	0.05492	0.80338	-0.09032	-0.66543
(CONSTANT)						0.64433	

FILE JEDIDAH (CREATION DATE = 13/05/83)

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE: Y2 FROM VARIABLE LIST 1
REGRESSION LIST 1

SEQNUM	OBSERVED Y2	PREDICTED Y2	RESIDUAL	PLOT OF STANDARDIZED RESIDUAL -2.0 -1.0 0.0 1.0 2.0
1	0.2110000	0.2075200	0.3480000E-02	*
2	0.3150000	0.3358000	-0.2080000E-01	* I
3	0.3590000	0.3485600	0.1044000E-01	I*
4	0.3380000	0.3310400	0.6960000E-02	I*

TECHNICAL FACTORS 13/05/83 PAGE 4

SEQNUM	OBSERVED Y2	PREDICTED Y2	RESIDUAL	PLOT
5	0.5230000	0.5230000	-0.1156636E-10	*

DURBIN-WATSON TEST OF RESIDUAL DIFFERENCES COMPARED BY CASE ORDER (SEQNUM).

VARIABLE LIST 1, REGRESSION LIST 1. DURBIN-WATSON TEST 2.70000

Table 4.10: Final Model for Technical Factors in Walling

(iii) <u>Human factors affecting labour productivity in concreting</u>.

The summary table in the print out shown in table 4.12 showed that only the following three variables affect labour productivity in concreting. Q_{16}-Frequency of payment of wages, Q_1-unskilled labour with primary level of education and last but not least Q_2-unskilled labour with secondary school level of education. The three variables gave a value of R^2 of 0-9994. This means that the three variables together account for 99.94% of the change in labour productivity in concreting. A value of R^2 of 0.9994 is very high and this means that the three variables explain almost all the variation. But as mentioned earlier, it is important to consider the theoretical relationship between the independent variables and the dependent variable.

Variable Q_{16}-frequency of payment of wages account for 85.19% of the variation in productivity, Q_1-unskilled labour with primary level of education accounted for 14.22% of the change and lastly Q_2-unskilled labour with secondary level of education accounted for 0.53% of the change. The explanation and the relevance of the RSQ values to the study will be given in the last chapter. All the other 15 variables in table 4.9 which were fed into the computer do not appear in the summary table since they were found not to affect productivity.

FILE HUMAN (CREATION DATE = 30/05/88)

* MULTIPLE REGRESSION * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. Y1 LABOR PROD.CONCRETING MEASURED IN CM\MHR

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
Q16	FREQUENCY OF PAYMENT OF WAGES"NO.OF DAYS	0.92300	0.85193	0.85193	-0.92300	-0.00421	-1.33407
Q1	UNSKILLED LABOR PRIM.LEVEL OF EDUC. %	0.99709	0.99419	0.14225	-0.35357	0.00024	0.46763
Q2	UNSKILLED LABOUR SEC.LEVEL OF EDUC. %	0.99975	0.99949	0.00530	0.68890	-0.00021	-0.16352
(CONSTANT)						0.12660	

HUMAN FACTORS 30/05/88 PAGE 5
REGRESSION DEP.="Y1"LABOR PROD.CONCRETING MEASURED IN CM\MHR
FILE HUMAN (CREATION DATE = 30/05/88)

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE: Y1 FROM VARIABLE LIST 1
REGRESSION LIST 1

PLOT OF STANDARDIZED RESIDUAL: -2.0 -1.0 0.0 1.0 2.0

SEQNUM	OBSERVED Y1	PREDICTED Y1	RESIDUAL	PLOT OF STANDARDIZED RESIDUAL
1	0.7700000E-01	0.7663431E-01	0.3656897E-03	*
2	0.8000000E-01	0.8035697E-01	-0.3569734E-03	*
3	0.8800000E-01	0.8800872E-01	-0.8716341E-05	*
4	0.1060000	0.1059609	0.3906507E-04	*
5	0.9300000E-01	0.9303907E-01	-0.3906507E-04	*

DURBIN-WATSON TEST OF RESIDUAL DIFFERENCES COMPARED BY CASE ORDER (SEQNUM).

VARIABLE LIST 1, REGRESSION LIST 1. DURBIN-WATSON TEST 2.47137

Table 4.12: Final Model for Human Factors in Concreting.

(iv) <u>Human factors affecting labour productivity in walling</u>.

The summary table in the computer print out shown in table 4.13 showed that only three variables are significant in labour productivity in walling. The three variables which appear in the summary tables are, Q_{18}-wages in shillings, Q_{13}-supervision and Q_3-skilled labour. These three variables give an R^2 value of 0.9998. This means that the three variables together account for 99.98% of the change in labour productivity in walling. An R^2 value of 0.9998 is very high and shows how complete the model is. But it should not be forgotten that this is only a mathematical necessity, which must be explained taking into consideration, the assumptions in the theoretical framework of the study.

Variable Q_{18}-wages in shillings account for 87.06% of the variation in labour productivity in walling, Q_{13}-supervision accounted for 12.68% of the change and finally Q_3-skilled labour explains 0.24% of the change, as shown by the value of the RSQ change. The explanation of the above is given in chapter five. It is also worth noting that the relationship between all the three variables and productivity is positive. This means that an increase in the value of any of these variables will cause an increase in the productivity.

FILE HUMAN (CREATION DATE = 30/05/88)

* MULTIPLE REGRESSION * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. Y2 LABOR PROD IN WALLING MEASURED IN SM\MHR

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
Q15	WAGES IN KSHS. PER DAY	0.93308	0.87063	0.87063	0.93308	0.02337	1.07527
Q13	SUPERVISION	0.99873	0.99747	0.12684	0.09029	0.03754	0.23377
Q3	SKILLED LABOUR %	0.99994	0.99988	0.00242	-0.15264	0.00163	0.15071
(CONSTANT)						-0.43509	

HUMAN FACTORS 30/05/88 PAGE 11
REGRESSION DEP.="Y2"LABOR PROD IN WALLING MEASURED IN SM\MHR
FILE HUMAN (CREATION DATE = 30/05/88)

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE: Y2 FROM VARIABLE LIST 1
REGRESSION LIST 1

SEQNUM	OBSERVED Y2	PREDICTED Y2	RESIDUAL	PLOT OF STANDARDIZED RESIDUAL -2.0 -1.0 0.0 1.0 2.0
1	0.2110000	0.2095434	0.1456593E-02	* (at 0.0)
2	0.3150000	0.3165303	-0.1530793E-02	* (at 0.0)
3	0.3590000	0.3594404	-0.4403652E-03	* (at 0.0)
4	0.3380000	0.3384404	-0.4403652E-03	* (at 0.0)
5	0.5230000	0.5219951	0.1004936E-02	* (at 0.0)

DURBIN-WATSON TEST OF RESIDUAL DIFFERENCES COMPARED BY CASE ORDER (SEQNUM).

