AN EVALUATION OF BRICKLAYERS' MOTIVATION AND PRODUCTIVITY

by

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DEDICATED TO THE LORD GOD ALMIGHTY

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ABSTRACT

Different motivation theories have been developed in general management to explain workers' attitude to production. Collectively, these theories represent manufacturing workers more than any other set of workers. Attempts made to apply these theories to construction operatives have produced different and often confused explanations of the motives behind construction operatives' productivity. This research approached construction operatives directly in order to evaluate their motivation in relation to their productivity.

The research aimed at proving or disproving a conceptualised positive relationship between construction operative motivation and productivity. Previous construction researchers assumed that there was a positive relationship between productivity and motivation without any empirical prove. This oversight was largely due to problems of quantifying abstract concepts such as motivation. This obstacle needed to be removed before the relationship between motivation and productivity could be empirically established.

A technique based on the Subjective Expected Utility Theory was developed to quantify motivation. Productivity was measured by activity sampling. Relating them together gave a third order polynomial relationship indicating that there is a basic motivation in every bricklayer regardless of his working environment. The relationship also provided an empirical prove of an earlier conceptualised optimal motivation theory.

The thesis shows that there is no significant causal relationship between motivation and work rate; rather, motivation significantly influences the proportion of working time spent productively. From a model of production output, motivation and skill, it was demonstrated that skill dominates productivity in bricklaying. Motivation accounted for 2.4% of the percentage variation in work rate and 25.3% of the percentage variation in percentage productive time. From a sensitivity analysis of the predominance of skill, critical activities controlling production output which could form the basis of a training programme for new bricklayers were identified.

After testing all observations and findings for validity, they were combined into a list of propositions which form the basis of a theory of construction operative motivation. Based on the affirmation of the optimal motivation theory in construction operatives, a new concept of hyper-production was proposed.

DECLARATION

No portion of the research referred to in this thesis has been submitted in support of an application for another degree or qualification at this or any other university or other institution of learning.

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APTC	Administrative, Professional, Technical and Clerical workers
ASCE	American Society of Civil Engineers
BRE	Building Research Establishment
BRS	Building Research Station
BS	Behavioural Science
BS I	British Standards Institution
CDF	Cummulative Distribution Function
CIOB	Chatered Institute of Building
CITB	Construction Industry Training Board
CV	Coefficient of Variation
DLO	Direct Labour Organisation
FIP	Financial Incentive Programmes
IE	Industrial Engineering
KITA	Kick In The Ass
LUT	Loughborough University of Technology
OT	Organisational Theory
PC	Principal Component
PCA	Principal Component Analysis
PDF	Probability Density Function
SERC	Science and Engineering Research Council
SEU	Subjective Expected Utility
TAT	Thematic Apperception Test
UK	United Kingdom of Great Britain and Northern Ireland
USA	United States of America
YTS	Youth Training Scheme

CHAPTER 1

CHAPTER 1
GENERAL INTRODUCTION

1.1 Introduction To Subject Matter

Necessary reconstruction after the second world war resulted in a surge in construction work. To cope with this surge, several incentive schemes were devised. These incentive schemes were to stimulate (motivate) greater production from the operatives. The observation after a short while however, was that these incentive schemes were not effective, or at best worked only when newly introduced. By 1968, Herzberg has described them as mere 'kicks in the ass' in the motivation process (59).

Construction industry's understanding and application of motivation concepts has remained largely the same; new schemes are being devised in a seemingly endless continuum. Could this ineffectiveness of incentive schemes not have been due to the lack of empirical establishment of the relationship between motivation and productivity ? Had this been achieved, it would have been possible to devise a more responsive system to motivating employees and management would have known how much attention to direct to the subject. It is this omission in construction operative motivation research that is the main stimulus for this research. Other reasons abound for evaluating operative motivation at this point in time.

The construction industry's fortunes fluctuate with those of the general economy. Its organisational patterns change with time, and are so varied that they can be difficult to comprehend. Few people would disagree that the variety of organisational patterns in the industry results from the ever changing socio-economic environment. One of the most apparent changes in the industry today is the move away from traditional in-house operative management to subcontracting. This is changing the loyalty base and consequently operatives' motivation. Since the loyalty base has changed, it would be very erroneous to devise new incentive schemes based on old assumptions. The new management environment needs to be evaluated and motivation patterns checked for congruence with old assumptions.

The current shortage of skilled manpower is giving many construction firms problems in coping with the current upsurge in construction work and the full workload they now have (139). But what is the link between skill shortage and motivation ? Because of the change to subcontract labour, the training function by main contractors has been neglected. The subcontractors who should have been expected to take it up have not, consequently the level of traditional apprenticeships has fallen too low to meet today's requirements (38). Coupled with the exodus of traditional crasftsmen from the industry because of the recession of the '70s, it is not surprising that the industry now lacks the skilled men required to do its work. Because of the lack of skilled men, the ones remaining need to be kept. One way of doing this is to use our knowledge of what motivates them.

Why study motivation when the industry is doing so well with a record 8.4% growth in output in 1987 (130) ? There is a possibility that when the industry is bouyant, less is obtained from the workers and at higher cost. A sudden jump in the value of tenders is already reported (133). While no one can pinpoint a single source for this, it is reasonable to suggest that tenders are getting higher because subcontractors are returning higher quotations to the main contractor because they have had to increase workers' wages in order to keep them.

While it takes some inferences to establish the relationship between skill shortage and motivation, it is less difficult to see the industry's lower productivity in comparison to manufacturing industry as a major reason for evaluating operative motivation at this point in time. Is the organisational structure of the industry as a whole and the nature of construction work (being an outdoor occupation in hostile weather like Britain's) not responsible for the discrepancy ? What is the impact of the construction environment on operative motivation really like ?

A cursory look at construction practice will reveal that the word 'motivation' only conjures financial incentives in the minds of construction managers. Are there no other variables motivating operatives to higher production within the working day ? Are wages so paramount as to cloud the effects of other variables ? Several motivating variables have been identified in general management. How relevant are they to the construction operative? What is the real role of wages in construction operative motivation? These questions necessitate an evaluation of motivation in the industry.

Although the fear of unemployment increasing with advancing technology has not been confirmed, it is logical to take the threat seriously. Robots are already bourgeoning this threat. If robots can or are going to replace manpower the optimal capacity of the operatives as reflected in their motivation and skill needs to be determined. This will form the basis of any cost benefit analysis before introducing robots.

At Loughborough University, research into operative productivity has been enhanced by the development of different softwares for data collection. Harris, Price and Emsley (56) have developed production analysis techniques which make it possible to simulate the building process based on materials handling and plant. This research compliments earlier developments by examining the human content in the production process in detail.

1.2 Objectives

In view of the discussions above, the research described herein evolved around establishing a relationship between operative motivation and productivity. Bricklaying was chosen because it is a fundamental trade to most building construction in Britain and it is being introduced to building construction in the author's country. Achieving the objective necessitated the development of a technique to quantify the motivation variable. It was also necessary to examine the interrelationship between different motivation influences and different production variables. The research therefore had the following sub-objectives which must be achieved in order to accomplish the overall objective:

a) to examine existing patterns (if any) of the relationship between productivity and motivation in bricklaying;

b) to design a system for collecting data on productivity and devise a technique for quantifying operative motivation;

c) to quantify production output and motivation of bricklayers using these techniques;

d) to model and test the relationship; and

e) to suggest ways for improving operative motivation and productivity in the construction industry.

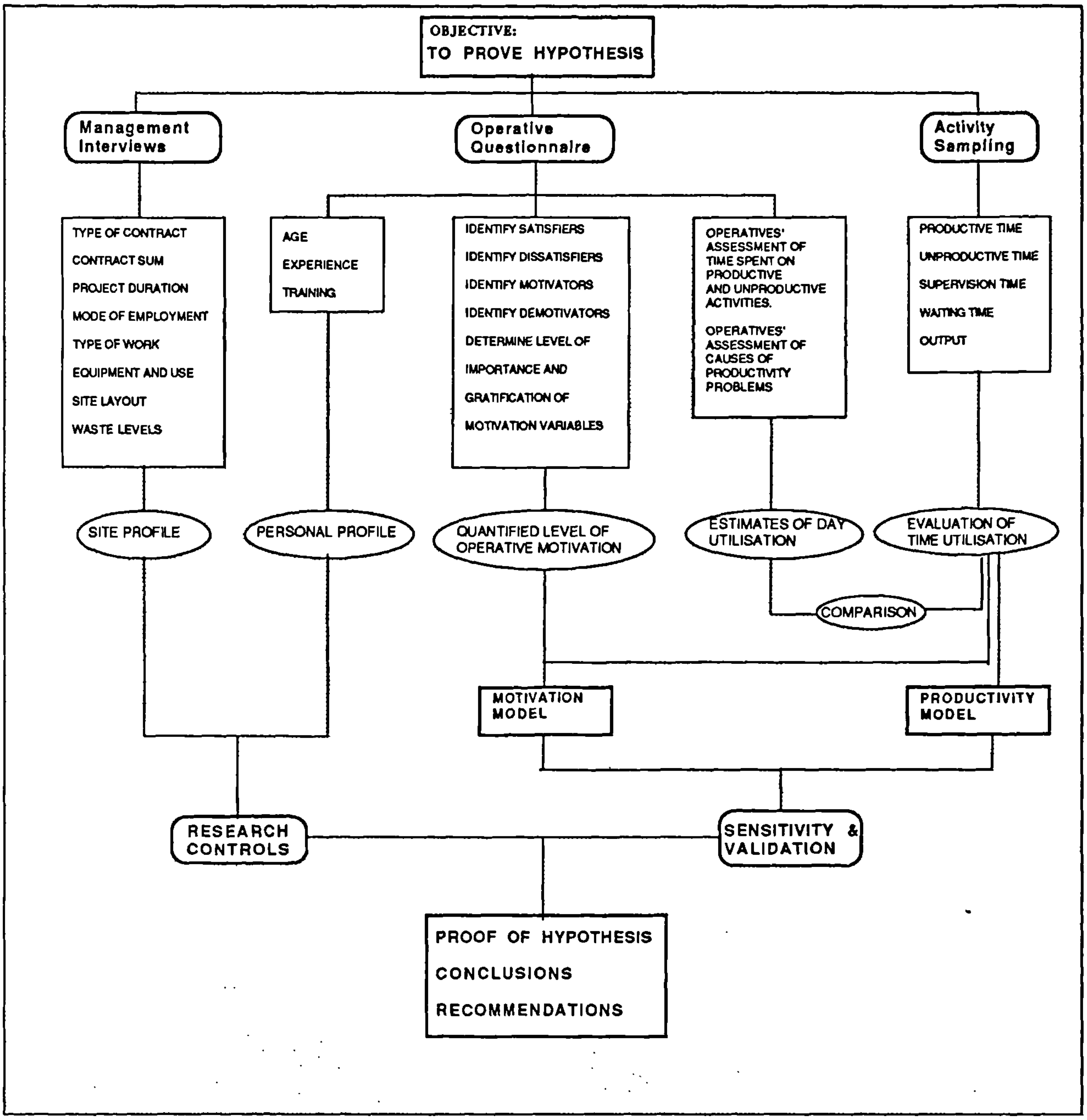
1.3 Methodology

This research arose out of the perceived need to understand operative motivation and was geared towards illuminating the relationship between motivation and productivity. After the literature review which established the theoretical background to the research, the rest of the research was divided into four phases: the development of techniques and procedures for data collection and analysis; the data collection; the analysis and development of models; and finally the validation of the models. Table 1.1 and Figure 1.1 explain this in greater detail.

Table 1.1. Methodology

Phase	Method	Aim
Literature Review	Books, and Journals reviewed. Experts and professionals in the research area interviewed.	To establish the evolution of the motivation concept and the basis of application to construction.
Phase 1	Techniques devised for measuring motivation. Major revisions made to data collection and analysis techniques developed at LUT. Questionnaires and interview formats developed.	To collect data to prove the established hypothesis for this research and provide insights on how to manage and analyse the data.
Phase 2	Site visits using the data collection techniques earlier developed. Visits to bonus departments of different construction organisations.	To collect data
Phase 3	Statistical analysis of data collected and the formulation of an operative motivation/ productivity model.	To analyse data collected and model any relationships.
Phase 4	Sites visits to collect new data to test the models and the development of a system to improve operative productivity.	To validate models and make recommendations

Figure 1.1 Data Collection and Analysis



1.4 Organisation of the Thesis.

Table 1.1 illustrates the various steps taken in this research to achieve the stated objective. These steps are classified into four main phases which are presented as nine core chapters which are now briefly described.

Chapter 2 - Since both the motivation and productivity concepts are intertwined, it is necessary to explain construction productivity in detail in order to see the link with motivation. This chapter provides a basic explanation about construction productivity. Definitional and measurement problems are highlighted. Also, factors affecting construction productivity as well as trends in construction productivity are discussed.

Chapter 3 - This chapter provides a basic explanation of the motivation concept. It reviews the evolution of the concept in psychology and its application in general management. Differences in approach to the study of motivation in these two fields are highlighted. Different motivation theories are also discussed.

Chapter 4 - With the background knowledge of the motivation concept as presented in chapter 3, its applications to construction operatives are reviewed in this chapter. Previous studies are critically assessed with misconceptions and contradictions brought to light. This provided the necessary springboard on which the hypothesis for this research is based.

Chapter 5 - Based on the literature review in the three preceding chapters, the hypothesis and the design of this research is presented in this chapter. The reasons for streamlining research to bricklaying and the criteria for choosing various research instruments are explained. The quantifying technique for measuring motivation is also presented. The sites and construction firms from which data for the research were collected are described.

Chapter 6 - Having confirmed the working environment as a major determinant of operative motivation, it is important to evaluate the working environment of the bricklayers. The evaluation of different variables affecting productivity in the workers' construction environment is presented in this chapter. Using both the computerised activity sampling and operative questionnaire survey techniques various problems contributing to ineffective time in the working day are identified. The prevalence of these problems are compared with that of the U.S and Nigeria. An evaluation of the personality of the worker using various statistical techniques is also presented.

Chapter 7 - An evaluation of operative motivation within the environment described in Chapter 6 is presented in this chapter. Various motivating and demotivating influences are identified and their level of importance determined. An empirical relational model of motivation and productivity is also presented.

Chapter 8 - With the aid of principal component analysis and stepwise regression techniques a model of critical activities to productivity in bricklaying is established. The influence of motivation in this model is evaluated. The predominant influence of skill in construction productivity is established. A simulated sensitivity analysis is also presented.

Chapter 9 - This describes the procedures taken to validate the developed models. Results of the validation exercise and how the models can help in cost estimating and skill acquisition are discussed.

Finally, **Chapter 10** concludes the results obtained in the research and give some fundamental propositions for a theory of construction operative motivation. Areas of future work are also suggested.

CHAPTER 2

CHAPTER 2

CONSTRUCTION PRODUCTIVITY IN PERSPECTIVE

2.1 Introduction

The importance of **productivity** to any profit oriented organisation cannot be over emphasised, as it is the effective and efficient conversion of resources into marketable products that determines business profitability. As a result, considerable effort has been directed to understanding the productivity concept. However, because of different approaches taken by different researchers, defining, measuring and applying this concept in everyday management is often confusing.

As a prelude to understanding the relationship between motivation and productivity, it is pertinent that the concept of productivity be well understood and any areas of confusion clarified. This chapter introduces the productivity concept and discusses different approaches to defining and measuring it. The factors controlling productivity trends in construction productivity are also discussed. From these discussions, the central importance of motivation in construction productivity is addressed.

2.2 Defining Productivity

In an industry where survival depends much on performance and tenders have to be won on competitive basis, it is imperative that all managers should be clear headed on the subject of productivity. Like most well understood concepts in life, defining productivity has remained very difficult. Most people understand what peace or love is but would offer different definitions of these concepts depending on their personality and situation at the time they are asked. Defining such concepts often leads not to a consistent set of words one would expect in definitions, but explanations of the main characteristics of the subject. Productivity faces the same definitional problems in the construction industry.

The Oxford dictionary defines productivity as " the power of being productive, efficiency and the rate at which goods are produced " (114). Although this definition gives us a good start to explaining the concept of productivity, it depicts the earlier mentioned difficulty of defining an abstract concept by using the word "productive" in defining productivity. Three distinct components of the concept of productivity are brought out by this definition. First is the *power of being productive* which is the force behind production itself. Second is *efficiency*, which is a measure of how well the factors are utilised. Third is the *rate* , a measure of the output of the factors of production over a defined period of time.