VARIABLE LIST 1, REGRESSION LIST 1. DURBIN-WATSON TEST 2.09614

FILE HUMAN (CREATION DATE = 30/05/88)

Table 4.13: Final Model for Human Factors in Walling.

Test of Significance

In the first chapter it was suggested that the trueness of the relationship between any of the independent variable in the summary tables and the labour productivity should be tested at 95% confidence level. What this tells us is that based on the data available from the construction sites investigated, we can be 95% confident, allowing for 5% error that the hypothesis formulated in respect of any independent variable with respect to the labour productivity is true or false.

For a given number of variables, the null and alternative hypothesis for each variable would be formulated in the form:

$$H_o: \delta^2_{1.234...n} = \delta^2_{2.124...n} = \delta^2_{.1234...n-1}$$

$$H_A: \delta^2_{1.234...n} \neq \delta^2_{2.124...n} \neq \delta^2_{.1234...n-1}$$

where $\delta^2_{1.234,}$; etc are expected variances of $x_1, x_2, ..., x_n$; when the effect of all other variables except the x_i under consideration are held constant.

The null hypothesis H_o, states that there is no relationship between each of the independent variables and the dependent variable. The alterantive hypothesis H_A states that there is a causal relationship between the independent and the dependent variable. The F statistic will be used to test the existence or otherwise of a relationship. The F statistic is given by:

$$F_{0.05,(r-1,\ n-r)} = \frac{\dfrac{(R^2_{1.234...r})}{r-1}}{\dfrac{(1-R^2_{1.234...r})}{n-r}}$$

The comparison of F values will be made from values obtained from the computer printout in the regression models i.e. calculated F values and the F values tabulated in Neaves statistics table at appropriate degrees of freedom

The null hypothesis was rejected in each case where the F value calculated exceeded the F value expected from the tables at the same degree of freedom; i.e. the alternative hypothesis that a relationship exists was accepted at 95% significance level, if the calculated F value was found to be bigger than the expected F value. The following table, table 4.14 shows the critical regions for the null hypothesis.

From the table the null hypothesis was accepted for all the technical factor variables in both concreting and walling model and rejected for all human factor variables in the labour productivity model for concreting and walling respectively. Contrary to what we expected the technical factors have no relationship to labour productivity at 95% confidence level. The possible explanation for the acceptance of the null hypothesis in this case are several. The reasons why a parameter estimate such as the variance may not be significant are many.

Table 4.14: Critical Region for the Null Hypothesis $H_o: \delta_1^2 = \delta_2^2$

(i) Technical factors affecting labour productivity in concreting.

Variable	F-calculated	F-tabulated	Significance @ 95%
X_9	0.005	216.00	Accepted
X_4	0.360	19.00	Accepted
X_3	0.247	10.13	Accepted

(ii) Technical factors affecting labour productivity in walling.

Variable	F-calculated	F-tabulated	Significance @ 95%
K_6	25.113	216.00	Accepted
K_1	17.487	19.00	Accepted
K_2	4.678	10.13	Accepted

Table 4.14: (Contd...)

(iii) Human factors affecting labour productivity in concreting

Variable	F-calculated	F-tabulated	Signficance @ 95%
Q_{18}	5470.247	216.00	Rejected
Q_{13}	53.483	19.00	Rejected
Q_{3}	20.699	10.13	Rejected

(iv) Human factors affecting labour productivity in walling

Variable	F-calculated	F-tabulated	Significance @ 95%
Q_{16}	912.82	216.00	Rejected
Q_{1}	186.691	19.00	Rejected
Q_{2}	10.429	10.13	Rejected

Some reasons why we might fail to uncover statistical significance even if the independent variable is actually related to the independent variable are: inadequate sample size, type II error, specification error and restricted variance in x. Another possibility is high multicollinearity, but this is ruled out in these results because the contingency table of correlation coefficient showed that non of the variables in the final model had a high correlation to each other.

With a larger sample, a given coefficient is more likely to be found significant. In very large samples of over 1,000, the statistical significance may actually be "too easy" to find since tiny coefficient can be statistically significant. In studies where the sample size is limited as a result of difficulties in obtaining case studies, the size of the sample could make the results not significant at the prescribed confidence interval.

When the null hypothesis is accepted as a result of type II error this implies that the null hypothesis is accepted while in fact it is false. In a case where the sample size is fixed the problem of choosing a significance level becomes important. The significance test in principle can be set at any level between 0 and 1. Most social scientists set it at 0.05 or 0.01. One of the convenient levels are usually selected at the beginning of a study. One might select a level of 0.025 prior to the investigation only to find that the significance at 0.05 is less demanding. In this case one may prefer to accept the results at the lower test. What this tells us is that the significance at a lower test level may be evident which at a higher test level it is not. In this study the test was set at a significant level of 0.05. If a significant level of 0.50 had been used, the technical factors may have emerged significant.

The other reason which was given for the acceptance of the null hypothesis is the presence of specification errors such as assuming a linear relationship between the independent and the dependent variables while the relationship is actually curvilinear or cases where relevant dependent variables are excluded and irrelevant variables included. The foregoing has been a discussion of the possible causes of the null hypothesis being accepted where in theory a strong relationship was expected. At this point one may ask whether there is any logical explanation as to why technical factors have a weaker relationship to productivity than the human factor. An attempt to answer this question will be made in the next and last chapter.

FOOTNOTES

1. Lewis-Beck, M.S. Applied Regression: An Introduction. Sage Publication Ltd. New York, 1980.

2. George C. Shen, "Productivity Measurement and Analysis, Asian Productivity Organization, Monograph Series, 1985, p.57.

CHAPTER FIVE

CONCLUSION

Introduction

This chapter consists of the conclusions drawn from the various final models and information obtained from informal interviews and discussions with various personnel on the site, and the recommendations of the whole study. The main objective of this study was to identify those technical and human factors that influence productivity of labour on site.

The conclusions will be drawn from the findings; this will determine how far the study objectives have been met. Before the conclusions can be made, the implications of these factors, i.e. technical factors and human factors on labour productivity of a firm and the industry in general will be discussed. Towards the end of the chapter recommendations on productivity improvement techniques will be made. These will be those techniques that are applicable to the construction firms in Kenya, in the light of those factors that have been found to affect productivity.

The recommendations made are for use by the management of the construction firms with the aim of improving productivity on site. It has been established from literature that there are many productivity improvement techniques which have been tried elsewhere in construction firms. Unless the factors that affect productivity are first identified and thereafter a productivity improvement scheme designed in light of these, then the efforts are not worthwhile.

The Implications of the Final Models.

Implication of Technical Factors of Labour Productivity in Concreting and Walling.

The final model for technical factors affecting labour productivity in concreting and the one for those factors affecting walling, both contain three variables. The contribution of each variable to variation in each model is shown in chapter four tables 4.10 and 4.11. The significance test using the F statistic showed that the null hypothesis was accepted for all the variables in the final models at 95% confidence interval. What this really means is that the model is not applicable to the construction site at the confidence interval of 95% or in other words that there is no relationship between the independent variables in the models and the dependent variable at the confidence interval allowing for 5% error. There are various reasons for the acceptance of the null hypothesis where it ought to have been rejected and these have been discussed in chapter four.

Although the null hypothesis was accepted for the technical factors affecting labour productivity in both concreting and walling, the implications of variables in the summary table of the final models will now be discussed at the end of which a conclusion will be drawn. The technical factors of labour productivity in concreting are variables X_9- condition of the mixer, X_4- capacity of mixer and X_3- number of labourers involved. The technical factors of labour productivity in walling are K_6 - number of labourers involved, K_1 - materials wastage on site and K_2 - distance of blocks from the wall. The technical factors affecting labour productivity in concreting will be discussed first followed by those affecting productivity in walling.

Variable X_9 - Condition of the Mixer

The condition of the mixer was represented by a dummy variable and was measured at two levels. The concrete mixer was either efficient denoted by 1 or inefficient denoted by 0. The working conditions of a mixer affects its efficiency as a machine. The efficiency of a mixer which is damaged or in need of repair and maintenance is lower. The condition of the mixer emerged as the most important technical factor in concreting and explains 28.78% of the change in productivity in concreting. The more inefficient the mixer the lower the productivity.

The concrete mixer was described as the centre of or the "nucleus" of the concreting activity. It is taken as the controlling factor in this activity at all times because it governs all the manning and movements in concreting. This would then imply that if the efficiency of the mixer is impaired, it will be reflected in a decrease in labour productivity in concreting.

The conclusion which can be drawn is that damaged plant affects labour productivity by decreasing it. The contractor should always ensure that pior to commencement of any work where plant is to be utilized, the plant is inspected and if found defective is repaired. This should apply to all plant used on a construction site and not only the concrete mixer.

Variable X_4 - Capacity of Mixer

The capacity of the mixer is the amount of concrete that can be mixed in a single operation of the concrete mixer and was measured in cubic metres. The capacity of the mixer accounted for 6.11% of the change in productivity. This is a small change and it can be concluded that it has a minimal effect on labour productivity in concreting.

The capacity of the mixer had a negative relationship to labour productivity in the model. An increase in the capacity of the mixer decreases productivity. What was hypothesized was that a larger mixer will mix more concrete per unit of time and this will speed up the placing of the concrete, resulting in a higher productivity in concreting. Thus a positive relationship was expected. What then is the explanation of the results being the opposite of what was expected?

The capacity of the mixer was one of the surrogates for the technique of concreting. In an earlier discussion it was outlined why the technique had to be represented by surrogates. The negative relationship can be explained by first examining the data from the field survey to obtain the number of labourers loading the mixer in each of the case studies. The reason is because other than the capacity of the mixer there are other factors which affect the output such as condition of the mixer and the number of persons loading it. Condition of the mixer was one of the independent variables but the number of persons loading the mixer was not because it has a high correlation with the capacity of the mixer.

The number of persons loading the materials into the mixer for mixing will determine how long the loading process will take. Given equal number of labourers loading a mixer, the smaller capacity mixer will be loaded faster than a larger one. This implies that for a larger mixer the number of persons loading it should be proportionately more than those loading a smaller mixer. On project B which had the larger capacity mixer, the number of labourers loading it was six while in all the other four sites with smaller mixers, a minimum of seven labourers did the loading. This explains why a negative relationship emerged as opposed to the expected.

In conclusion it can be said that the capacity of the mixer is one of the technical factors that affect labour productivity in concreting and the number of labourers loading the mixer should be proportional to the capacity of the mixer.

Variable X_3 - Number of Labourers Involved

The number of labourers involved in the concreting activity was measured as the total of all the persons involved, which included those loading the mixer, those operating the mixer, those transporting the green concrete to the point of placing and those placing and compacting it. The number involved accounted for 12.88% of the change in labour productivity. Thus an increase in the number of labourers involved results in an increase in labour productivity.

The result imply that concreting requires a large gang of workers. The reason for this lies in the fact that this activity is labour intensive and the bigger the size of the gang the higher the output. The size of the gang on the other hand cannot be increased indefinitely because beyond a certain number there will be overcrowding. Overcrowding would result in crew interfacing. Crew interfacing would result in reduced output. This study has not attempted to determine the optimum size of the gang, but it could be an area of further investigation.

To summarize the implications of technical factors on labour productivity in concreting, it can be said that the technique of concreting is important as shown by the total change in labour productivity due to capacity of mixer and the number of labourers involved. These two variables were surrogates for technique of concreting. The conclusion which can be made is that the contractors should choose the optimum capacity of the mixer and the right size of gang. Having done this, he should also ensure the mixer is in good working condition.

The final model accounts for only 47.78% of the change and the other factors not known 52.22% of the change in labour productivity. Thus the model explains less than half the change and the other unknown factors account for overhalf of the change. Further investigations should be carried out to find out these other factors not known that affect labour productivity in concreting.