Often, definitions of productivity offered by different researchers are limited to only one or two of the three distinct components highlighted above. For example, economists often define productivity as the ratio of physical input to physical output which only reflects the third component, i.e. rate. English and Marchione suggested that this definition used by economists raises more question than it answers (35). They argued that output involves not only quantity but also quality. They also tried to define what constitutes the true input dimension of productivity. Whether it be a question of raw materials, capital and wages or does also involve management, organisation, ingenuity, creativity and attitudes. Although management input into the production process is often invisible, they obviously have great influence on productivity levels.

English and Marchione's argument is buttressed by Fenske (40) in his analysis of meanings of fifteen different definitions of productivity. Although he agrees with economists that productivity is a "tangible reality", he believes that instead of limiting productivity to physical outputs and inputs, it should also include invisible SERVICES. He concluded that productivity could be defined as " the amount of goods and services produced by a productive factor in a unit of time". But can a productive factor singularly produce? No!

We may therefore consider Levitt's definition of productivity, which states that "the ratio between the value of a unit of output and the cost of all of the inputs that went into producing it" (81), as a better alternative. But is ratio not just a measure? This brings us to our starting point that definitions often align with one or two of the three previously identified components of productivity. Davis' definition that productivity is " the degree to which the power to make or provide goods or services having exchange value is utilised as measured by the output from the resources utilised" (26), seems to occupy the centre ground'because it incorporates the three main characteristics of the productivity concept.

2.3 Measuring Productivity

Although productivity is not the same as performance (some workers perform strenuously but have low productivity owing to ineffective methods), two performance measures feature prominently in productivity discussions. These are the concepts of *effectiveness* and *efficiency*. Both generally work together but have entirely different meanings. *Effectiveness* measures whether goals, such as profit or market share, are met while efficiency is a measure of productivity. The expression for efficiency in engineering applications and that of productivity are the same.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

Measuring productivity with this efficiency equation looks quite simple until one begins to look into what constitutes the input part of the production process. To avoid complications some early clarifications are necessary.

The resources utilised in the production process are : Manpower, Management, Materials, Money and Machines. When productivity is measured in relation to all these factors of production, it is termed TOTAL FACTOR PRODUCTIVITY. This is a measure of the overall efficiency of an industry or organisation. Other measures of productivity consider the relationship between output and a particular input or an incomplete combination of factors, e.g. labour. This is called PARTIAL PRODUCTIVITY. These can be expressed in equation form below:

$$\text{TOTAL PRODUCTIVITY} = \frac{\text{TOTAL OUTPUT}}{\text{TOTAL INPUT}}$$

$$\text{PARTIAL PRODUCTIVITY} = \frac{\text{TOTAL OUTPUT}}{\text{PARTIAL INPUT(S)}}$$

Measuring total factor productivity brings forth an aggregation problem as output and all inputs have to be expressed in money terms, since money is the only common base of expression. The resultant productivity index is ECONOMIC PRODUCTIVITY not physical productivity which is more meaningful to the construction setting. Consequently, a partial measure of productivity is more widely used and the factor which receives the bulk of emphasis is the labour input. Levitt cautioned that partial measures of productivity are really partial derivatives of a multivariate function - total productivity. They quantify the effect of a single variable on the function assuming all other variables remain constant (81). But other variables never remain constant (1), making partial productivity measures dubious expressions of productivity levels.

Lowe (87) agrees with other researchers that total productivity is the best measure of productivity, but in its absence capital will be a better factor for partial measure than labour which has traditionally dominated the scene. His argument rests mainly on obtaining indices for inter firm comparison and measures of overall efficiency of the industry. Whilst capital is globally superior to labour, it becomes meaningless in job sequencing, number of men to be employed or in day to day job planning on construction sites. Iyaniwura and Osoba argued that if capital is to be taken as the variable for partial measure of productivity, information will be required in money terms for the value of land, machinery and equipment as well as on the rate of any depreciation. "Unfortunately data in respect of capital are usually less readily available especially in the required form " (67). On the other hand, labour is a quantifiable factor of production and it is the only factor that has a conscious control over its contribution to the production process.

2.4 Other Measurement Problems

Measuring productivity in the construction industry is further compounded by the extreme difficulty encountered in measuring and comparing values of output over long periods of time. The price of a given input/output changes over time due to:

(i) changes in the general level of prices, i.e. inflation;

(ii) changes in the supply - demand equilibrium for a given resource causing its price to rise faster or slower than prices in general; and

(iii) changes in the quality of the output. For example. a detached bungalow built in 1988 may be more aesthetically pleasing and more functional than a similar house built in 1968.

Existing productivity measures can capture these changes in price or value through the use of indices. These indices define the product as a standard item and attempt to measure real changes in value and prices (123).

Other measurement problems include identifying what unit of measurement to adopt. For example, one trade may contribute to several operations. If one is to measure the productivity of joiners will it be in windows, doors or formwork ? Even each distinct operation can be further divided into several minor operations. The very nature of the operations makes it difficult to decide whether output should be calculated per day, month or year or in relation to the completion of a specific assignment. There are, however, some construction operations where measurement problems are not too inhibiting. In bricklaying and concreting, there are not many problems arriving at partial productivity in physical terms.

2.5 Factors Influencing Construction Productivity

" Construction productivity is difficult to study because the factors that affect it are never constant, varying from job to job" (86). It is a multivariate function with no particular limit to the number of factors determining its level. Everything affects productivity (81). Production factors are the tangible reality forming the bottom line of any production process. It is not difficult to appreciate that anything that can influence these factors can subsequently affect production level. To discuss these factors we shall take a global outlook by first classifying the factors into two categories - EXTERNAL and INTERNAL. External factors being those outside the control of a firm's management. Internal factors are those which originate in or around the firm.

2.5.1 External Factors

2.5.1.1 The Nature of the Industry

The complex nature of the construction industry has been identified as a major influence on its productivity. The traditional separation of design and construction functions was identified by Stone as one major factor affecting construction productivity (131). The possibility of more rational and economic use of construction resources is enhanced when the two processes are under one 'roof' as in the manufacturing industry. The buildability of the designed structure can be evaluated right at the sketch design stage if the builder and designer are under the same management. The separation of the processes result in considerable time wastage, waiting for drawings on sites and rework due to changes in design (111). However, this traditional separation is now being bridged with new forms of contract, e.g. design and build contracts.

2.5.1.2 The Construction Client

Construction clients have been impediments to construction productivity with their lack of knowledge of construction procedures. Recognising this, clients usually employ a team comprising architects, engineers and quantity surveyors to look after their interests in the construction process. But variations still occur during the course of projects due to changes in owners' requirements or his insistence on materials not easily available in the market. Kellog et.al found that clients often have negative leverage on site labour situations (72). It is easy dealing with a rational client, but an irrational and unpredictable one increases the uncertainty element during construction with negative effects on job sequencing and execution.

2.5.1.3 Weather.

Being an outdoor industry, the construction industry is exposed to the various climatic elements which vary with the geographical location of the project. Markham (97) found that men work most efficiently where the daily temperature is between 60^0 and 76^0F with a moderate 40 - 70% humidity. Mountjoy (105) also concluded from her studies that hot and wet climates are far less conducive to mental and physical energy, and tropical climates do not favour muscular activity which generates body heat and discomfort. In their 1971 studies, Baldwin and Monthei (10) found that weather was the highest ranking cause of construction delays in the U.S.. Harris (54) developed a model to evaluate effects of weather on construction projects in the U.K.. A careful application of the model could help avert the negative effect of the British weather on the country's construction productivity.

2.5.1.4 Level of Economic Development

The global productivity of the construction industry depends greatly on the level of economic development and bouyancy. In developing economies there are many new infrastructural facilities to be built, while in developed economies, existing structures have to be maintained. Both situations are ready sources of work for the construction industry. Should the economy boom with money available to execute developmental projects, the construction industry's productivity will increase. The industry's productivity suffers most when there is depression or a downturn in economic fortunes. Intermingled with this is political stability which determines to great extent how much investors are ready to put into the economy. In most cases, political stability closely reflects the level of economic development.

2.5.2 Internal Factors

2.5.2.1 The Management.

In Taylor's (132) advocation for scientific management, he constantly held the view that the responsibility for employing, training and equiping men for the job in order to achieve optimum productivity belongs to the management. This same view was echoed by Maloney (91). It is the management that plans, controls and coordinates the use of resources on construction sites. With increase in project size and complexity, this responsibility for optimising productivity, in order to make profit, has become even more important. Any inadequacy on the management side to function properly in this primary responsibility will result in a waste of resources with consequent losses in productivity.

Productivity is not often thought of as a managerial output. The common story whenever things go wrong for an organisation is that the employees are not cooperating, the government's new legislation is against the firm or the plant has suddenly stopped functioning ! Management tries to blame others, not itself when things go wrong; but quickly congratulate its own 'ingenuity' when goals are met! English and Marchione (35) argued that this hypocrisy is mainly because of the traditional view by management that workers are merely means to an end. Explaining this further, they stated that when an autocratic management puts pressure on the employees without removing the causes of low production the result will be more absenteeism, staff turnover, sabotage, or strikes. A democratic management's attempt to change workers' attitude without performing its own traditional functions will result only in negligible improvement. Management can unlock the latent abilities of its workers only when it has performed its own functions adequately.

2.5.2.2 Technology.

Elementary physics explains the principle of 'mechanical advantage'. The global search for increased productivity has led to the application of this principle to the adoption and usage of plant, equipment and tools within the construction industry. The productivity of construction craftsmen improves with the use of plant and tools. It is a common knowledge that digging with an excavator will produce more than manual digging. Apart from quantity, quality improves when suitable machines are used. With advances in technology, construction operatives are having to adapt to new equipment everyday. Their training is being revolutionised daily with the traditional apprenticeships failing to cope with the new skills required when qualified. The fast pace of technological growth may be accountable for the current skill shortage in the industry. It is possible that there are enough traditionally skilled operatives but they are not able to cope with the new demands.

Robots and the application of robotic principles (143) are being tested on various construction operations. Painting can now be done faster and safer for everyone on tall walls and roofs by robots with consequent increase in productivity. While there may be fears of machines taking over craftsmen' jobs in some quarters, the technology level at present and the low key invasion of 'high tech' on sites do not justify such fears. Most jobs will be lost in the offices where the computer revolution will, if not already, lead to some clerical staff losing their jobs.

Machines cannot do construction jobs or improve productivity on sites unless properly managed. Adequate maintenance and optimal resourcing are the keys to reaping the full benefit of technological advances in the industry. The 'big bang' approach (35) to increasing productivity whereby the management seek to improve productivity through large capital expenditure is naive because more investment in technology is not necessarily a cure to low construction productivity. Adequate management cannot be over emphasised.

2.5.2.3 Labour

As earlier mentioned, the productivity question in construction is often dominated by labour. Arguing that labour has the most significant influence on construction productivity, Maloney opined that the level of productivity is directly related to the "driving, induced and restraining forces acting upon workers" (91). These forces could act positively or negatively on the production levels. When construction productivity is perceived globally, the direct influence of labour cannot be clearly seen. If one is interested in the return on investment, capital productivity becomes more relevant. But when one is interested in on-site production, labour acts as the hub on which other resources depend.

Labour has long been identified as a major controlling variable in the productivity multivariate function. It should be noted that Labour can mean workers individually or collectively through their unions. Let us now discuss the influence of Labour unions on construction productivity.

2.5.2.3.1 The Influence of Unions

Unions have always been seen by management to have negative influence on workers' productivity. Construction managers in the U.S. would readily identify restrictive union practices as the cause of low productivity on their sites - claiming that union members do not give a fair days work for the wages paid. "Low productivity, although not restricted to union labour, becomes widespread when labour has the protection of unions " (95).

Unions have for long being alleged to be against productivity growth because they perceive it a threat to job security. With such a stance against productivity, the unions are often accused to be working against the interest of the society! " The mob goes in search of bread, and the means it employs is generally to wreck the bakeries" (112). Kellog et. al. also stated that " ....improvement of productivity is often beyond the control of management of the nation's contractors and subcontractors - it is effected more by restrictive union work practices on the one extreme" (72) .

All these allegations, though not unfounded, may be an indication of our earlier argument that management often tries to blame others for its failures. Gates and Scarpa (49) argued against the 'abuses and indignities that labour suffers at the hands of management'. They claimed that of all the western civilised nations, it is only in the U.S. that a construction worker can be laid off at the end of a work day without any advance notice whatsoever! Referring to cost overruns mentioned in Borcherding et. al (18), Gates and Scarpa (49) continued that since accounting is often done by the management side, they often report that the cost of labour incurred exceed estimates by a factor of three or more! "So on the books, labour will be the scapegoat for managements' defects once again" (49).

Construction unions are not so powerful in the U.K.. Membership is very low because of the casual nature of employment with only 40 to 50% of directly employed operatives as members and generally less than 30% of all operatives (61). Their little influence is now being further eroded by the individualism being promoted by subcontracting. In the U.S. there are now 'no-strike' and productivity clauses in labour contracts when dealing with Union labour.

2.5.2.3.2 The Construction Operative.

It is widely recognised that there are some personal attributes of the worker that affect his productivity in a particular trade, craft or operation. These attributes are broadly defined as follows.

(i) The skill, qualification, training and experience of the worker.

(ii) His innate ability - both physical and mental energy.

(iii) The intensity of the application of both his skill and innate ability to the production process.

Training is needed to acquire the necessary skill to be qualified as a construction tradesman. Although construction trades might appear to a simple or untrained person as mere physical exertion, the skill comes only through training and experience. Traditionally there are apprenticeship schemes in which apprentices undergo training supervised by a skilled craftsman for periods ranging from 5 to 7 years, after which the apprentice qualifies as a craftsman. With the current shortage of skilled manpower in the industry, it can not afford such a long period to train apprentices. There is the CITB route and some firms have their own training centres. The YTS scheme is also a route to becoming a qualified craftsman. Whatever the length of training, most educationists will agree that the innate physical and mental ability of the individual will first affect the amount of skill acquired in both formal and informal training and consequently affect how fast/well the individual works.

Even when skilled in the trade, what determines productivity, at the end of the day, is the intensity of the application of the acquired skill, mental and physical ability to the construction process. There is an internal engine, which can be explained by the psychology subject of motivation. This is the focus of the current research effort. The motivation concept and its application to construction operatives are reviewed in Chapters 3 and 4.

2.6 Trends in Construction Productivity

In this section we would examine the cumulative effect of the factors discussed above on construction productivity over a period of time. Governments and construction firms alike have become much more aware of construction productivity and its effects on the standard of living. The influence of this awareness has risen so much over the years that it is feared, in many quarters, that the industry is now being used to regulate the national economy (61). This might have stemmed out of the industry's sizeable contribution to the Gross National Product (GNP).

Despite this growing awareness, both the definitional and measurement problems highlighted earlier on make it quite difficult to follow trends in construction productivity. Data sources are rare and in some cases non existent. Where available, they are haphazardly arranged. Until Fleming (42) was commissioned by the Department of the Environment no readable data was compiled for the industry. Despite the enormous work done by Fleming, some of the data are still not usable as a little analysis would reveal basic flaws in the data. When usable, comparative analysis of data from two sources often gives contradictory views. For example, Betts (12) compared data on public expenditure as a measure of construction output with contractors' output (in monetary terms) only to discover a gulf of differences in the two output measures. Apart from quantifiable differences, he identified undue politicising of Government's expenditure figures for the industry which, in most cases, are higher than what the industry is reporting as its output. However, attempts have been made to watch the trend in the industry even with these inadequacies in the data available.

Hillebrandt (61) recommended three main sources of data and methods for measuring and comparing construction productivity per man in the industry. These are:

(i) money value of work done by the industry divided by the corresponding manpower figures, this data is obtainable from Housing and Construction Statistics (63);

(ii) census of Industrial Production data which gives gross value added at factor cost per head, and

(iii) the National Income Expenditure Accounts data which give the net GDP in construction divided by the number employed in the industry.

The first method is available for detailed breakdown on quarterly basis and is more popular in different publications. Criticising this method, Fleming (41) argued that it raises more questions of interpretation than it provides answers on efficiency. His main objections are as follows.

(i) Other resource inputs e.g. materials, often form a large proportion of total output and the eventual productivity index so derived critically depends on the proportions of these other inputs.

(ii) There are different types of construction works, e.g. roads, residential buildings or industrial buildings. The productivity index derived by this method may reflect just the mix in the type of work rather than a change in construction productivity.

(iii) The Department of Environment data are limited. They are defficient in coverage and do not take account of all workers, e.g. self employed workers.

(iv) The price index base for discounting prices to constant levels still has significant errors of accuracy.

These arguments are quite reasonable but can be easily discounted in the absence of any other reliable data for measuring overall construction productivity. The first argument is the normal rhetoric against labour as a partial measure of productivity. The second is simply because of the nature of the industry which cannot be suddenly changed. Thirdly, the Department of the Environment needed to start collecting and documenting data for the construction industry at a point only to become efficient with time. Fourthly, the accuracy of price indices have been improving and even Fleming (41) acknowledges this. Based on these answers to Fleming's criticisms we can progress to using this method to examining the overall trend in construction productivity.

Tables 2.1 and 2.2 show construction output and the number of employees over the 1976-1986 period. The construction output figures are at 1980 prices having used the recommended price indices (63). Figures 2.1 and 2.2 are the results of the analysis done to derive output per man.

Hillebrandt (61) did a similar analysis for the 1970 - 1981 period finding that gross output per man fell by 12% within this period. She reasoned that this fall was primarily because of the change in the proportion of new work, repair and maintenance. New work which has higher material content decreased, with repairs and maintenance with little material content increasing. The net result is the decline in total construction output per man.

In the 1976-1986 analysis, the picture is very much different. At 1980 prices, a short rise in output per man was witnessed between 1976 and 1978 with a brief decline between 1978 and 1980 after which the industry has been witnessing a steadier rise. This general pattern (of all operatives) is reflected in the output per operative trend. The picture for Administrative, Professional, Technical and Clerical (APTC) workers is a bit different. It peaked in 1978, declined until 1981 instead of 1980. See Figure 2.1.

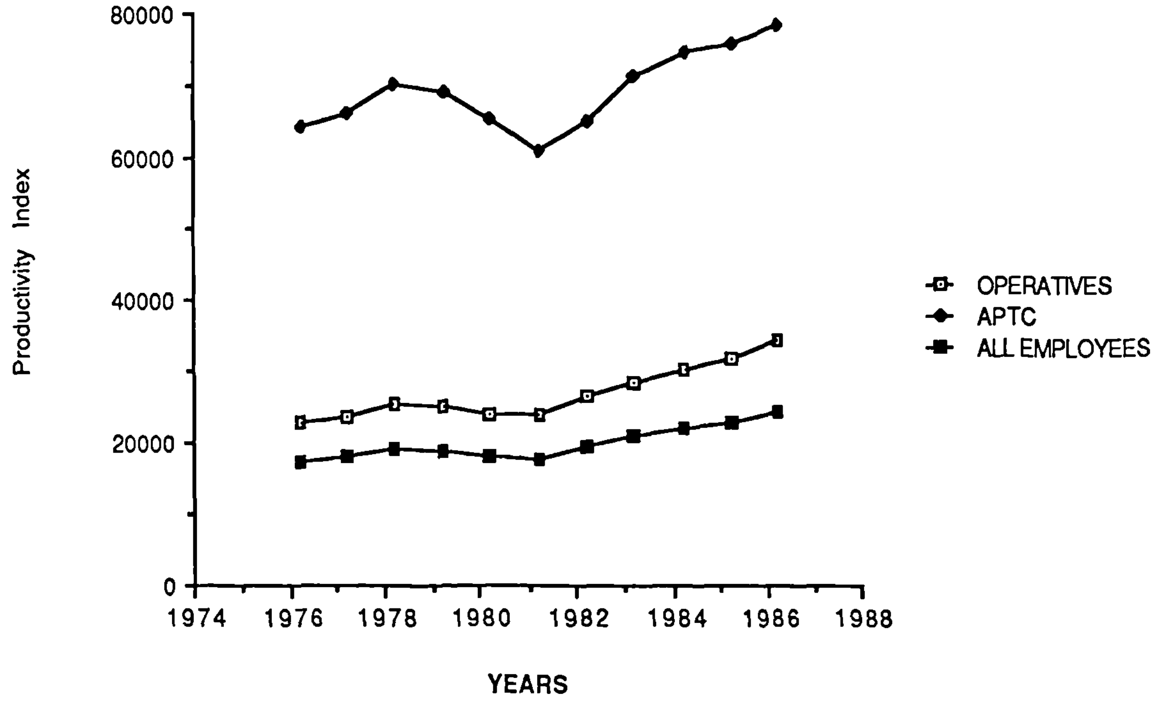
Table 2.1-Construction Outputs and Employment Figures 1976-1986

Year	Output Million £	Operatives '000	All APTC '000	All Men '000
1976	21701	1006	344	1350
1977	21617	967	334	1300
1978	23109	958	335	1294
1979	23260	980	344	1324
1980	22052	979	345	1325
1981	19947	883	334	1218
1982	20260	806	318	1123
1983	21101	783	302	1084
1984	21824	757	298	1055
1985	22072	725	297	1022
1986	22670	690	294	985

Table 2.2 - Contractors and Direct Labour Organisations' Output and Employment Figures 1976-1986.

Year	Contractors Output £M.	DLO Output	Contr. Operatvs.	Contr. APTC	DLO Operatvs.	DLO APTC
1976	10714	2526	774	231	232	113
1977	11667	2468	743	224	224	110
1978	13848	2532	737	226	221	109
1979	16757	2523	763	232	217	112
1980	19537	2515	767	235	212	110
1981	18859	2349	678	230	205	104
1982	19736	2225	619	223	187	95
1983	21341	2251	600	214	183	88
1984	23238	2092	585	214	172	84
1985	24761	2073	556	216	169	84
1986	27010	1996	530	212	160	82

Figure 2.1 Output Per Man Employed at 1980 Prices



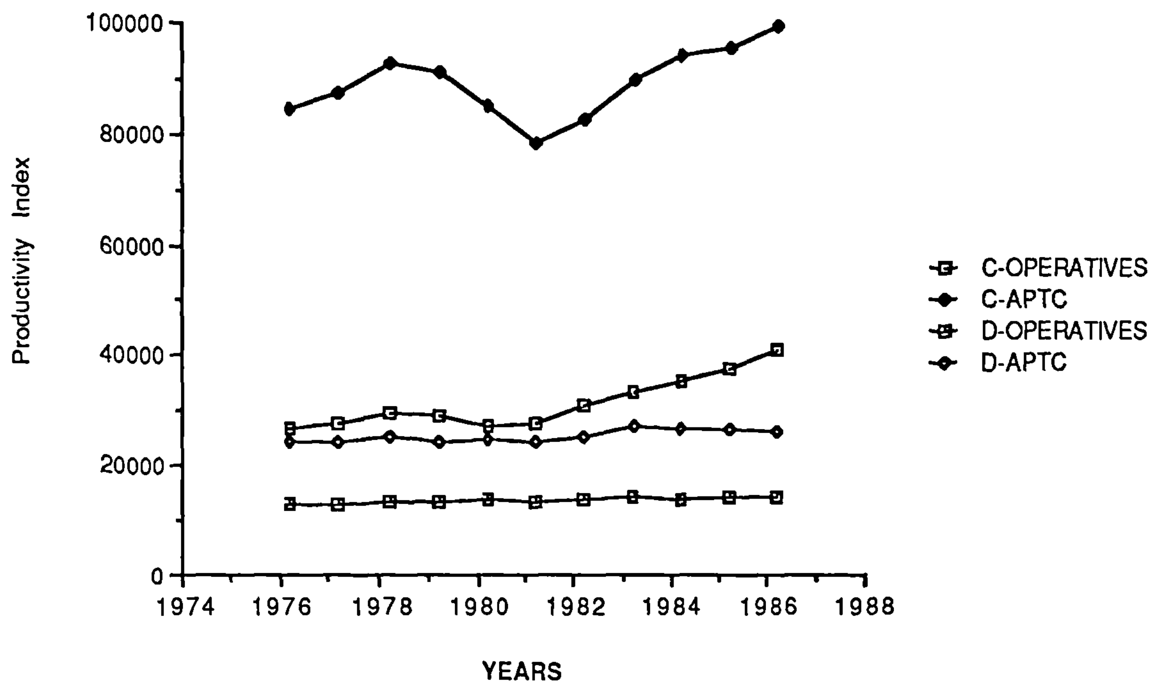
There is a strong link between the output figures and productivity per man. The little bump in the trend may be a result of the industry, just like in 1973 (61), not being able to cope with the increase in work load or because managers in the industry were not prepared and could not manage the sudden rise in demands on the industry. Also, it is possible that output was deliberately increased by an increase in Government expenditure - as a run up to the 1979 General Election. The decline thereafter may also be explained politically as a period of consolidation and economic restructuring with the change of government. The strong rise in construction output per man (1980 to 1986) closely reflects the healthy performance of the British economy in recent years. From forecasts however, the picture is about to change. The construction industry will witness only a 4% growth in 1988 compared to the 8.4% growth in output in 1987 (130).

2.7 Contractors and Direct Labour Organisations (DLO)

In the same pattern, the output per man in both contracting and direct labour organisations were analysed for comparison. Direct labour organisations employ some 10% of men working in the construction industry. Contractors undertake a significantly higher value of work than direct labour organisations. Consequently, output per man in DLOs is significantly lower than contractors'. DLOs undertake a high proportion of repair and maintenance work which is of lower value than new works which contractors are more involved in. The general trend earlier described largely holds for operatives in both contracting and direct labour organisations.

It has been argued by Langford that if the public authorities allow DLOs to operate as business ventures, there is no reason why they cannot be as productive as the contracting organisations (74).

Figure 2.2 - Contractors' Productivity Vs. Direct Labour Productivity



So long as DLOs remain appendages of public authorities, their work will be restricted to repair and maintenance and their overall productivity will continue to be lower than contractors'. Hillebrandt argued that "it is high time the matter of their efficiency compared with that of contractors was removed from the political arena to one of calm investigation, in order to facilitate optimum resource allocation" (61).

2.8 Productivity Levels

The trends discussed so far are what Flemming (41) termed 'movements' in output per man. While it is useful to know the overall productivity of the industry which these 'movement' trends show, what is more relevant to the site manager is the efficiency of a particular resource input in the construction process. The Building Research Establishment conducts studies from time to time to determine productivity levels in physical terms, e.g. man hours per house or per $1000m^2$. Lemenssany and Clapp (79, 80) conducted a series of studies to determine labour requirements for different types of housing. These studies showed that for new Local Authourity housing, the average labour input per dwelling was 182 man days for a dwelling of $70m^2$. For public housing the labour input was shown to be 194 man days for $84m^2$. Not suprisingly, they found that the method of construction affected the labour required and that man days required per dwelling decreased with increased prefabrication. One of their most significant findings was that the distributions of the trades and skills have remained fairly constant over the years and that site labour employed on Local Authourity work has been decreasing at an annual rate of 3%.

In the studies (43, 44, 79, 80), a constant mention is made of the skill of the worker, the construction environment he is working in and the percentage of time spent working as the main determinants of the productivity level. It is the construction environment that influences the percentage of time spent working. The construction environment influence the operatives' motivation to perform. Although everyone believes that motivation influences productivity, the relationship has neither been confirmed nor refuted in the construction setting. This dissertation aims at establishing the relationship. The following two chapters explain in some detail the concept of motivation in general and in construction operative in particular.

2.9 Summary

The following points summarise this chapter.

1. The productivity concept is well understood but still suffers from both definitional and measurement problems.
2. Total factor productivity is the best measure of productivity but there are enormous data gathering problems which make the use of partial productivity measures inevitable. The choice of partial measure depends largely on the factor of production the researcher is interested in. Studies into labour productivity predominate studies in construction productivity.
3. Factors affecting productivity are innumerable. Although management tries not to blame itself for low productivity, it is its primary function and so should be held responsible for productivity problems. Other factors simply react to management controls on the working environment.
4. Two main factors affect labour productivity. These are **Skill** - a function of natural ability , training and experience; and **Motivation** which is influenced by the working environment. These are the foci of this research.

CHAPTER 3

CHAPTER 3
A REVIEW OF MOTIVATION THEORY

3.1 *Introduction*

The preceding chapter explained construction productivity in detail, discussing the various factors influencing the industry's productivity. Motivation was identified to be of central importance in construction operative productivity. This chapter examines both the psychological and managerial roots of motivation as a basis for the next chapter which specifically reviews construction operative motivation. Without a thorough knowledge of the basic concepts of motivation, it is impossible to comprehend its application to the construction operative. By first reviewing the basic concept, the gap between the psychological and managerial views on the subject can be bridged, thereby making a single point of view possible. The first part of this chapter clarifies the traditional meaning of motivation before an indepth exposition of different conceptions in later sections.

3.2 The Traditional Meaning of Motivation

Psychological investigations of motivation seek to develop and explain why individuals behave as they do. Traditionally, the study of motivation examines the various factors inciting or directing behaviour in individuals. Jones (71) defined the problem of studying motivation as seeking explanation for "how behaviour gets started, is energised, is sustained, is directed, is stopped, and what kind of subjective reaction is present in the organism while all this is going on". With more understanding of the subject, coupled with the traditional conflict of explaining the same observation by different individuals, motivation has evolved and continues to evolve beyond Jones' definition. Atkinson and Birch (7) argued that there is now an entirely different premise for defining and studying motivation. How have thoughts on motivation evolved?

3.3 The Evolution of Thoughts on Motivation.

If Darwin's theory of evolution is applicable to every situation, it would be possible to assume that the common sense conception of motivation several thousand years ago would be different from today's. Human beings have for long been conceived as more rational, capable of thought, capable of conscious deliberation and voluntary free choice than animals. Also, for many years, the doctrine of hedonism, which states that the pursuit of pleasure and avoidance of pain guides most human behaviour, has for long dug its roots in the traditional conception of motives behind human behaviour. However, as society evolved, more intricate patterns of behaviour emerged demanding more detailed explanation than in the past. Different researchers have different conceptions of the science of behaviour and motivation. The differences in conceptions can be traced to variations in researchers' perception of the interrelationships between behavioural variables.

To clinical psychologists who counsel depressed people, the term motivation refers to the conscious or sub-conscious conflicting tendencies within a person. For the Experimental psychologists seeking explanation to the principles of behaviour through experiments with animals, 'motivation' refers to the various states of the animal when it is hungry or afraid. For neuro-physiological psychologists seeking to explain behaviour, 'motivation' refers to neuro-physiological events associated with drinking, sexual activities and other activities relating to survival.

The approaches taken by different psychologists are often referred to as 'languages' (7) because they seek to explain the same thing and are capable of being translated from one to another. There are three main 'language' groups. First is ***Experiential***, which explains the conscious experience of emotions, desires, feelings of determination and action. Second is ***Neurophysiological***, which describes the motivation process when experiential language is not available or inadequate. Third is ***Behavioural***, which considers "motivation in terms of description of the initiation and persistence of behaviour in relation to observable environmental conditions" (7). The recognition of the presence of these different languages of motivation would explain the apparent confusion in explaining the term 'motivation'.

3.3.1 Motivation 19th Century - 1950s.

By late 19th century, the experientialists have been able to establish the basis of perception and memory which were believed to be the foundations of motives but not how motives translate into action. The experientialists concentrated on the main catalysts of action such as instinct, habit gained from experience and the relationship between pain, pleasure, emotions and actions. There was then a great interest to explain the basic components of action. Consciousness was viewed as the main cause of action and James' (68) analysis of consciousness, revealed that action occurs when the idea to act in a particular direction gains dominance over others.

The predominance of consciousness as the source of action was later challenged by Freud (45, 47) who discovered that individuals are often unaware of motives behind their actions. This formed the first main significant shift in motivation thought. It affected the way researchers view the subject and consequently their method. He also conceived 'need' as the main stimulus for action.

However, both James judgement and Freud's observation seem to have been borne out of inferences on different 'populations' observed, not on any scientific premise. Soon came the scientifically oriented psychologists who believe that motivation studies should not only be based on inferences but on scientifically provable experimentation of individuals. They recognised that although an analysis of the constituents of the mind of individuals is an impossible task, it is possible to observe what the individuals do or say. This viewpoint is summarised in what psychologists term 'behaviourism'; an expression for concepts aimed at explaining the principles of motivation.