After discussing the implication of the technical factors affecting labour productivity in concreting, the following is a discussion of the implication of the technical factors affecting productivity in walling.

Variable K_6 - Number of Labourers Inolved

This variable accounted for 66.4% of the change in productivity. The number of labourers involved was taken as the total number of all the labourers working at one point of the wall construction as a gang. This number ranged between 6 and 3 on the five construction sites. The relationship between the number of labourers involved and productivity is negative, i.e. an increase in the number of labourers will cause a decrease in productivity. This implies that there is a minimum number of workers who should work in a gang and once this number is exceeded the result is loss in productivity. This minimum number of labourers is not the scope of the study and can form an area of further investigation.

The management of the construction site should thus keep the size of the gang at the minimum possible if productivity is to be maintained. The number of labourers involved was one surrogate for the technique of wall construction and so it can be concluded that the technique of wall construction is important and should be carefully analysed before deciding on the number of labourers to be engaged in the activity.

Variable K_1 - Materials Wastage on Site

The variable was a dummy variable and was measured at two levels only; (0) represented a site where there was no wastage and (1) represented a site where there was wastage. The model shows that an increase in the amount of wastage on site causes an increase in labour productivity in walling. Material wastage accounted for 26.97% of the change in labour productivity.

An increase in the materials wastage on a construction site was expected to cause a decrease in productivity and not an increase. This is because the wastage leads to delay which in turn results in loss in labour productivity. The likely reasons for this result was the manner in which wastage was measured and also the fact that wastage did not vary very much among sites. Material wastage varied on one site alone. If the wastage was measured more accurately, for example, counting the number of broken blocks or measuring the approximate quantity of mortar going to waste, then a true picture of the effect of wastage may have been obtained.

Variable K_2 - Distance of Blocks from Wall

The distance of the blocks from the wall was measured in linear metres. This was the distance from the stock pile of blocks to the point at which the wall construction was taking place. The distance accounted for 5.49% of the change in labour productivity. The models indicate that an increase in the distance of blocks from the wall under construction causes a decrease in labour productivity.

The distance of the blocks from the point of placing is related to the layout of the work place and was taken as the surrogate to represent the layout of the work place. The layout of the work place is important. The proper layout ensures that there is no overcrowding or crew interfacing and that the flow of materials is unobstructed. It is also important if double handling of materials is to be avoided. Double handling results in delay and unnecessary work.

The construction site management should always take the points mentioned above into consideration during the planning of the site layout. The blocks should be placed as near as possible to the point of placing. The main reason for this is because blocks are heavy and if the work is to proceed smoothly and fast the blocks have to be as near as possible so that the labourers, working with the mason do not get tired quickly by having to fetch the blocks from far off places.

To summarise the implication of technical factors on labour productivity in walling, it can be said that the technique of wall construction and layout of work place are important in wall construction. These two factors can cause a decrease in labour productivity if proper attention is not paid to them during the planning and scheduling of the construction work. In order to improve productivity in wall construction it is important that the management pay attention to the manning and layout of the work place in terms of the labourers carrying out the work and the distance of materials from the point of placing.

Implications of Human Factors on Labour Productivity in Concreting and Walling

The final models for human factors affecting productivity in concreting and walling consist of three variables each. These variables are shown in tables 4.12 and 4.13 respectively. The three variables in the final model of human factors of labour productivity in concreting are Q_{16} - frequency of payment of wages, Q_1 - unskilled labour with primary level of education and Q_2 - unskilled labour with secondary school level of education. These three variables account for 99.94% of the change in labour productivity in concreting. The three variables in the final model for factors of labour productivity in walling are Q_{18} - wages in Kenya shillings, Q_3 - skilled labour and Q_{13} - supervision. The three variables account for 99.98% of the change in productivity.

The variables in the two final models explain almost all the variation in labour productivity in both cases of concreting and walling. The fact that almost all variation is explained is only a statistical convenience and the theory behind it has to be examined for this to have any meaning in the study.

The significance test using the F-statistics showed that the null hypothesis was rejected at the confidence interval of 95%. What this means is that there is a causal relationship between the independent variables and the dependent variable in the model at 95% confidence interval allowing for an error of 5%. The implication of these models on labour productivity now follow. Each variable will be discussed one at a time starting with the model for human factors of labour productivity in concreting.

Variable Q_{16} - Frequency of Payment of Wages

The frequency of payment of wages to the labour force was measured in days. This was the number of days between one payment of wages and the next. The frequency of payment of wages ranged from seven days to fourteen days on some construction sites. The frequency of payment of wages was found to be very important as it accounted for 85.19% of the change in labour productivity in concreting.

From literature review in chapter two, the motivation of the labourers was established as a factor that causes variation in labour productivity. Further it was discussed that motivation results from interaction of physical conditions on site, social conditions on site and the individual needs of the labourers. The frequency of payment of wages or the mode of payment is one of the social conditions of the job. It can therefore be concluded that the frequency of payment of wages is the only motivational variable that affects productivity in concreting.

An increase in the duration of the interval between payments of wages will cause a decrease in labour productivity according to the final model. The b value is negative, so that the less the frequency of payment of wages the lower the labour productivity.

The reason for this high value of RSQ for Q_{16} which equals 0.8519 lies in the importance which the labourers attach to the form of employment on construction sites. On the construction site, the duration of the employment is dependent on the duration of the project and in some instances the duration of a task. In such cases the frequency of payment of wages is a very important factor. This stems from the job insecurity associated with construction sites.

The labourers only feel secure once they have received their dues for the work done. This coupled with the fact that the wages are generally low, will make the labourers work harder for the next payment when the interval between the payments is smaller.

What the above discussion implies is that with the type of construction work such as concreting it pays to shorten the interval between the payment of the wages to the shortest reasonable time; in this case payment every three working days to one is recommended. Daily payment of wages would be the best as it could act as an incentive to motivate the labourers towards a higher output. But daily payment of wages would entail paying the labourers at the end of each working day before the labourers leave for home which can be time wasting.