3.3.2 Concepts of Human Motivation

Lewin (84) took the next giant step towards a science of motivation. In 1938, he developed an explicit mathematical model of human motivation as:

$$\mathbf{B} = F\,(\mathbf{P},\mathbf{E}).$$

where:

B = Behaviour
P = Personality
E = Immediate psychological environment

Stressing the immediate environment in the equation, Lewin believed that behaviour at a given time is a function of the personality involved (P) and the immediate environment (E).

Elaborating on the immediate environment component of the equation, Atkinson and Birch (134) explained that Lewin's expression means that an individual's behaviour on say Tuesday might have something to do with what happened on Monday, i.e. the lasting effect of Monday's experience on the personality will affect his behaviour on Tuesday. They further expanded the personality component of Lewin's expression into the following equation.

$$\mathbf{P} = F\,(\mathbf{H}, \mathbf{E}_{\mathbf{form}})$$

This expression means that the personality of an individual (P) is a function of both heredity (H) and the formative environment (E_{form}). The social or cultural heritage as mediated by those who had influence on an individual's past. By introducing the concept of formative environment, Atkinson and Birch brought in two types of environment into

Lewin's original equation, i.e. formative and immediate. The behaviour of the operative would depend on his psychological response to these environments.

The view in Thorndike (134) and Palov (116) is that there is a connection between environmental stimulus and operant's action. In what he called the 'law of effect", Thorndike (134) stated that stimulus and response are strengthened in a satisfying state of affairs. Watson (144) built on this hypothesis. He conducted some experiments to establish that all instances of behaviour represent response to particular stimuli which motivated the response. As attempts to explain the main problem of motivation were being made, other problems of specifying the interaction between Personality and Environment began to emerge.

3.3.3 Alternative Traditional Concepts of Motivation.

Hull (65) departed from the traditional thought that response is motivated by stimulus in all situations. In what is now known as the Principles of Motivation, he explained the basic problem of motivation by the following equation.

$$ {}_{s}E_{r} = D \times {}_{s}H_{r} $$

This states that the strength of the tendency to react in a certain way (${}_{S}E_{r}$), depends on the magnitude of Drive (D) and the strength of habit of responding that way in that stimulus situation (${}_{S}H_{r}$). According to this principle, the various biological needs (e.g. hunger, sex or thirst) are the sources of the drive, while the habit of responding in a certain way depends on the operative's formative environment. This DRIVE x HABIT principle of motivation is often referred to as the 'mechanistic' view of motivation (145). This was a dominant view of motivation between 1940-1960 and is still considered a useful way of explaining motivation today. Dollard and Miller (29) argued that this Hullian principle is a re-representation of the fixation (habit) and motivation (drive) concept earlier advanced by Freud.

It soon became apparent in the 1950s, that there is an alternative to the Drive x Habit principle of motivation. Newman and Morganen (145) advanced the "cognitive" view of motivation, which states that the emphasis in the study of motivation ought to be the determination of the roles of expectation or consequences; expressed as:

$$SEU = P_1U_1 + P_2U_2 \ldots\ldots\ldots P_nU_n.$$

The Subjective Expected Utility (SEU), the overall strength of the tendency to respond, is a function of the sum of the contribution of each of the expected consequences of the action. The strength of each component of motivation in turn depends on the product of the subjective probability (P) of that outcome and the subjective value or utility (U) of that outcome. This has often been referred to as the Expectancy theory of motivation.

This was later expanded by Edwards (34), in line with proposals by Tolman (135, 137, 138) and Lewin (82, 83, 84), as an initial formulation of the 'theory of achievement motivation'. This theory attributes the strength of a tendency to undertake some activity to the strength of the cognitive expectation (or belief) that the activity will produce a certain attractiveness (subjective value) of consequence to the individual. It refers to those activities undertaken by individuals with the expectation that performance will be evaluated in relation to outcome.

It is presumed that any situation which may arouse an expectation of success (positive outcome) may as well arouse an expectation of failure (negative outcome). Thus an achievement oriented activity is often influenced by the conflict between the tendencies of failure or success. Achievement is also influenced by EXTRINSIC motivational tendencies attributable to different kinds of motives which may serve as incentives to good performance (e.g. social approval, money etc.).

Individuals often seek to maximise their Subjective Expected Utility (SEU) for alternative activities in a given setting. Should this be true, it can be stated that the overall tendency to undertake an activity in preference to another should correspond to the SEU with greater value. The strength of SEU should be equivalent to the summation of the degree of probability of the different motivational tendencies in an individual; such as the tendency to achieve success (P_1U_1) plus the tendency to gain approval P_2U_2 etc..

It is often assumed in different tests (7) of this theory that performance is a function of the total strength of tendency to perform a particular task (T_x) and that this equals achievement related motivation ($T_s + T_f$) plus extrinsic motivation (T_{ext}) i.e.

$$\mathbf{T_x = (T_s + T_f) + T_{ext}.}$$

Extrinsic motivation refers to the tendency to act due to the influence of other motives plus incentives that are not intrinsically related to the evaluation of performance. Using this equation as a basis for determining the tendency to choose one task in preference to another, Feather (39) stated that an operative will turn to an alternative activity B from A when $T_A < T_B$ in the relationship where:

$$T_A = (T_{SA} + T_{FA}) + T_{extA} < T_B = (T_{SB} + T_{FB}) + T_{extB}$$

or vice versa.

3.4 A Critique of the Traditional Theories

The traditional stimulus-response relationship and the Expectancy conception lead to the consideration of motivation as a reaction to stimuli. They are both stimuli bound theories of motivation encouraging thought of the immediate stimulus situation, to which the individual is exposed, as the cause of his actions. Can it therefore be inferred that without some stimulus setting things in motion (by eliciting a previously learned habit), there can be no excitatory tendency to act according to these theories ?

Kendler (73) observed that the success of "stimulus-response" conception of motivation is partly due to the fact that it forces its user to think in terms of manipulable experimental variables and observable responses dividing behaviour into different episodes. Atkinson and Feather (8) argued that this is an inadequate description of human motivation. Feather (39) inferred, from his experiments on persistence, that " it is impossible to predict when a person would cease working at his initial task without knowing something or at least assuming something about the strength of his tendency to do something else". A stimulus - response event is just an incident within the goal directed trend of behaviour. On this assertion was built the achievement motivation theory which emphasises that the psychology of motivation should, instead of the episodic stimulus-response relationships, be concerned with the problem of change in on-going activities. Motivation is now conceived in psychology as a continuous stream, characterised by choice between competing activities in an environment (7).

The achievement motivation theory exemplifies the second episodic expectancy theory (34, 85, 137, 140). The unique contribution of achievement motivation theory is that it specifies how differences in personality (measured by diagnostic tests) and features of the immediate environment combine to produce differences in the reaction of individuals to the same stimulus situation. Various motives and incentives which are the main components of motivation often combine to determine the level of an individual's motivation at a particular point in time.

However, the theory does not clearly state what these motives and incentives are. It also fails to show how differences in ability, as reflected in skill or complexity of task, influence the subjective probability of success of a particular motive or incentive at a future date. The traditional episodic theories of motivation also over-emphasise the behavioural implications of the immediate stimulus situation to the neglect of other factors influencing motivation (7).

3.5. Concepts of Motivation in Management

The study of motivation is no longer in the exclusive domain of psychologists. Management experts have contributed and are contributing to the development of this important phenomenon in human behaviour. Managers are interested in this subject mainly because they desire to get the best from operatives by understanding the innate desires or motives behind their behaviour. Whilst psychologists have been pre-occupied with theoretical concepts, management researchers are guided by the desire to understand those energising elements that can bring out the best from their workers. It is therefore not difficult to see why most management theories on motivation are 'goal' oriented. Indeed, motivation is gradually becoming one of the dominant subjects in management. Jones (70) argued that although many perceive the purpose of management as getting disciplined reponse to management's plan, its real objective is the motivation of a group of workers to use its energy to achieve success. In this section, three theories, described as having captured the imagination of managers (52), are discussed in contrast to the traditional theoretical approach of psychologists. The three theories are those of Maslow, McGregor and Herzberg.

3.5.1 Maslow's Hierarchy of Needs Motivation Theory

In the preface to this theory, Maslow (98) made 13 different propositions which should be included in any definitive theory of motivation. These provide a link between his theory and previous works on the subject. These propositions include the following.

1. Any theory of motivation must basically be goal oriented.
2. The appearance of human needs usually rests on the prior satisfaction of another, more prepotent need. "Man is a perpetually wanting animal."
3. Motivation theory is not synonymous with behaviour theory. Motivations are only one of the many determinants of behaviour.
4. Motivation theory should be human centered rather than animal.

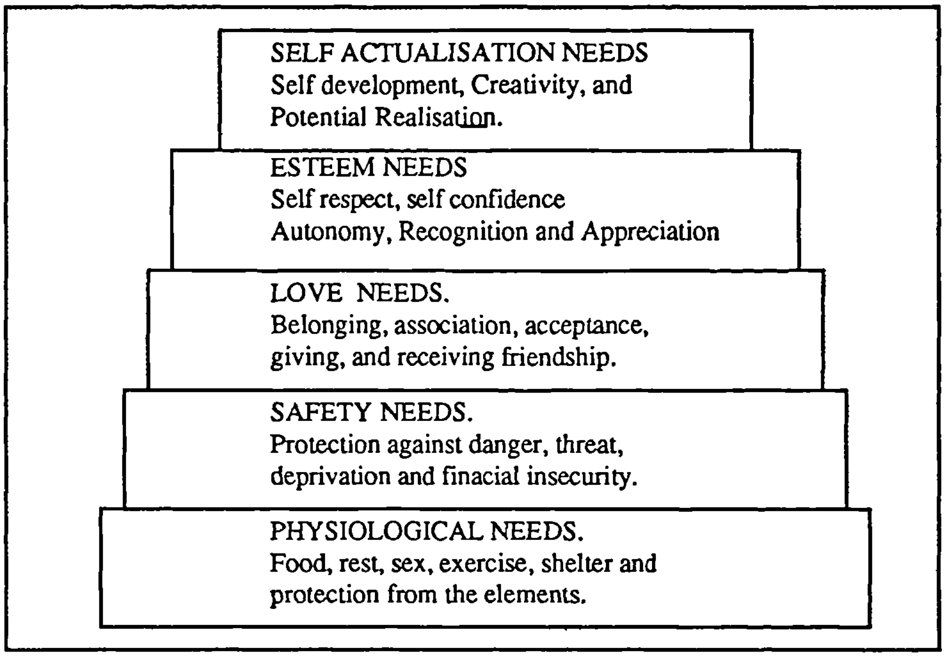
Based on these propositions he formulated what he described as a "positive theory of motivation" to satisfy both practical and theoretical demands. The theory stems from the dynamic relationship between behaviour and environment introduced into behaviour theory by Freud (46) and Adler (3).

3.5.1.1 The Physiological Needs

These are normally taken as the starting point for motivation theory. They are the needs for food, sex, sleep, sheer activity, tastes, smell, tickling, stroking, etc. (All these are physiological and may be the goals of motivated behaviour.) Making an exhaustive list of psychological needs is impossible; the length of the list depends on the degree of specificity or description. Maslow pointed out that any physiological need may serve as a channel for other sets of needs; e.g. an hungry person may actually be seeking more comfort rather than vitamins or proteins. The physiological needs are the most prepotent of all needs. "A person who is lacking food, safety, love and esteem would most probably hunger for food more strongly than for anything else".

Maslow believes that a good way to to get a lopsided view of human capacities, human nature and motivation is to make the person extremely and chronically hungry or thirsty. When a person is full, other needs emerge and dominate him provided he hasn't lost grip with the first prepotent need.

Figure 3.1 Maslow's Hierarchy of Needs



One implication of this is that meeting a need is as important as deprivation; as it releases the individual from the domination of a prepotent need thereby permitting the emergence of other needs.

3.5.1.2 Safety Needs

These emerge only after physiological needs have been relatively well gratified. All foregoing postulations on physiological needs are equally applicable to safety needs - they may dominate the individual and make the individual a safety-seeking mechanism.

Practically everything looks less important than safety, even sometimes the importance of the physiological needs which were earlier satisfied are now forgotten.

3.5.1.3 Love Needs

If both physiological and safety needs are fairly well gratified, there will then emerge love, affection and attachment needs. The whole cycle already described will repeat itself with this new centre. Now the individual keenly feels, as never before, the absence of his friends, wife or children. A fact not to be overlooked, stressed Maslow, is that love needs involve both giving and receiving.

3.5.1.4 Esteem Needs.

But for pathological exceptions, Maslow believes that every individual has a need for a stable, firmly based and usually high evaluation of themselves for self-respect or self-esteem and for the esteem of others. He classified these needs into two. Firstly, the desire for strength, achievement, adequacy, confidence, independence and freedom. Secondly, the desire for reputation, recognition, attention, importance and appreciation.

When satisfied, self esteem needs lead to self confidence, strength, capability and adequacy of being useful and necessary in the world. But when not met, esteem needs produce feelings of inferiority, weakness or helplessness.

3.5.1.5 The Need for Self Actualisation

If all the previously discussed needs are met, there may be discontent followed by restlessness unless the individual is doing what he is best at doing. The term self actualisation refers to the desire for self fulfillment, i.e. actualising what the individual is potentially capable of. It is the desire to become everything an individual is capable of becoming.

Maslow suggested some pre-conditions for the basic needs to be satisfied. These include, freedom of speech and expression, freedom to investigate and seek information, freedom to defend one's self, justice, fairness, honesty, orderliness in the group etc.. A lack of any of these will result in emergency reactions. Maslow defended these preconditions arguing that without them, basic satisfactions are quite impossible, or at least, very severely endangered.

3.5.1.6 Other Characteristics of Basic Needs

Although the needs have thus far been presented as though the hierarchy are fixed this is not always the case. The following are exceptions to the general hierarchy presented.

1. Some people take self esteem to be more important than love.
2. Some prefer self actualisation to any other need.
3. In certain people the level of aspiration may be permanently deadened or lowered, e.g. a person who has experienced life at a very low level - with chronic unemployment, may continue to be satisfied for the rest of his life so long as he can get food.
4. Some have psychopathic personality - no love because they have been starved of love in the earliest months of their lives and have simply lost forever the desire and ability to give and receive affection.
5. When a need has been satisfied for a long time, it may become under-evaluated. People who have never experienced chronic hunger may underestimate its effects and look upon food as a rather unimportant thing.
6. There are many determinants of behaviour other than needs and desires.
7. Habituation - sheer habit.

3.5.2 Macgregor's Theories X and Y

Bennis (11) describe Macgregor's (102) work on motivation in the same strength as economists would describe Keynes. In his view, Macgregor created a 'new taste' across the entire field of management and organisational behaviour on the subject of motivation. Macgregor postulated a twin theory of man - theories X and Y.

Theory X is a series of propositions which he felt are the conventional conception of management's task in harnessing man's energy to meet organisational requirements.

- Management is responsible for organising the elements of productive enterprise - money, materials, equipment, people - in the interest of economic ends.
- With respect to people, this is a process of directing their efforts, motivating them, controlling their actions, modifying their behaviour to fit the needs of the organisation.
- Without this active intervention by management, people would be passive - even resistant - to organisational needs.
- The average man is indolent - he works as little as possible.
- He lacks ambition, dislikes responsibility, prefers to be led.
- He is inherently self-centered, indifferent to organisational needs.
- He is by nature resistant to change.
- He is gullible, not very bright, the ready dupe of the charlattan and the demagogue.

Macgregor believed that conventional organisational structures, practices and managerial policies reflect these assumptions. Bennis (11) reinforced these assumptions by claiming that Theory X is not only alive in industrial organisations but also in basic assumptions behind advertisements, political rallies, and the management of welfare and health institutions in the U.S..

Theory Y contains another set of propositions.

- Work is natural for most people, they do not avoid it.
- If the individual is committed to an organisation's objectives, he or she will get satisfaction from helping to achieve these goals and thus be self motivated.
- The strength of commitment is related to the rewards it brings.
- In a non-threatening atmosphere, most people will accept and even seek responsibility.
- Creative problem solving is a potential of many individuals, not just a few.

Macgregor is of the opinion that human growth is self generated and improved in an environment of trust, feedback and authentic human relationship. Theory Y does not tolerate "pseudo growth" forced on an individual by the supervisor who manipulates, no matter how well intentioned he is, or by a sadist who uses fear as a crutch to hide his own fears (11). Growth is natural. The best a leader can do is to understand the condition creating a climate of growth and then do his best to irrigate it.