Variable Q_1 - Unskilled Labour with Primary School Level of Education

The unskilled labour with primary school level of education was measured as a percentage of the total number of labourers involved in concreting and walling. This variable accounted for 14.23% of the change in labour productivity as shown in table 4.12 in chapter four. The unskilled labour with primary level of education was one of the measures of quality of labour on construction sites. This percentage gave an idea of the education level of the labourers. From the data it has been noted that over 60% of all the labour on each site had primary level of education. This implies that the majority of the construction workers employed on the construction sites which were under investigation are primary school leavers.

According to the model, an increase in the percentage of the labourers with primary school level of education will cause an increase in labour productivity in concreting. The conclusion which can be drawn from these findings, is that the importance of the unskilled labour with primary level of education is due to the fact that the majority of the labour force on the construction sites has this level of education and this majority is the backbone of the concreting activity. And therefore increasing the number of labourers with this level of education will result in increased labour productivity in concreting. It was expected that the percentage of skilled labour would be crucial in productivity according to the literature review, but the results have indicated otherwise. The possible explanation for this is that the activity of concreting is labour intensive and depends on other factors other than the level of skill of the labour force.

A general conclusion is that the quality of labour on construction sites in Nairobi in terms of education is low. This can only be improved by employing more people with higher education level than primary school education.

Variable Q_2 - Unskilled Labour with Secondary School Level of Education

The unskilled labour with secondary school level of education was measured as a percentage of the total number of labourers involved. According to the model an increase in the percentage of unskilled labour with secondary level of education causes a decrease in labour productivity. This is not what was expected. It was expected that an increase in the percentage of unskilled labour with secondary level of education will cause an increase in productivity because we are raising the quality of labour on the site in terms of education. The reason for the results being the way they are in the model is because very few secondary school leavers are employed on construction sites and in particular on the five sites under investigation. Secondary school leavers prefer to get employment elsewhere such as in offices and industries. They tend to shan manual work and only turn to construction sites when no other forms of employment is available. This is supported by the very low number of such workers encountered in the five sites during the investigation. The secondary school leavers that end up on the construction sites are few and do so as a last resort when they cannot get employment in any other sector of the economy.

Having discussed the implications of the model for human factors of productivity in concreting, the following is a discussion of the model for human factors of productivity in walling.

Variable Q_{18} - Wages in Kenya Shillings

The wages on the construction site was measured in Kenya shillings. This was the amount paid to the workers per day. The wages were assumed to be inclusive of housing allowances and all other allowances such as insurance and hospital fund. The wages varied considerably among all the sites. The wages paid to the labourers was found to be the most important single variable which affects labour productivity in walling. This variable accounts for 87.06% of the change in productivity. This implies that the wages are very important to the labourers.

According to the model, an increase in the wages paid to the labourers causes an increase in labour productivity. The wages paid to the labourers was one of the variables that represented the individual needs of the workers. This was based on the assumption that the wages are used to purchase food, clothing and shelter. The physiological needs are the lowest level needs among the individual needs. The physiological needs or the lowest needs are the most important needs to a construction worker and the only ones that motivate him to work. This is the conclusion which can be drawn from the model. Higher needs cannot therefore motivate the construction workers towards higher productivity, until the lower needs are met.

From the field survey, every single labourer interviewed was of the opinion that the wages paid to them is not sufficient and the only thing the management of the firm, can do to improve the production is to increase their wages. The wages paid to the labour ranged between Ksh.25/- per day to sh.39/- per day. Those getting sh.25/- per day, therefore receive an equivalent of sh.660/- per month. This is very low wages taking into consideration the inflation levels in the country. With this amount of wages then there is no way these workers can afford decent food, shelter or clothing without supplementing their incomes. The lowest paid workers were getting less than the gazetted minimum wages for casual labourers. This in essence means that the contractor contravened the minimum government wage guideline. The unscrupulous contractors and other employers seem to have decided to cash in on the problem of unemployment by exploiting their casual workers to maximise profits and evade the requirements of the Industrial Act.[1]

In order to improve labour productivity in walling and generally, the contractors should raise the wages paid to their workers and also provide other monetary oriented incentive schemes through which the worker can earn some extra money over and above their basic pay. This move would have a profound effect on the output of the labour force because, the individual needs of the workers are the most important motivation factors affecting productivity of the construction workers.

Variable Q_3 - Skilled Labour

Skilled labour was measured as a percentage of the total number of labour force. Skilled labour varied on all sites. The skill of the labourer is one of the measures of quality of labour cited in the literature review. The higher the percentage of skilled labour on a construction site the better the quality of the labour. The results in the final model supported this, in that an increase in the amount of skilled labour will cause an increase in labour productivity in walling.

What the above implies is that skill is important in wall construction. In order to improve the labour productivity in walling on a construction site, the management should employ skilled labour. Unlike in concrete where skill does not account for much, skill is shown to be important in walling. The main reason is that wall construction can only be effectively carried out by skilled labour with some assistance because it is a specialised task requiring knowledge and skill.

Variable Q_{13} - Supervision

Supervision was measured using a dummy variable. It was measured at three levels, namely: (0) which represented below average, (1) represented average and (2) representing above average. According to the results in the model an increase in the quality of supervision causes an increase in labour productivity in walling. Supervision is one of the social conditions of the job. Social conditions on the job affect the motivation of the worker. It can therefore be concluded that of all the social conditions on the job, the most important on the five sites investigated is the quality of supervision.

Supervision is very important in construction work in order to produce good workmanship. The person supervising should be qualified for his job in order to supervise efficiently. It has been pointed out that close supervision is necessary on construction sites, because majority of the labourers are not skilled and thus need close supervision in order to produce good workmanship. Another reason is that construction workers tend to relax and even start talking once they notice that the supervision has been relaxed or once the supervisor moves away. For the productivity in walling to be improved the management of the site should ensure that they select well qualified supervisors to maintain strict quality supervision at all times.

A Summary of all the Implications of Technical and Human Factors

The human factors of productivity are more important determinants of labour productivity in both concreting and wall construction in all the sites investigated. It has been shown that technical factors are not significant at 95% confidence interval. This means that for all the five sites investigated we can say that at 95% confidence interval technical factors are not significant in labour productivity. Various reasons have been discussed in chapter four. This does not mean that the technical variables are not significant at all, even with the given sample size. A test using a lower confidence interval of say 80% or 90% may reveal significance.