Theories X and Y do not necessarily represent the workers but constitute sets of assumptions held by the manager towards his workers. They are both hypotheses of the manager on human motivation. It is the way managers see motivation that create conditions generating Y or X conditions.

Macgregor's work provided an explanation that an individual's perceptions of situations can affect his understanding of the behaviour of others. If he perceives correctly, he will be able to predict the behaviour of others.

One of the main criticisms of theory Y is that it gives away the perogatives of decision making to subordinates? It sounds like communism (11). The counter argument by some of

Macgregor's fans is that he was only advocating 'power equalisation', not a surrender, in his theory Y.

According to Macgregor (102), "a theory Y leader is caring, protective, a wise-helper and counsellor. He rarely intervenes except when asked or when absolutely necessary. He is a perceptive human ecologist, adjusting dials and cultivating the perfect organisational climate so that his labours, unsung and unnoticed create pygmalion-like transformations in his charges. The failure or success of his subordinates is his responsibility." Attacking this description, Bennis (11) said that Macgregor's description does not take into consideration the needs and distortions of the leader himself. He is too employee oriented. Another popular criticism of Macgregor's theories is that they do not take full account of changing world situations which influence working patterns from time to time, educational advancement, population growth and advances in technology.

3.5.3 Herzberg's Motivation Hygiene Theory

Herzberg (59) first identified 8 prevailing different schemes and approaches by management to motivating employees in his methodical presentation of his motivation-hygiene theory. These are:

1. reducing time spent at work,
2. spiralling wages,
3. fringe benefits,
4. human relation training,
5. sensitivity training,
6. communication,
7. job participation, and
8. employee counseling.

These he described as the KITA (kick in the ass) approach to motivation which bears much resemblance to traditional ways of getting an animal (pet) to obey commands. These KITA approaches have short term MOVEMENT effects not MOTIVATION. Motivation he argued pulls not pushes. Pushes only result in temporary MOVEMENTS in behaviour and could be costly to maintain as the effect wears out quickly.

Likening the installation of motivation to installing a generator in employees, Herzberg drew the first conception of his theory from the events in the lives of Engineers and Accountants. To this original work has been added 16 other investigations from various population samples. The main thrust of the theory states " the factors involved in producing job satisfaction (and motivation) are separate and distinct from factors that lead to job dissatisfaction". Job satisfying and dissatisfying feelings are not opposites. He affirmed that the opposite of job satisfaction is not job dissatisfaction, but, rather, no job satisfaction; and similarly, the opposite of job dissatisfaction is not job satisfaction, but no job dissatisfaction.

He identified two basic needs of men - the **BIOLOGICAL** need to avoid pain from the environment such as hunger, and the **GROWTH** need which relates to the unique human characteristic to achieve, and through achievement to experience psychological growth, e.g. job content which stimulates growth in contrast to the pain avoidance stimuli present in the job environment.

The growth factors or motivators are:

- achievement,
- recognition of achievement,
- the work itself,
- responsibility, and
- growth and advancement.

The Dissatisfaction - Avoidance or Hygiene (KITA) factors are:

- company policy and administration,
- supervision,
- interpersonal relationships,

- working conditions,
- salary,
- status, and
- security.

These factors were presented to 1685 employees in a survey to conclude that of all the factors contributing to job satisfaction, 81% were motivators and of all the factors contributing to employee dissatisfaction, 69% were hygiene related.

3.5.3.1 Job Enrichment

In what Herzberg described as the "Eternal Triangle", the three general philosophies of personnel management - Organisation Theory (OT), Industrial Engineering (IE) and Behavioural Science (BS) were described as ineffective approaches to operative motivation. Although OT and IE have achieved much, BS has been facing the question - "What is the cost in human problems that eventually cause more expense to the organisation - for instance, turnover, absenteeism, errors, violation of safety rules, strikes, restriction of output, higher wages, and greater fringe benefits ?" On the other hand, behavioural scientists are unable to pinpoint the relationship between their method of motivating and real improvement in personnel management.

Depicting these philosophies as a triangle with each on an apex, Herzberg argued that his motivation-hygiene theory should claim the same apex as IE but for opposite goals. Instead of rationalising work to increase efficiency as in IE, he suggested that work should be **enriched** to bring effective utilisation of personnel. He described this as JOB ENRICHMENT. He also suggested the principles and practical steps of this new line of thought based on his successful experiments. The main thrust of his principle was 'vertical job loading', i.e. providing motivating factors in jobs; rather than 'horizontal job loading' in which management often reduces employees' growth in their jobs. His suggested steps for job enrichment are listed below.

1. Select jobs in which:
   - Attitudes are poor
   - Industrial Engineering won't be costly
   - Hygiene is costly
   - Motivation will make a difference in performance.
2. Be convinced that jobs can be enriched.
3. Brainstorm a list of changes that may enrich the jobs, without concern for their practicality.
4. Screen the list to eliminate suggestions that involve hygiene rather than actual motivation.
5. Screen the list for general suggestions.
6. Screen the list to eliminate any horizontal loading suggestions.
7. Avoid direct participation by employees whose jobs are to be enriched.
8. Set up a controlled experiment.
9. Be prepared for a drop in performance in the experimental group in the first few weeks
10. Expect hostilities to first line supervisor from operatives on enriching the job.

Herzberg's theory was borne out of his desire to redress the over-concern of the industrial social scientists about treating workers to the neglect of work design. Although the theory, according to him, holds across nations and professions, his advocation for job enrichment has fallen on deaf ears. In a retrospective comment on his theory Herzberg (60) is now of the opinion that finance is of utmost concern to management, not the job content or relationships at work. In his view, electronic communication has promoted detachment and abstraction on shop floors. KITA factors still predominate. His comment was concluded thus:

"The work ethic and the quality of worklife movement have succumbed to the pragmatics of worldwide competition and the escalation of management direction by the abstract fields of finance and marketing - as opposed to production and sales, where palpable knowledge of clients and products resides. These abstract fields are more conducive to movement than to motivation. I find the new entrants in the world of work on the whole a passionless lot intent

on serving financial indexes rather than clients and products. Motivation encompasses passion; movement is sterile".

The foregoing theories dominate the subject of motivation in management. Several other theories are being postulated daily, to explain the operative in different settings. Some of these are: Ouchi's theory Z (113), Locke's Goal theory (75), Brehm's Reactance theory (2) and the Equity theory (2). One distinction between the approaches by management researchers and psychologists has been brought out in the discussion so far - Psychologists see the study of motivation as an end in itself while managers see motivation as a means to an end. The managers' approach is pragmatic but void without the psychological foundations. Motivation clearly relates to performance and it must be measurable or it would remain an abstract science.

3.6 Motivation and Performance

What is the relationship between motivation and performance really like? This question can be reframed from our earlier understanding of the achievement motivation theory in terms of three main variables.

1. To what extent does the individual think his performance in a particular task will lead to success ?
2. How much incentive does success give the individual in this particular activity ? Because of past experience in similar situations to the one now confronted, an individual's expectancy of success may be very strong, moderately strong or weak.
3. What is the value of the incentive to succeed? This is one of the immediate determinants of the strength of motivation. Tolman and Lewin (136) argued that the amount of incentive or value of the expected consequence should be considered in relating motivation to performance. Also, Atkinson (6) showed

that both the monetary incentive and the strength of expectancy of the probability of success have significant effects on the level of performance. This fits common sense prediction and is congruent with any theory treating incentive as a determinant of performance.

Motivation has been widely recognised as a great influence on performance in two fundamental ways:

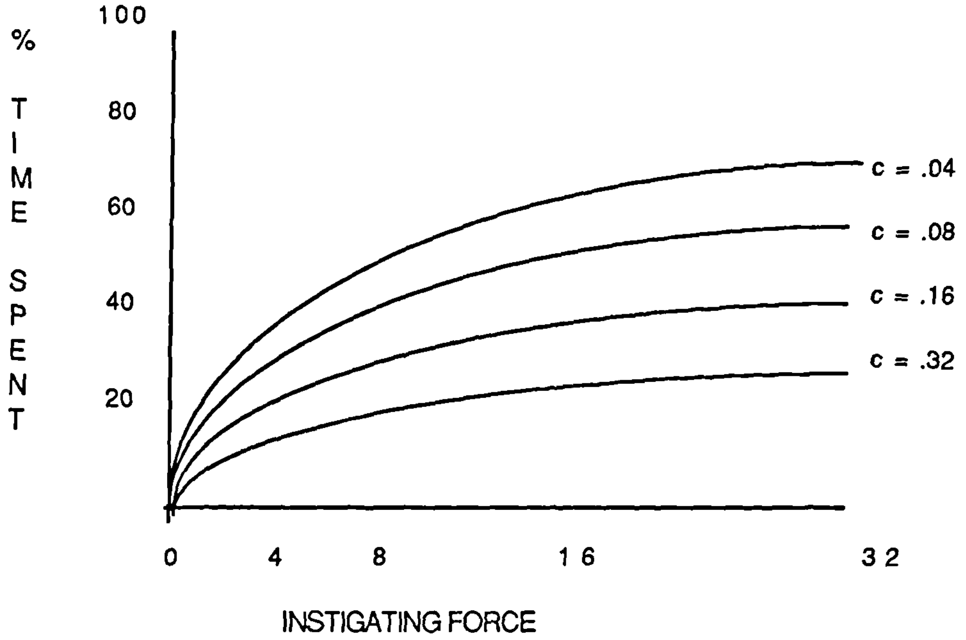
i) the time spent in an activity, and
ii) the efficiency of performing an activity.

Motivation has been related to the time spent in an activity by the relationship:

$$\textbf{\% Time Spent in Activity A} = \frac{F_a / C_a}{F_a/C_a + F_b/C_b + \ldots\ldots\ldots F_n/C_n}$$

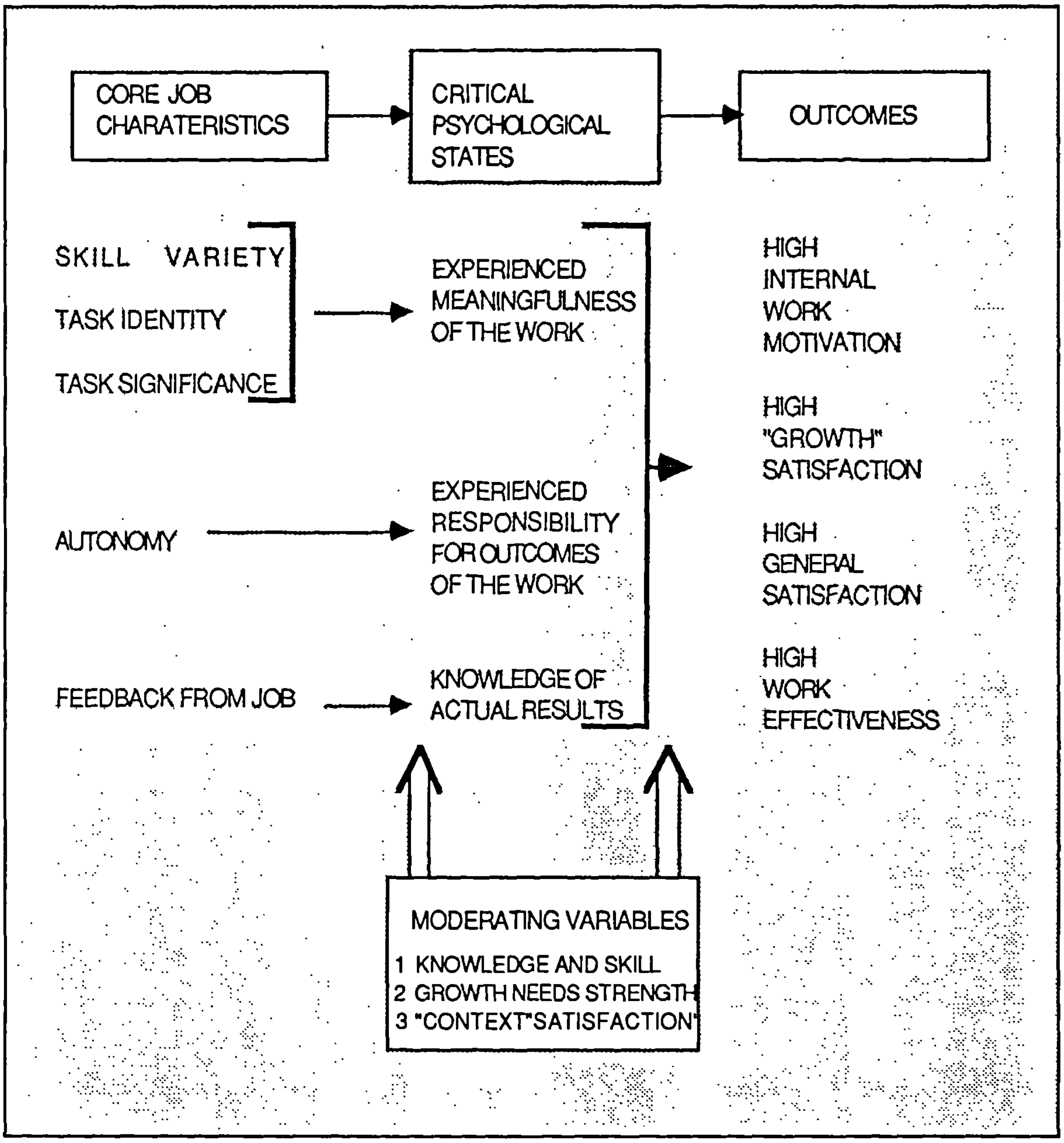
This principle states that the proportion of time spent in a given activity depends on the strength of the tendency (i.e.motivation) to do it relative to the number and strength of tendencies for all the competing activities in that situation. From the relationship, it is apparent that both the instigating force (F) for an activity (a function of the stimulus situation) and the consummatory value (C) of the activity (a function of behaviour itself) influence the time spent in an activity. The proportion of time spent increases as the magnitude of instigating force becomes stronger, and it decreases as the consummatory value of the activity becomes greater. The proportion of time will also depend upon the number of competing activities, their instigating forces and consummatory values. See figure 3.2.

Figure 3.2 **Instigating Forces, Consummatory Values and % Time Spent in an Activity.**



Workers' performance is often influenced by the nature of the task, which in turn influences workers' motivation. The impact of work-design upon employee motivation has been the focus of many management researches. A comprehensive 'job characteristics model' developed by Hackman and Oldham (53) summarises the various efforts, see Figure 3.3. The model has four main components - core job characteristics, critical psychological states, outcomes and moderating variables. The main argument in the model is that some 'moderating variables' influence the 'core job characteristics', these in turn affect the reactions of the workers to the job (i.e. critical psychological states), which in turn affect the motivation of the workers, their performance and satisfaction; collectively described as 'outcomes'. See Figure 3.3.

Figure 3.3 : *Job Characteristics Model* (33)



How would workers react to the job characteristics? The reactions are reflected in the psychological states which can be grouped into three : experienced meaningfulness, responsibility for outcomes and knowledge of results. Experienced meaningfulness refers to the workers seeing the work as meeting their set values. Responsibility for outcomes refers to the feeling of the worker that he is responsible for the quantity and quality of work performed. Knowledge of results is defined as the availability of information from the job itself which allows the worker to judge his level of performance. Hackman and Oldham are of the opinion that these three conditions must be met if a strong internal motivation for high performance is to develop.