The human factors in the final model for both concreting and walling are related to labour productivity at a confidence interval of 95%, allowing for an error of 5%. Out of the significant human factors variables, motivational factors that are money related were found to be more important in both walling and concreting. The two most important motivational variables in concreting and walling are frequency of payment of wages and the amount of wages paid to the labourers respectively. The implication which can be drawn from these two variables is that the construction worker in the study attach great importance to his wages. This then would lead us to the conclusion that productivity can be improved through monetary based productivity improvement schemes such as incentive payment.

The other human factors that affect labour productivity is the quality of labour in terms of education and skills. The education level and the skill achieved by the labourers was shown to be important especially in walling. What this implies is that by employing worker with higher qualifications, productivity can be improved. Alternatively the contractor can set up a training programme within the firm to help the workers upgrade their skills.

Lastly, social conditions on the job such as the quality of supervision and the mode of payment of wages were also found to be important. Improvement in the quality of supervision by having more supervisors and better qualified ones can increase productivity of the labour force.

Results from Informal Interviews

Apart from the results recorded in the data collection form or the questionnaires, other important information became apparent from informal interviews and personal observation on site. It was observed in all the five case studies that the contractors did not offer any form of training to the labourers. When the absence of training programmes from the site was queried, the reasons given by the contractor were similar.

All the contractors said that they had at one time made an attempt to train some of their most promising labourers. These labourers that were selected were mainly those that had shown keen interest in the various trades on the construction site. The contractors lamented that once trained these labourers usually left the firm to join other better paying firms. One firm quoted a labourer who had been trained in masonry for two years only to leave and join another firm which offered him a few shillings over and above what he was getting. What was not clear from the contractors is whether once trained, the labourers were given prospects such as increase in wages that would persuade them not to leave.

The tendency of trained workers to leave and seek for better paying jobs has discouraged the contractors from carrying out training on their sites. They feel that, they would rather pay training levy to the government rather than undertake the task of training the workers. Other problems encountered in the training programmes are discontinuation of the training. Discontinuation can result from lack of adequate work load to sustain all the trainees or due to the trainees themselves deserting before completion of the training period. Training is also an additional expense to the contractor which most felt they could not afford, because they do not set aside any funds in their budget for training purposes.

The effect of the absence of training in the construction firms has been to limit the supply of skilled labour in the construction industry. Although unskilled labour is abundant, there is a shortage of skilled labour. This is because the government training institutions such as technical schools and polytechnics coupled with self-help village polytechnics cannot meet the increasing demand for skilled labour in all the sectors of the economy. The construction industry has therefore got to compete with other sectors of the economy who employ workers with skills similar to those required in the construction sites and workshops. Skilled labour was one of the factors that was found to affect labour productivity, it can therefore be concluded that if the supply of skilled labour can be increased this would result in improved productivity.

The conclusion which can be made from this observation is that contractors are reluctant to provide training in the construction industry because, the trained staff desert the training firm on completion, trainees discontinue their training due to inadequate workload or due to the trainees deserting before the course is over and the expenses incurred by the firm in training programmes.

The other important observation made was the general ignorance displayed by the construction labourers in the case studies. The construction labourers are ill informed of their legal rights under the laws of the country as was evident from informal interviews on site. They are not aware that there are Acts of Parliament such as the Factories Act Cap 514 and Public Health Act among others which seek to protect the workers. These Acts stipulate the conditions under which different trades should be carried out and the general welfare which the workers should be provided with. This ignorance has resulted in construction workers being exposed to hazardous working environment and being provided with inadequate welfare facilities. Chapter three of the study has discussed the welfare facilities which should be provided to the construction worker. Almost all the labourers interviewed were not aware of whether they are entitled to any compensation and the procedure which are followed while claiming compensation as a result of injury received in the course of carrying out their work.

The ignorance of the construction workers is compounded by the low level of education of most of labourers. This is confirmed by the results from the data analysis which showed that over 60% of all the construction workers in each site had primary level of education, and the absence of strong labour unions. Out of the five case studies, it was in only two of them where some labourers belonged to a construction workers union. The labour union can play an important role in educating the workers on their rights under the law and can also bargain on their behalf for better terms of service. All the contractors resented unionisation of the labourers and did not entertain visits by union officials to the sites. They viewed the union officials as trouble makers.

To conclude, the awareness of the construction labourers can be raised through lectures and talks on relevant topics organized and delivered by their union officials. This can only be possible if the contractors are willing to allow the union officials to give these lectures and talks over lunch hour and after work on the sites. This is the only way through which these workers can gain more information, because the other alternative of giving them relevant literature to go and read at home would not help them because most of them can not get the opportunity to read at home coupled with their low education level. If the awareness of the labourers is raised they would be in a position to press for their rights and in turn would be aware of what is expected of them. This would have a positive effect on the labour productivity.

Recommendations

This study has established that the level of skill is a factor that affects labour productivity on construction sites. This study therefore recommends that the construction firms should look into ways of improving the skills of their workers by providing on the job training or sponsoring them to training institutions in the country. On-the-job training is necessary especially where the education level of the workers is such that there are doubts as to whether they can qualify for selection into a training institution. Some workers can gain meaningful knowledge and skills through training. Any training given, should be accompanied by some documentary evidence such as certificate. This certificate is important to the workers because it is an indication or evidence that he has obtained training in that particular course named in the certificate.

It was also established that supervision on the site affects labour productivity in walling. The study therefore recommends that the quality of supervision on construction site should be improved. Supervision can only be effective if certain factors are fulfilled. Effective supervision on a site is of overriding importance because it exercises a direct influence on several factors. These factors are, the amount and quality of work produced, the working relations with both the labourers and the employer and the financial results of the project. The method of site supervision is determined by the sizes of the firm and site.

Notwithstanding the size of the site, the quality of supervision in terms of numbers of supervisory staff, their qualifications and their management skills are important. The site should be provided with a qualified supervisor and if necessary he should have assistant supervisors where the project is large enough to warrant it. One important distinction between the labourers to be supervised and the supervisor is their level of education. The supervisor should have a higher level of education and should also have a higher level of technical education. Leadership qualities are also necessary. The amount of freedom that can be given to supervisors and their success in solving planning and site organization problems depend increasingly on their level of technical education.