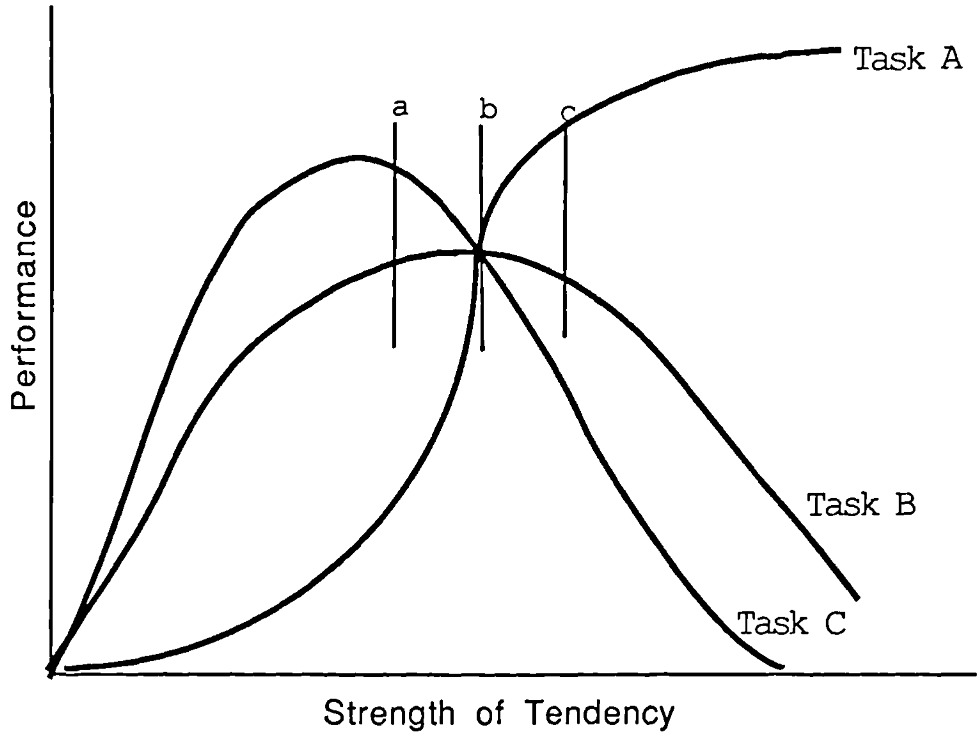
An old idea, supported mainly by evidence from studies of animals, states that the relationship between intensity of motivation (however conceived) and the level of efficiency of performance can be generally described by an inverted U-shaped curve, see figure 3.4. This hypothesis is widely known as the Yerkes - Dodson (153) law, and is the basis of the concept of optimal -motivation. Supportive evidence comes from several areas of research (21, 24, 37, 58, 100, 140).

Persons of equivalent ability might have substantially different performance levels in the same activity as a result of differences in motivation. It has been proposed that:

Level of Performance = Ability x Efficiency.

Where efficiency is a non-monotonic function of the strength of motivation. This implies that the true level of ability in a person is fully expressed only when the person is optimally motivated given the requirements of the task. Individual levels of optimal motivation may differ from task to task.

Figure 3.4 Illustration of Yerkes Dodson Law



Source (7)

3. 7 Measuring Human Motivation

Measuring human motivation has been an enduring problem in psychology. In the late 1940s, when there was no generally acceptable/reliable measure of motivation, McClleland et.al. (101) recognised the need for a generally useful and valid method of measuring human motives. Hypothesising that human motivation is expressible in free-associative thought, they started experiments aimed at manipulating and controlling the strength of motivation. They adopted Murray's Thematic Apperception Test (TAT) and were initially guided by Murray's conception of personality as a hierarchy or configuration of basic needs or motives (106).

McClleland et. al. (101) emphasised that motivation would get the greatest lift as both a distinct research area and theoretical variable only if some distinct methods for measuring it could be developed. One of their main hypothesis is that motives could be experimentally aroused by manipulating external conditions. The problem they concentrated on was that of attempting to arouse human motives experimentally and to measure their effects. Their experiments suggested that when human beings are deprived of their basic needs in different degrees, the degree of deprivation is reflected in 'brief imaginative stories'. From this they obtained a reliable measure of n-achievement (a measure of motivational strength). Their work demonstrated that deriving a measure of motivational strength from experiments is practicable and applicable to measuring different motives. Shipley and Veroff (128) also applied the TAT process to measuring motivation but instead of stories they used pictures to derive a measure of the need for affiliation.

3.8 Summary

1. Motivation has for long been confused with behaviour in traditional psychology. As pointed out by Herzberg, this should not be so.
2. Motivation can be defined in the light of the discussions as a generating element in workers.
3. Management has produced "straight jacket" theories which do not allow the manoeuvrability that managers need.
4. Much theoretical work has been done to relate motivation to performance. They are mostly hypothetical representations.
5. Motivation is quantifiable to high degrees of accuracy if carefully evaluated.
6. There are too many conceptions of a single subject. In most cases the proponent's background dominates his thoughts.
7. Herzberg's experiment demonstrate that it is possible to analyse the constituents of motivation and see trends develop on which valid conclusions could be drawn.

CHAPTER 4

CHAPTER 4

A REVIEW OF CONSTRUCTION OPERATIVE MOTIVATION

4.1 Introduction

The preceding chapter reviewed the evolution of human motivation as a distinct subject in both psychology and management. Motivation was aptly described as an inner generator of actions and reactions. The innate nature of motivation firmly links it to psychology. The applications of this 'phenomenon' to management were also discussed with a detailed description of its main conceptions in general management. As previously noted, management is interested in 'motivation' as a means to an end - the optimisation of the human resource in the production process. There is a deluge of publications on the subject applied to general management, but few in the specialised field of construction management.

Why is it necessary to study this subject specifically in the construction environment? Are the general management theories not enough? Do they not explain labour motivation enough for direct application into the construction setting? The first section of this chapter explains the answers given to these fundamental questions by various construction researchers, after which the current literature on the subject are reviewed. The aim is to evaluate available knowledge, determine if there are deficiencies and suggest further research if necessary.

4.2 Basis For Motivation Studies in the Construction Industry

There are as many justifications for carrying out research into construction operative motivation as there are publications on the subject, however, there is common ground in these justifications. This common ground can be traced back to our discussions on the principles of human motivation in the previous chapter. Motivation is dependent on the environment (both genetic and formative), the personality involved and the task / job characteristics. Since the construction industry offers a different working environment and distinct job characteristics when compared to other industries, its workers should be studied separately if a specific knowledge of their motivation is to be acquired. This simple argument summarises the justifications for specific studies into construction operative motivation.

Although the construction industry offers work which is naturally attractive to a number of workers (such as challenging and interesting tasks, comparatively high rewards and outdoor work), its need for high labour mobility, job insecurity and frequent changes in methods and technology often dissuade many from joining the industry (13). Workers in the industry must then be peculiar - coping with the advantages and disadvantages that the industry offers. They may have basic needs similar to all other workers, but the satisfaction of these needs is different because of the controlling environment (70,107,117,124).

The construction process is often separated into 'design' and 'construction' functions, the organisation of which is vastly different from the 'one roof' organisation of the production process associated with the manufacturing industry. The design team is often different from the management team which can also be different from the construction team. The current phenomenal growth of labour-only subcontracting divides the construction function even further. All these lead to a lack of cohesion and single organisational focus which other industries enjoy. In the U.S., where construction unions are very strong, workers simply have two masters and in most cases the union which has no financial stake in the project can dictate the tune.

The foregoing notwithstanding, there is a generally held view by construction managers that the industry's comparatively healthier record of industrial disputes is due to high motivation. This has been disputed by Wallace (142). He emphasised that the fragmented nature of the industry, its high labour turnover and mobility reduces group cohesion which consequently retards the growth of "construction operative solidarity". It is this lack of solidarity among workers that causes the industry to have fewer disputes; they are not necessarily highly motivated.

None of the general management theories are construction industry based. In most cases, these theories are manufacturing industry based. Since these theories attempt to model the real world, they should be directly related to the people they represent. Assuming the theories are general to all workers in the true sense of the word, why are they not saying the same thing? The variance in the management theories show that differences are bound to exist from one environment to the other.

Maloney and Mcfillen (93) advanced three reasons why social scientists have not considered the construction industry in their motivation studies.

i) They have little or no knowledge of construction.

ii) There has been inadequate research funding from the construction industry.

iii) Few construction researchers have a good understanding of psychology and physiology necessary for such studies.

They suggested an interdisciplinary approach to an indepth study of the subject in construction. One wonders if it is not possible for interested construction researchers to acquire the necessary knowledge of psychology to explain motivation in their own industry ! Having highlighted the reasons for special studies into construction operative motivation, we go on to examine what the studies have achieved.

4.3 Studies in Construction Operative Motivation

Different authors construe construction operative motivation differently, often to their special bias. Some take it to mean 'incentive', some as 'motivation' and others as a reflection of the degree of 'satisfaction' based on the general notion that a satisfied worker will produce. All refer to the same thing - turning on the 'generator' inside workers. For clarification, two broad groups are considered in this review as they cover most of the existing works on construction motivation. These are **Conceptual studies** (i.e. studies that examine existing theories with respect to the construction operative without any scientific testing) and **Empirical studies** having to do with findings from experimental and observational based studies.

4.3.1 Conceptual Studies

As previously stated, none of the existing general management theories on motivation is construction industry based. Maloney and McFillen (93) advocated that instead of concentrating on the differences between construction and other industries, similarities should be sought that permit the adoption and transfer of existing knowledge. This was the approach taken by most conceptual researchers in construction operative motivation. There is no single specialised theory of construction operative motivation, all we have are the applications of the general theories. There is wisdom in this, as it affords researchers the opportunity to understand the different characteristics of the workers before developing them into a specific theory. Moreso, it is not necessary to develop a theory for development sake, if there is an adequate existing one. Let us now discuss some of these conceptual studies.

4.3.1.1 Conceptual Application of Maslow's Hierarchy of Needs to Construction Operatives.

Maslow's hierarchy is based on the prepotency principle of five principal classes of needs. These needs are Physiological, Security, Love and Belonginness, Esteem and Self Actualisation. While Maslow's hierarchy is very logical, it has not been subjected to any serious empirical verification. It is, therefore, not surprising that most applications of this theory as a conceptual base for motivating construction operatives are rather subjective and at best descriptive.

Schrader (125), Haseltine (57), Nave (107), and Neal (108) used the Maslow model as a base for construction operative motivation. Schrader believes that American construction workers can meet physiological needs when employed because they earn enough money to pay for them, and these needs are truely at the lowest scale of importance in construction today according to Maslow's ranking. He gave no evidence to support this. Haseltine agrees with him, ~~claiming that~~ most 'working people' have satisfied these basic needs and are now only motivated by higher needs - ~~he too did not offer any evidence.~~

Haseltine believes that the next set of needs - safety needs- which include job security, protection against danger, threat and deprivation are also satisfied for many U.S. workers. On the other hand Schrader is of the opinion that safety needs (especially the job security portion) is a motivator but not as strong as in other industries primarily because construction workers have become used to changing jobs from time to time. ~~What then is the real situation?~~

Social needs, claims Schrader, is one of the main motivators to construction operatives. He wrote: "..it is an undeniable fact that many construction workers fulfill their desires to become a member of a group by making serious efforts to work with their buddies and form cliques..." This ~~view is supported by Zelst's (107) experiment on the effects of operative behaviour on~~ construction ~~productivity in which he~~ allowed individuals ~~to choose whom to work with. Operative turnover consequently reduced with improvement in productivity.~~

Schrader also believes that construction workers have ego needs which are satisfied in competition, praise or upliftment of status. In the U.S., this is often frustrated by construction unions' restrictive practises. If it is truly frustrated as claimed, how did he measure it or how did he come about this assertion ? However, the Hawthorne experiment (62) shows that ego, though often difficult to measure, can motivate.

Self Actualisation needs are the last in Maslow's hierarchy, and Schrader's descriptive work is of the opinion that while these are paramount, they are rarely fulfilled in construction terms. For example, some workers, who could have been promoted, stick to their craft because they want to remain craftsmen without the responsibilities of foremen.

One fundamental flaw in these studies is that none of them tried to show any proof of the prepotency of needs conceptualised by Maslow. They are rather subjective and, in most cases, only relational. Nothing is proved or disproved. Secondly, it seems the authors' suggestions for increasing productivity are questionable as they addressed operative motivation from their own perspective - not the workers'. Individuals' perception of needs differ and in many cases are unique. They should, however, be commended for their insights to construction operative motivation.

4.3.1.2. Conceptual Application of Theories X and Y to Construction Operatives.

Haseltine (57) further developed his earlier analysis of construction workers in line with Macgregor's view (102). Haseltine opined that traditional management techniques of providing good wages, good working conditions, excellent fringe benefits and continuous employment are not effective motivators in construction. They only satisfy the first two needs which do not appear to motivate construction workers. He concluded that emphasis should be on satisfying the higher needs which motivate workers to higher production. This 'satisfaction before production' doctrine was denounced by Brayfield and Crocket (19) as being simplistic, as the relationship between satisfaction and productivity is complex and varies with individuals.

The motivational techniques suggested by Schrader (125) emphasise higher needs which are a basic extention of theory Y. Haseltine (57) also recommended a progressive theory Y approach in the construction setting. The basic question both Haseltine and Schrader failed to answer is - would increased satisfaction lead to higher productivity ? Maloney (90) is of the opinion that Macgregor's theories are fundamentally wrong in proposing a 'best' way of motivating employees and rigidly categorising workers as X or Y. Instead he suggested that since individuals differ, their behaviour should be conceived as a continuum of assumptions made in both theories.

4.3.1.3 Conceptual Application of Herzberg's Theory to Construction Operatives.

Although Herzberg's theory is often used as basis for some empirical studies (see next section), only Haseltine (57) applied this theory conceptually to the construction operative. As in previous criticism of his studies, Haseltine offered no firm evidence of its applicability in construction. He supports the view that Herzberg's theory is a basic extension of Macgregor's theories, saying that the traditional KITA oriented motivation techniques are not good motivators (59). He is also of the opinion that the domineering influence of construction unions in the United States offsets most KITA motivational techniques, leaving contractors (employers) little room for manoeuvre compared to Herzberg's job enrichment technique. However, this is not sufficent justification for an wholesale adoption of Herzberg's theory in the construction industry. In the U.K., where the majority of construction workers are 'open shop' workers, there is the tendency to identify with management goals and be motivated (not only moved as suggested by Herzberg) by KITA forces. As Herzberg himself has now seen, the enthusiasm to job enrichment programme waning (60), the theory's suitability for the construction industry for the construction industry may be under question.

4.3.1.4 Conceptual Application of Expectancy Theory and the Construction Operative.

Maloney and Mcfillen (93) approach to the conceptual application of the expectancy theory to construction operatives was more methodical and less unguarded than the earlier discussed conceptual studies. Their approach was quite distinct in that, instead of wholesale application, they suggested different research approaches that should be taken when applying the expectancy theory to construction operatives. With supportive evidence from social sciences, they are convinced that the expectancy concept is relevant to the construction operative. They advocated 'rigorous empirical research' into worker performance and motivation, as dynamically related in the expectancy model, should the construction industry be interested in improving worker performance.

On the other hand, Wesley-Lees (146) applied the concept wholesale to construction operatives in U.K.. His work did not prove or disprove this theory as an adequate representation of operative performance and motivation in construction. He believed that the principal potential motivators to high performance are financial incentives and job security, and conclude that financial incentives can successfully raise productivity only if operative motivation is the principal determinant of output. This conclusion shows a basic flaw in his application of the expectancy theory to construction. The expectancy model is wholistic and it is not possible to single out a motivator - financial incentive - as being primary and more or less representative of total motivation.

4.3.2 Empirical Studies in Construction Operative Motivation.

The application of general management theories to construction operatives was discussed in the preceding section. It has been recognised by various researchers that empirical researches into construction operative motivation and performance are a good starting point for the development of relevant set of theories for the industry. Most empirical studies are based on the existing theoretical approaches in management.

Wilson's (152) study of operative motivation is an example of a straightforward empirical approach to acquiring a knowledge of motivators in the construction industry. He designed an experiment to evaluate the degree of importance workers attach to certain motives. The motives were those often cited in management literature as being capable of motivating workers. He found that the greatest motivators were safety and belonging needs. These findings were tabulated against Maslow's hierarchy, by Mackenzie and Harris (88), to conclude that Maslow's theory explains motivation in construction operatives only in the early stages of the hierarchy with the pattern becoming quite confusing in the later stages.

Olomolaiye and Ogunlana (109) took a similar approach to Wilson on some Nigerian sites, and found that the greatest motivation influences on construction operatives in Nigeria are for physiological and safety needs. When the two studies were comparatively analysed, Olomolaiye and Ogunlana (109) concluded that the level of economic development in a particular country may be a determinant of what level a certain set of workers fall in the hierarchy. The hierarchy is not as prepotential as suggested by Maslow; and as Schrader and Haseltine would like us to believe. From Wilson (152), and Olomolaiye and Ogunlana (109), it is clear that a more vivid picture of the construction operative can be obtained by directly approaching the worker with no bias to any theory. One obvious deficiency in both studies is the level of dependence or confidence attached to the list of motives. An examination of the motives reveals some inclination to Herzberg's list of motivation influences. This inclination may be traced to Herzberg being the only theorist with a long list of motivation influences.

Mackenzie and Harris (88), and Olomolaiye and Ogunlana differ in their classification of motivators on Maslow's model. Mackenzie and Harris classified wages into the first class of needs, based on the general assumption that money can buy most of the physiological needs. This approach may be wrong in that money, also influences perceptions of the other four classes of needs. Olomolaiye and Ogunlana did not classify money as a motivator which is more in line with Herzberg's thoughts that it is just a 'movement' factor, see Table 4.1. But Olomolaiye and Ogunlana later included fringe benefits in the list on the Maslow scale which makes the picture rather confusing. Fringe benefits in construction are in most cases related to money. Apart from this criticism, both studies demonstrated that Maslow's theory can, to some extent, explain motivation in construction and were quite unique in determining the level of importance of the motivators before searching for a theory that is near to explaining their findings. Other empirical studies approached construction motivation by applying existing theories to the construction situation. Three distinct schools of thought can be identified in this approach, led by the main writers on construction operative motivation - Bocherding, Maloney and Mcfillen, and the Financial Incentive Group (traceable to the classical school of thought led by Adam Smith).

4.3.2.1 Satisfaction and Dissatisfaction of Construction Operatives

From Herzberg oriented studies into construction operative motivation, Bocherding (alone and with others) published six articles which have contributed immensely to an understanding of different motivating influences in construction. Although they were apparently Herzberg based, with their emphasis on satisfaction, no special mention of Herzberg was made in the articles, no specific definitions were suggested and the research methods did not follow a definite plan of proving or disproving Herzberg. They are therefore conceptually weak. Exposing this conceptual weakness, Maloney (90) pointed out that 'nowhere in the articles do the authors define job satisfaction, job dissatisfaction, productivity, morale or motivation or indicate how they are to be measured'.

This weak conceptual and methodology background of the articles can be traced to the inherent problems associated with proving Herzberg's theory. Schwab and Cunnings (126) in their review of performance and satisfaction theories concluded that there has never been a full replication of Herzberg's research. Lawler and Porter (78) also showed that the relationship between satisfaction and productivity, as advanced by Herzberg, is only correlational and is not necessarily an indication of causality. Apart form this criticism, there are sampling problems with Bocherding's methodology. It appears that he depended only on the total number of operatives responding to his questionnaire without considering basic random sampling techniques in statistics. Consequently, his conclusions are not necessarily valid for the construction setting. These criticisms apart, the studies have made significant contributions to the understanding of construction motivation.

Table 4.1 Comparison of Motivation Ranking in U.K. and Nigeria

Theoretical Ranking (After Maslow)	U.K Operative Ranking (Wilson and Harris)	Nigerian Operative Ranking (Olomolaiye and Ogunlana)
Physiological Needs		
Earnings Related (Fringe Benefits)	3rd	1st
Safety Needs		
Physical / Safety / Working conditions	1st	6th
Welfare conditions	2nd	-
Job Security	11th	4th
Belonging Needs		
Good relationship with mates	4th	2nd
Good orientation programme	4th	8th
Good supervision	8th	9th
Needs for Esteem		
Recognition on the job	7th	5th
Need for Self Actualisation		
Challenging job	9th	3rd
Participation in decision making	6th	7th

4.3.2.1.1. Satisfaction.

From a survey of 650 construction operatives with 1- 5 hr interviews, Borcherding and Oglesby (16) found that productive jobs often created high job satisfaction, while non productive jobs produced dissatisfaction for the client, the professionals and the operatives involved. From this the hypothesis that "satisfaction comes about because each workman was, through his individual efforts, producing a highly visible physical structure, in effect, construction on the site appeared to have a built-in 'super-ordinate goal' " was developed (16). Thus, satisfaction resulted if the work was going well; dissatisfaction arose when production was thwarted by poor management such as errors in planning, scheduling or materials procurement.

Job satisfiers

Borcherding and Oglesby asked the 650 workers to identify what satisfied them in their jobs. Being an exploratory study an unstructured open-ended approach was taken. This makes it rather difficult to know the relative importance of the workers' responses. However, it is possible, from their tabulated responses, to obtain a rough idea of the overall rankings of the different satisfiers, see Table 4.2. The rankings are not very useful because the primary data concentrated on individuals considered to be highly productive by their respective companies. This group cannot give a true representation of satisfiers as they are extreme and their being selected could have influenced their answers.

Table 4.2 Rank Ordering of Job Satisfiers

Satisfiers	Ranking By:				
	Owners	Managers	Superintendent	Foremen	Operatives
Job making a profit	1st	1st	-	-	-
Satisfied Customer	2nd	3rd	-	-	-
Job completed on schedule	3rd	-	-	-	-
Tangible physical structure	4th	5th	-	4th	3rd
Good workmanship	5th	2nd	2rd	3rd	1st
Owner satisfied	-	3rd	-	-	-
Good working relationship	-	4th	5th	5th	-
Maintain the job	-	-	1st	-	-
Meeting a challenge	-	-	2nd	-	-
Job costs below estimate	-	-	4th	-	-
Challenge of running the work	-	-	-	1st	-
Maintain the job schedule	-	-	-	2nd	-
Productive day	-	-	-	-	2nd
Social work relation	-	-	-	-	4th

Adapted from (16)

A question often raised is - Why survey people who have never been satisfied in their work? But we may respond - Why survey only the most productive or the most satisfied set of operatives ? Random sampling is statistically more justifiable. To increase job satisfaction Borcherding and Oglesby (16) suggested a wholistic approach encompassing all the participants in the construction process. Listed in Table 4.3 are their recommendations for each participant.

Table 4.3 Recommendations on Increasing Job Satisfaction

Participants	Recommendations
Owners and Project Managers	Timely feedback Plan rather than restructure job content Beware of change orders Ensure good workmanship Identify with the goal of a built structure
Superintendents and Foremen	Be aware of the effects of challenging work in decision making Effective field planning and management support Share cost information Identify with the goal of a built structure Develop good crew relations
Operatives	Task accomplishment. Identify with the goal of a built structure. Maintaining good crew relations.

Adapted from (16)

Maloney and McFillen (94) examined operative satisfaction more scientifically using a random sample of unionised construction workers. Instead of the open ended unstructured interviews by Borcherding and Oglesby, they had a structured questionnaire listing some job related factors to which the workers were asked to indicate their level of importance and their own satisfaction with each factor, see Table 4.4.

Table 4.4 Factor Scale Rankings of Job Outcomes of 703 workers in Different Construction Trades.

Job Outcomes	Importance	Satisfaction
Intrinsic rewards	1st	4th
Opportunity	7th	7th
Interpersonal rewards	6th	3rd
Feedback	3rd	5th
Supervision	5th	6th
Performance level	2nd	1st
Extrinsic rewards	3rd	2nd

Adapted from (94)

The most important set of factors were those relating to the intrinsic nature of the work such as working like a craftsman or performing challenging work. The set of factors with which the workers were most satisfied was that of performance level , such as high productivity, good quality and doing work in a craftsmanlike manner. Their findings are almost in perfect agreement with Borcherding and Oglesby's work - a strong indication that intrinsic factors make the greatest contribution to workers' satisfaction.

4.3.2.1.2 Job Dissatisfaction

In the same fashion, but on premise that factors bringing job dissatisfaction are not the exact opposite of satisfiers, Borcherding and Oglesby (17) established the job-dissatisifiers as presented in Table 4.5. They also recommended different measures to reduce or remove the causes of dissatisfaction. They further emphasised that being dissatisfied does not necessarily mean that individuals will reduce their efforts; but personal relationships are usually strained and communication may suffer. To improve personal relationships it is, therefore, necessary to concentrate on eliminating factors contributing to the dissatisfaction of crews.

Table 4.5 **Job Dissatisfaction Factors**

Participants	Job Dissatisfiers
Owners:	Dealing with labour unions Company making mistakes Customers discontent with work done Customers not paying or not collecting work on time
Project Managers:	Company making mistakes Inability to maintain schedule Unpleasant working relationships Poor workmanship
Superintendents:	Lack of coordination between the supervisory personnel Subcontractors not meeting schedule Unions Unproductive operatives
Foremen:	Unqualified and unproductive workmen Uncooperative attitudes of some workers Poor working arrangements Jurisdictional disputes with the trades Poor managerial support from own company
Operatives:	Mainly poor interpersonal working relations Poor workmanship The task allocated

Adapted from (17)

4.3.3 Motivating and Demotivating Influences

Borcherding and Garner (15) identified different motivating and demotivating influences for construction operatives from 12 sites in the U.S.. As this study, unlike Mackenzie and Harris (88) or Olomolaiye and Ogunlana (109), did not rank these factors, it is difficult to know their relative importance. The following general conclusions were made by Borcherding and Garner.

- Construction work contains some inherent intrinsic motivators. To motivate workers, the management should provide a congenial working climate for motivators, such as the work itself, feelings of accomplishment by the worker and recognition for effort.
- Remuneration is a lower level motivator and should not be treated as a prime motivator.
- The chief demotivators are frustration and lack of accomplishment . They demoralise.
- Demotivators can be easily removed because they are mostly from trivial sources.
- All recommendations for improving productivity often relate to the provision of adequate support to operatives and encouraging cooperation between everyone involved in the construction process. One great asset is participation by everyone in the decision making process.

4.3.4 Participative Decision Making.

Schrader (125) observed the impact of the concept of participative decision making and made suggestions for the construction industry without any empirical validation. Borcherding (14) tested it within the construction environment. The organisational behaviourist, Vroom (140), observed that participation makes an individual feel that the group's decisions are his own and tries his best to make it succeed. In general, workers are suspicious of new techniques introduced by management. They often cooperate when the direct supervisor is around and revert to their old ways when he is not. Borcherding found that on large construction projects there is evidence of this concept in practice. His study showed that foremen have considerable responsibility on decision making but often take it for granted. However, their feelings of achievement often come from the fact that there are few restrictions placed on their authourity to make decisions. He also found that operatives are more effective when charged with individual responsibility for the methods employed. Being able to accomplish tasks in which their ideas are included result in feeling of achievement which is the operatives' greatest source of job satisfaction. With the absence of elaborate 'suggestion box' schemes or participative decision making programmes on the sites studied, Borcherding rightly concluded that the construction industry may be the only industry where the actual challenge of the working environment causes participation by the operatives in the decision making process rather than as a designed scheme to improve production. Considering its importance to operative motivation, Borcherding suggested that it should be allowed to flourish by encouraging the operatives more.

4.3.5 Construction Operative Motivation and Performance.

Maloney and Mcfillen (93) rightly hold that the first step in developing a theory of construction operative motivation is through a good understanding of the relationship between motivation and performance. With the opinion that the expectancy model is of great relevance in explaining construction operative motivation (an opinion presented in a discussion by Laufer and Jenkins (77)) they conducted a survey of 703 unionised operatives using the model. They found, amongst other things, that:

i) the quantity and quality of performance were strongly but not perfectly related ($r=0.37$, $p < 0.0001$),
ii) effort was strongly correlated with quantity of performance ($r=0.35$, $p < 0.0001$),

iii) expectancy was highly related to effort ($r=0.33$, $p<0.0001$), quantity of performance ($r=0.35$, $p<0.0001$) and quality of performance ($r=0.36$, $p <0.0001$), and

iv) expectancy and effort were significantly related to the degree of job clarity present in the job.

Most of the relationships anticipated by expectancy theory were generally supported by this study. This leaves open to question the assumption that the construction operative is significantly different to other workers. Nothing new is revealed by this study to justify a separate theory of construction operative motivation. It perfectly conforms with the norm because it was a self evaluating exercise. One of the variables should, in the least, have been independently measured, e.g. quantity could have been measured in output terms and quality of performance assessed by supervisor rating. There is often an inherent bias for upward adjustment of performance in self measures, which makes it impossible to possess lower variance than would be true with objective measures. Maloney and Mcfillen's work is invalidated and cannot be used as a basis for developing any true theory of construction motivation. They, however, point out the need for the construction industry to devote serious attention to determining the relationship between motivation and performance. This view was also reinforced by Pullan (121).

4.3.5 Job Characteristics.

In the same fashion as their application of the expectancy model to the construction setting, Maloney and Mcfillen (92) applied Hackman and Oldham's (53) job characteristics model to the construction operative. The main argument in the model is that there are some "moderating variables" of "core job characteristics" which affect the reactions of workers to their jobs with great effects on workers' motivation to perform and be satisfied. Although their study was largely exploratory, they came up with some interesting findings:

i) there are statistically significant differences in skill variety, autonomy and feedback in construction trades;

ii) construction workers do not see their jobs as being enriched contrary to Borcherding's findings;

iii) motivating potentials do not vary with the degree of skill among construction operative;

iv) motivating potentials are low in construction; and

v) there is the need to restructure jobs to improve their motivating potential.

These conclusions contradict the established notion that construction jobs are enriched. Could this be because the sample was based on unionised workers ? Further investigation is necessary to know the true situation.

4.3.6 Financial Incentives.

The foregoing discussions on motivation are of the modern systematic approach of the behaviourists to the subject of human motivation. The classical thoughts on human motivation championed, by Adam Smith (129), hold money to be the chief motivator of operatives performance. Adam Smith believes that :

> "Workmen........when they are liberally paid by piece are very apt to overwork themselves and to ruin their health and constitution in a few years...... the desire for greater gain frequently prompted them to overwork themselves and to hurt their health by excessive work."

This classical view is well echoed in construction operative motivation studies in Price's (120) evaluation of the impact of the level of pay on concretors' productivity. For instance he found that for concretors wage level is a domineering motivator in improving productivity. He also indicated a number of other factors that motivate this set of workers.

This classical line of thought has been repeatedly dismissed by the modern school as being an inadequate representation of human complexities, hence their approaches which firmly dominate American literature on construction operative motivation. Apart from the domination by the modern movement in U.S. motivation thought, the extent of unionism in the industry, which forbids any form of financial incentive to its members, restricts U.S. construction researchers in the examination of this alternative to stimulating workers' performance. Some American construction researchers have advocated the adoption of financial incentives as performance stimulators. Schrader (125), for example, cited several examples where financial incentives helped to improve performance on some American sites. In a survey of 37 top productivity experts in the U.S. on the benefit of Financial Incentive Programmes (FIP) to the U.S construction industry, Laufer and Borcherding (76) concluded that FIP can both shorten construction time and increase the earnings of the workers.

The construction industry in many other countries, especially Britain, has over the years believed in the efficiency of FIP as a virile alternative to the highly theoretical approaches to motivation in the U.S.. Several studies (4, 28, 36) describe how FIP have been effectively employed in the U.K.. Marriot (96) compared construction labour expenditure under fixed wage payments with FIP, producing results of up to 15% man-hour savings under FIP. Another study showed that average production output jumped by 34% when FIP was introduced (66).

The most common form of financial incentive scheme in U.K. is the 'hours-saved' scheme. In this scheme, target output (in manhour) are set for each item of work. At the end of the week the cash value of the difference between the manhour value of the work done and the actual hours expended is distributed to the operatives as bonus - basic pay having been paid in accordance with the working rule agreement. There are different versions of this 'hour saved' scheme:

i) fair target, low pay for hours saved;

ii) difficult target, handsome pay for hours saved;

iii) straight forward piece work;

iv) mixture of bonus scheme and piece work; and

v) job - and - finish, e.g for large concrete pours.

Oxley (115) identified the following as the basic principles of good FIP.

i) The amount of bonus paid to the operative should be in direct proportion to the time saved with no upper limit to the amount that can be earned.

ii) Targets should be known to the workers before work commences. The targets should be in 'packages' that can be completed on time by the operatives.

iii) Targets should not be altered during the course of the operation.

iv) The operatives should know how the bonus is calculated.

v) Arrangements should be made to cover lost time outside the control of the operatives, e.g. equipment breakdown.

vi) Bonuses should be paid regularly.

But do incentives really work? Neale (108), much in line with Herzberg's description of wages as a traditional KITA which only 'move', argued that financial incentives work only when newly introduced because workers are excited on its introduction. This excitement wanes off with workers asking for more over a period of time. It has become an annual ritual for workers to ask for wage/salary increases. Another factor, that does not make financial incentives to work, claims Neale, is the welfarism in Britain where wages can be 'topped' up by the government if the worker does not earn enough to keep himself. He also questioned the basis of the target output as being unrealistic and in most cases just guesses.

Another problem in operating incentive schemes is how to deal with situations where the operatives are held up for reasons outside their control (115). What do you pay them ? Some firms pay them 'average' bonus based on past performance, some pay a fixed standard bonus or pay for the time at normal hourly rate. But are these fair or equitable ? Bonus has become more or less part of the workers' wages in most firms with some paid even when they have not done any thing to justify it. In a random telephone survey of some firms in the East Midlands, it was found that 92% of the firms have changed or updated their FIP more than six times since inception averaging once every two years. They seem to agree with Neale that most of the programmes work only at inception - they are KITA, not motivators.