The responsibility of the supervisor should be clearly defined and his authority and prestige should also be reasonably supported in relation to site operations. The supervisors should not be burdened with a lot of clerical duties such as time keeping, recording wages, materials etc. In all but the smallest sites he should have clerical assistance. The maximum number of men one supervisor can effectively handle without clerical assistance will depend on the type of work to be carried out and should not be more than forty men.

The construction firm should give the supervisor some general knowledge of the trend of the financial results of his site. This is to enable him to gauge his performance. Incentive payments to supervisors which are linked to the results of their jobs are also likely to be a justified practice and their use should always be carefully considered. The firm can also consider improving or raising the quality of their supervisors through supported external and internal courses of action.

Productivity Improvement Methods Applicable on Construction Sites in Kenya

There are many techniques that have been applied to improve construction productivity in western countries. Some have been successful but many have not. The result is not because of inadequacies in the techniques but rather in the misapplication.[2] The techniques applied should not be arbitrarily selected. There should be a broad-based data as well as data on specific problems. It is only after the problem is grasped that a productivity improvement method can be designed which will overcome these problems and improve productivity.

The study has established that the most important factors that affect productivity in both the activities investigated are money related. In order to improve productivity on the construction sites in Kenya and in particular the five sites investigated, the study recommends the use of incentive payment.

Incentive payment is defined as a monetary incentive which has the specific intention of encouraging and rewarding higher productivity than normal.[3] Monetary incentives are by no doubts the most effective on construction sites and are usually preferred by the labour.

There are several objectives of an incentive scheme:

(i) To reduce the cost of building by increasing efficiency.

(ii) To increase individual and collective production and lastly;

(iii) To provide opportunity for increasing earnings.

For the above objectives to be achieved it is imperative that in any proper incentive scheme, payments are strictly related to production. Only this way will increased efficiency and output on one hand and higher earnings for operatives on the other hand be achieved. The basis on which the incentive scheme is set is very important. The basis of incentive schemes is additional payment, over and above the standard rate of wages. It should be made to labourers in respect of their production compared with a target for the operation which can be expressed in terms of either time or value.

The scheme should be expressed simply in order that workers may know readily and exactly what they have to do to increase their earnings also to avoid misunderstandings and disputes. In an incentive scheme, the rate of ouput and quality of work on which the scheme is based should be such as can be reasonably and consistently attained by the average labourers, working under average conditions. The agreement on the amount of payment to be made to operatives in respect of savings achieved on the target should be reached in advance. The payment should be made on a trade or on a gang basis.

The target on which the incentive scheme is based should be issued by management and, whenever it is practicable to do so, agreed with the representative of the labourers on the site before an operation is started. It should be set down in writing for record purposes. The target should only be altered if there is materials change in the circumstances. The target should be stated as a given quantity or work to be done to the satisfaction of the site management, in a given period of time or within a given value. The target should take into account the ratio of skilled labourers to unskilled labour and plant to be used. The production payments earned by the labourers should be paid at regular intervals.

In the hurry to increase the production in order to maximise on an incentive scheme, the labourers should ensure that all the safety, health and welfare regulations are observed. They should also maintain a high standard of workmanship, avoiding wastage of materials and using the plant efficiently. The foregoing has been the requirements of an incentive scheme. The above requirements and regulations are based on the "National Working Rules for the Building Industry" published by the National Joint Council of Building Industry in Britain. There are no such regulations for the construction industry in Kenya, but these requirements and regulations are equally applicable to the situation in Kenya. Based on these requirements and regulation the best incentive payment recommended by this study is a target Bonus system.

The target bonus system is applied to the work of a gang such as the concreting gang or any other on the site. In this method a target for each operation or activity is set. For example, in walling the target is set for the construction of a given area of wall measured in square metres within a given period of time. In the case of concreting, this can be measured in cubic metres of concrete placed. The scheme operates in such a way that all the saving realised relative to a target set for the operations is paid to the workers. The labourers are also guaranteed hourly minimum earnings. If the target is not met, they only receive their minimum earnings. But if the target is met within the specified period of time the operatives are paid the minimum wages plus the savings, relative to the target. This is distributed among the members of the gang.

This scheme has been found to be effective, in that the bonus paid to the workers is solely related to the output of the gang. The bonus should be distributed evenly among the members of the gang irrespective of whether they are skilled or unskilled. This method if properly implemented will encourage the workers to raise their production at the same time their efforts are awarded. This method outlined above is one of the many incentive payments which are applicable on construction sites generally but this particular one is the one recommended in our construction sites in Kenya. Mainly because in this incentive payment both the contractor and the labourer stand to gain.

Areas of Further Studies

Although this study was interested in those factors that affect labour productivity on construction sites, it has become apparent in the course of carrying out the study that other areas require investigation. One such area of further studies is productivity of the management in a construction firm. An investigation to determine what factors affect management productivity in a construction firm can be carried out. By the term management, it refers to those employed at the head office, and site office whose work can be termed as management. The factors that affect management productivity can be identified through a suitably designed study, and further investigation to try and reveal how management productivity relate to labour productivity on site can be carried out.

Another area of further studies which this study recommends is a study of the total productivity of the construction firm as whole. This study considered the labour productivity on a single construction site of a given construction firm. A study of total productivity of a firm will have wider scope as it will not only consider labour but will include other inputs such as capital and plant and will consider a firm as whole and not only one site. Such a study can only be a comparative one to examine how total productivity vary from firm to firm and what factors play an important role in determining total productivity.

FOOTNOTES

1. ________ Kenya Times, Comment by the Minister for Labour, Mr. Peter Okondo, February 9th 1987.

2. H.R. Thomas, "A Prescription for Construction Productivity Improvement," Proceedings of CIB W-65 Fourth Symposium V.2. Ontario, Canada, April 1984.

3. R.G. Samson, Organization of Building Sites, H.M.S.O. London, 1959, p.55.

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APPENDIX A

LETTER OF INTRODUCTION TO CONTRACTORS

University of Nairobi
Dept. of Land Devpt.
P.O. Box 30197,
Nairobi.

29th Jan., 1987.

Dear Sir,

I am appealing to you for help. I am not asking for funds, all I am asking for is a few minutes of your time and access to one of your construction sites within Nairobi Province.

I am a postgraduate student in Building Management. My area of interest is in labour productivity on construction sites and problems associated with it. The results from the study will be used purely for academic reasons.

I have a questionnaire with which I would like to interview the management and another for the labourers. The site activities which I am interested in is concreting and walling.

Your help and co-operation will be very much appreciated. I will forward a copy of my results to you, which might be of interest if not of help.

Yours faithfully,

Jedidah Muthoni Nyagah (Mrs.)

APPENDIX B (1)

QUESTIONNAIRE ADMINISTERED TO CONTRACTORS

CONTRACTOR

1. Could you please tell me when your firm was registered?

   ____

2. Is the firm registered with the Ministry of Works, Housing and Physical Planning? Yes/No

   If yes in what category? ______________________

   Is the firm a member of any other association or organizations?

   Yes/No

   If yes, could you please name them?

   1. ______________________
   2. ______________________
   3. ______________________

3. How many departments are there in the firm?

   ____

   Which are they?

   1. ______________________
   2. ______________________
   3. ______________________

4. What is the number of the permanent members of staff?

____

What is the number of the casual employees on this construction project? ____________________________

5. How many on-going projects do you have at the moment?

____

6. Who is in charge of each project? __________________

7. How do you select the site labour? __________________

8. Do you set a target or a standard output which is expected from each man per day?

Yes/No ________________

9. How long in advance do the labourers know what work they will be doing for that day?

(a) more than two days

(b) one day

(c) same day

10. Do the labourers work in gangs or is each individual allocated his work by the supervisor? ______________

____

11. How are the labourers paid?

(b) end of the day

(c) end of the week

(c) end of the month

(d) after finishing a predetermined piece of work.

12. How much is paid to each of the following category of workers

Skilled ____________________

Semi-skilled ________________

Unskilled ___________________

13. Is there apprenticeship offered in the firm? Yes/No

If yes in what trade? ______________________________

14. Does the firm have on-job training scheme of any kind?

Yes/No

15. Does the firm sponsor semi-skilled or unskilled labour for training at Institutions of Training? Yes/No

16. What incentives does the firm offer its site labour so that they may improve their output? ________________

Could you please name the motivational incentives

1. ____________________________

2. ____________________________

3. ____________________________

4. ____________________________

Work improvement techniques:

1. ____________________________

2. ____________________________

3. ______________________________

4. ______________________________

17. Is there any protective clothing, such as crash helmets which is provided to the labourers by the firm? Yes/No

18. Is there any safety training on the site for the general site labour? Yes/No

19. Does the site have a medical attendant on duty in case of an accident? Yes/No

20. Is there a tea-break for site labour? Yes/No
How long is it? ____________________
How long is the lunch-break? ______________________

21. Is there a food canteen on the site? Yes/No
Are food hawkers allowed on site at break-time?
Yes/No

22. Is transport to and from the site for the labourers provided? Yes/No

23. Are there any social activities such as football, Volleyball etc. supported by the firm for the labourers?
Yes/No.
If yes what social activities? ______________________
____

24. How many workers does one supervisor supervise?

____

How are the supervisors selected?

____

How does the management view the quality of supervision on the site?

(a) Below average (bad)

(b) Average (good)

(c) Above average (very good)

25. Do the site labourers belong to any labour unions collectively? Yes/No

If yes which unions?

1. ____________________

2. ____________________

3. ____________________

How strong is(are) the union in representing the workers?

(a) Strong

(b) Weak

26. How is labour turnover among site labourers?

(a) High

(b) Average

(c) Low

27. Where do you buy your building blocks, cement, sand and aggregate from? ______________________

Do you have one particular material supplier for the above materials? Yes/No __________

Are there days when site labour has had to be turned away as a result of shortage of building materials on the site? Yes/No _________

28. Are the equipment used in concreting hired or owned? ______________________________

Are the labourers who handle the equipment trained in handling them? Yes/No

29. Do you provide all tools used in concreting and walling? Yes/No

If No who provides them? ____________________

30. Who decides on the techniques and methods to be used for e.g. concreting, walling? __________________

Is the personnel who does it formally trained? Yes/No

Is the labourer asked for his opinion on the method or techniques? Yes/no

31. Do you carry out project planning and control on this

project? Yes/No

If yes, is the personnel who does it formally trained?

32. Who designs the site layout for the sheds, equipment and the contractors other works? ____________________

____

Is the personnel who does it formally trained?

Yes/No

33. Lastly please could you tell me which is the most serious problem facing the construction industry today?

(a) Productivity

(b) Quality of workmanship

(c) Cost overruns

(d) Scheduling problems

(e) Design problems.

Which of the above is the most serious in your projects?

____

Thank you very much.

APPENDIX B (2)

QUESTIONNAIRE ADMINISTERED TO SITE LABOURERS

SITE LABOUR

1. Could you please tell me how long you have worked in the construction industry? ____________________

2. What is your education level?

   (a) Primary School Certificate

   (b) Technical Training after Primary school

   (c) Secondary School Certificate

   (d) Technical Training after Secondary school

   (e) Higher School Certificate

3. Have you had any training in the work you do? Yes/No

4. Have you many friends among your workmates on the site? Yes/No

5. Are you interested in the work you do? Yes/No

6. How can the management make working on the construction site better? ____________________

   ____

7. Do you regard the wages you get as being fair regarding the amount of work you do? Yes/No

8. Where do you live? ______________________________

9. How do you come to work? ______________________

10. How much do you pay for rent per month? ________

11. Do you have a family? ___________________________

12. Is there any medical problem which sometimes keeps you away from the site? Yes/No

13. How many meals do you eat per day?

    (a) One

    (b) Two

    (c) Three

14. Lastly could you please tell me about how old you are?

    (a) 15-20 years

    (b) 20-30 years

    (c) 30-40 years

    (d) Over 40 years

Thank you very much.

APPENDIX C

DATA COLLECTION FORM

Project: ______________________________

Date of study: ___________

Prepared by: __________________________

Ground Conditions:

Weather:

Number of operatives: Skilled = Unskilled =

Plant and Equipment:

Materials and Tools:

Method and Technique	Sketch of layout of work place:
Operation:	
List of elements and Break point:	

Time started:

Time stopped:

Delay and Breaks:

Total hours worked = (Time stopped - Time started) - Total delays and breaks

=

Output =