4.4. Summary

1. Construction management researchers are coming to grasp with the motivation subject; but not as enthusiastic as general management researchers.
2. Although they all agree that the construction operative is different in a number of ways to the manufacturing worker, on whom most of the general theories are based, they have made no attempt at formulating a theory of construction operative motivation. There is no valid theory of construction operative motivation.
3. While Maloney and Mcfillen have used the expectancy theory to explain significant relationships between motivation and performance, their self evaluating technique for measuring both variables, i.e. performance and motivation, does not give much confidence in the relationship established.
4. There are no specific measures of motivation for the construction operative and the social scientists use highly theoretical measures which are not easily adaptable to the construction industry.
5. No existing theory fully explains the construction operative.

CHAPTER 5

CHAPTER 5

PROCEDURE FOR EVALUATING BRICKLAYERS' MOTIVATION AND PRODUCTIVITY

5.1 Introduction

The last three chapters have brought about an understanding of construction productivity and motivation. Based on the literature findings in these three chapters, we shall build up a statement of the hypothesis on which this dissertation rests. We shall also discuss the experimental procedures and the techniques adopted for establishing the relationship between the concepts of motivation and productivity. Other specific areas of research, reasons and the subsequent data analysis procedure are all discussed in this chapter. We start with the statement of the hypothesis for this work.

5.2 Statement of the Hypothesis

In chapter 2, it was concluded that the concept of productivity, though well understood, suffers from both definitional and measurement problems. The measurement problem is globally more acute when measuring total factor productivity. Labour was singled out as the most popular factor in productivity research and the only factor of production which has conscious control on its contribution to the production process. It was also found that there has been an upward trend in overall construction productivity, however, the forecast is that the industry is about witnessing a downward trend.

In chapters 3 and 4 the concept of motivation was brought to light as having deep psychological foundations and is currently one of the most researched topics in general management. The literature review revealed that there is no agreed hierarchy of influences on construction operatives' motivation. There is no validated theory of operative motivation in the construction industry. The industry's employment and operational patterns are different from manufacturing industry where most existing theories of motivation originate. An enduring problem in motivation studies is the measurement problem. It is possibly this measurement problem that makes it rather difficult for construction managers, with their quantitative engineering background, to appreciate motivation as a necessary ingredient in their management style. Once this measurement problem is resolved and the relationship between motivation and productivity is scientifically proved, motivation can become the necessary impetus for improving construction operatives' productivity.

Apart from the measurement problems in motivation studies there is apparent confusion in the understanding of motives energising construction operatives. While some have emphasised financial incentives as predominant motivators in construction, others have claimed that money is not a motivator and support Herzberg's view on job enrichment. In view of this apparent confusion, this thesis hypothesises that operative motivation is a melting pot of numerous motivating and demotivating influences; prepotency is difficult to substantiate as one factor juxtaposes with others. When prepotency or level of importance is substantiated it is only time dependent. The general economic bouyancy at a particular time can produce different ranking of motivational variables from other times.

Productivity has been earlier described as a multivariate function. Seen in the light of the predominance of motivation in this dissertation, it would be erroneous to perceive motivation as all that the management needs to boost construction operatives' productivity. As earlier discussed, skill is another important factor. Skill depends much on training, experience and the natural ability of the operative. An operative's skill is often reflected in how fast he is able to go through all the elements of the process needed for the desired end product. If workers' skill is assessed in light of time for performance over a specified standard quality, and motivation too is assessed, the two main elements of operatives' productivity would have been determined. It should then be possible to predict productivity from the knowledge of these main variables in the multivariate function. The second hypothesis in this thesis is that it is possible to predict productivity in construction operations from the knowledge of the relationship between the main controlling variables. To prove this, some experimental procedure is necessary. But first, which construction operation is most suitable for proving these hypotheses ?

5.3 Which Construction Operation ?

It is not possible to cover every construction operation in a research such as this. First, not every construction operation will fit the 'bill' of the hypothesis above. The hypothesis demands a trade/craft in which both skill and motivation are expressible. Secondly, it is not feasible to cover all operations because of finance and other practical purposes. The research therefore focusses on bricklaying operations.

The decision to focus on bricklaying in preference to other trades lies in the predominance of bricks as one of the main construction materials in the U.K.. Being cheaper to produce it is being introduced into house construction as a substitute for sandcrete blocks in the author's country. Its study is therefore mutually beneficial to the two sponsoring organisations. Apart from this, a bulk of construction manpower goes into bricklaying as it remains highly labour intensive. Coupled with this, the apparent rigidity of bricklayers in adjusting or changing to proven, more productive methods developed by the Building Research Station (148) makes it imperative to examine their much loved method with a view to improving their productivity using the same method via motivation. It is believed that a predictive model of productivity in any construction operation could have detected the current skill shortage (139) at an earlier stage and knowing the main variables, could have helped training instructors in knowing the main areas of concentration in training new recruits. With the gradual introduction of robots into construction, bricklaying is likely to be one of its early 'captives' because of its definable motions to which a machine can easily be adapted. It is therefore reasonable to want to know the optimal capacity of bricklayers and the cost of employing them vis a vis the possible advantage of robots in this important construction operation. If motivation and productivity in bricklaying are quantified, then it would be possible to relate them in form of a mathematical model which could be used to predict productivity for future works.

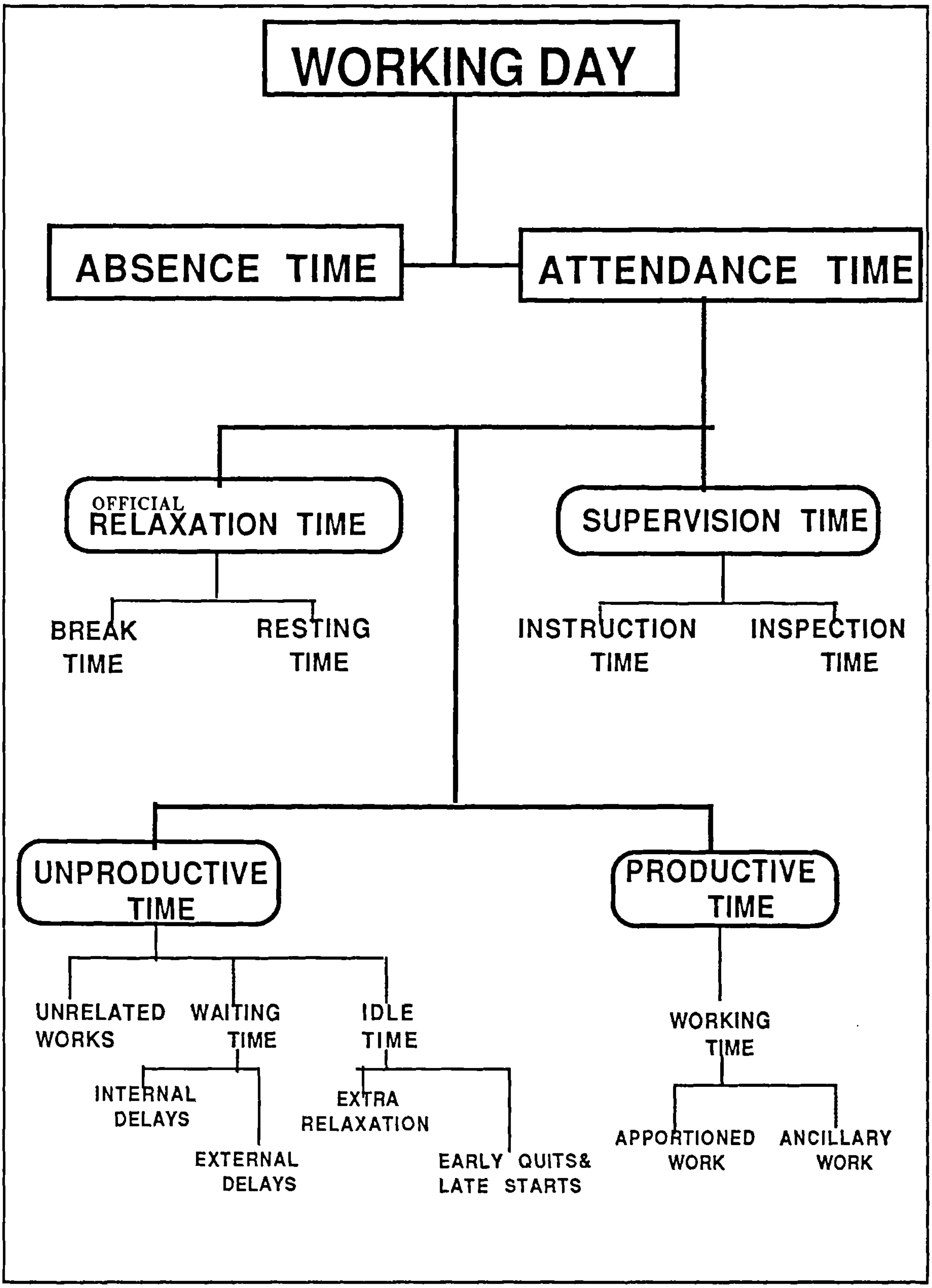
5.4 Experimental Procedure.

A model can be simply defined as an imitation of a real life situation which makes it possible to reproduce the life situation, assuming all things are equal. To construct a model, it is therefore necessary to know how the real life situation works, i.e. how a bricklayer works on site in a working day. To do this one needs to record what he does, how he does it and probably why he does it in particular way or rate. This will provide a detailed account of how he spends his working day and the production level attained (or attainable) at the end of the day. We are essentially set to know how he spends his working day in order to be able to predict him for future work. In this research, we need to examine in detail the components of the working day, quantify productivity and motivation in different environments. Let us first examine the components of the working day.

5.4.1 Definition and Classification of a Construction Working Day.

BS 3138: 1979 (20) defines a working day/week as "the normal daily or weekly hours as agreed in the local situation or within the industry and beyond which overtime may be payable". There are usually official breaks for relaxation. Figure 5.1 shows further classification of this working day as adopted in this research.

Figure 5.1 Classification of Construction Working Day



The construction working day is initially divided into two broad groups - ABSENCE TIME and ATTENDANCE TIME. Absence time is any period when a worker is absent from work during the normal working day or week. Attendance time is the total time spent by a worker at the place of employment, whether working or not, for which payment is made. The Attendance Time is further classified into Relaxation Time (official break plus allowable physiological relaxation when working), Supervision Time (time spent taking instructions or inspection delays), Productive Time (time spent working on apportioned and ancillary work), and Unproductive Time (time spent not working or doing unrelated works).

5.4.1.1 Productive Activities.

The proportions of time spent on the above classified categories will logically affect the production levels of every bricklayer and gang on different construction sites. Depending on the time regularly spent in these categories, it is possible to predict their productivity. But this will be a grossly inadequate prediction of a system that depends on so many subclasses of these main classification. This inadequacy will further be reflected in that productivity is not only time dependent, i.e. the amount of time spent productively in a working day cannot be equated to a certain level of output because of variations in skill; skill is a main determinant of how much can be produced over a period of time. To bring the impact of skill into the construction of the model it is, therefore, essential to break down the productive time into the main component elements and determine how time is spent on these elements in order to detect the skill factor in the determination of output within a productive time. The productive time has been classified into nine separate activities to reflect the main motions in bricklaying. Table 5.1 describes these elements.

It should be noted that these activities cover the cycle in bricklaying in any part of the building; whether they are facing or rough works. This classification can be expanded or contracted depending on the investigator. It has been adopted in order to focus the main turning points in the bricklaying cycle (44).

The physiological relaxation cycle should develop into a rhythm which measures the skill of the bricklayer depending on how fast he's able to finish a cycle, start and finish another and so on. His speed and ability to skip some of these activities determines his output at the end of the working day. However, other factors apart from relaxation, break the rhythm and result in unproductive time for the worker.

Table 5.1 Productive Activities in Bricklaying

Code	Productive Activities	Descriptions
1	Spreading Mortar	Spreading mortar on the wall or course in preparation for laying bricks.
2.	Fetching Mortar	Collecting mortar with trowel for spreading or buttering bricks to be laid.
3.	Fetching Brick	Taking brick from the stack for buttering, cutting or laying.
4.	Cutting Brick	Getting bricks to actual size needed using a trowel or chisel.
5.	Laying Brick	Positioning and pressing the brick on course including tapping.
6.	Filling Joints	Placing or inserting and compacting mortar into vertical gaps between bricks.
7.	Measuring	Checking distances in line with drawings using tape or any other devise.
8.	Setting and Checking	Setting line for the course or for the next course and the process of checking verticality or horizontality using spirit level or any other devise.
9.	Raking and Pointing	Removing excess mortar from joints using a trowel or pointing (depending on design) using pointing bars.

5.4.1.2 Unproductive Activities.

Different factors account for the unproductive time in a working day. Some of these are innate while others can be physically accounted for. Usually the innate factors are reflected in the physical factors. There may be a lack of essential production resources which may result in the bricklayer waiting for materials, or the worker may be simply idle even though the work and resources are available. The different reasons for this have been explained in literature (111, 127) as low wage levels, unfriendly working atmosphere, unbalanced distribution of resources, interference between gangs and crew members etc.. These deficiencies soon result in operative frustration and bring into focus the question of motivation. The motivation element is brought into better focus in a later section of this chapter.

Table 5.2 is produced to describe each unproductive activity; in line with the pattern in Table 5.1. The unproductive activities are many but are quite distinct from one another. It is essential that the elements of unproductive time are broken down in detail in order to avoid the problem of confusing classification of activities when observing workers on different sites. This classification of the unproductive portion of the working day was adopted for the study after a pilot study of bricklayers on seven sites in Nigeria (109). They adequately cover the unproductive portion of the working day.

A problem of classifying activities on construction sites into productive or unproductive arises with activities such as Instruction and Inspection delays (Supervision Time), which though not contributing to the physical output would affect the utilisation of the productive time. The problem is knowing when an inspection or instruction time becomes unproductive or the

Table 5.2 **Unproductive Activities in Bricklaying**

Code	Unproductive Activities	Description
10.	Instruction and Inspection	Taking instructions from the supervisor or interruptions during supervisor's inspection. These may also be from mates.
11.	Idle and Away	Operative not working while work is available or not on plot for no obvious reasons.
12.	Relaxation	Apparent relaxation for necessary physiological fatigue
13.	Waiting	Waiting by the operative for materials, tools or due to interference by another crew.
14.	Searching	Looking for misplaced tools or any other necessary equipment for implementing the task at hand.
15.	Rework	Removing and replacing already completed work due to either operative's or management's fault.
16.	Confused	Undecided or abrupt stoppage of work sometimes followed by consultation.
17.	Ancillary work	Doing works relevant to bricklaying such as fixing lintels, windows, doors, anchors, thermal insulations, setting platforms etc..
18.	Other works	Doing works not directly relevant to the bricklaying process to which the bricklayer was not initially assigned to.
19.	Drive dumper	Usually by the labourer but also done by bricklayers for collecting and distributing materials.
20.	Operate mixer	Ditto. To mix mortar including loading the mixer with sand and cement.
21.	Climb	Climbing to or from distributing materials.
22.	Distribute brick or mortar	Distribution of mortar unto mortar boards using shovel, bucket or wheel barrow and distributing bricks into stacks between mortar boards on the platform.
23.	Fetching	Fetching bricks or mortar from depot or mixer for distribution and fetching tools for or by operatives
24.	Cleaning	Washing the mixer, removing excess mortar, broken pieces of bricks and other things usually by the labourer at the end of the working day.
25.	Read drawing	Checking drawings for necessary details before or during setting.

degree of its contribution to output. Another activity which poses some problem is ancillary activity which is indirectly or futuristically related to productivity. We shall, however, stick to these classification at this stage of the work envisaging that if these activities are found to have significant relationship with output as presently designed, we shall have to further clarrify their definitions and classification before further analysis.

5.4.2 Activity Sampling.

Building a model of the relationship between motivation and productivity in bricklaying becomes less arduous with the choice of an adequate technique to record how bricklayers spend their working day. Different methods have been developed or adopted for this by construction researchers and companies alike. These include techniques such as the Craftsmen Survey (22), Foreman Delay Survey (32), Time-Lapse Photography (32), Videotape Recording (118,119,149,151), Snap Observation and Work Study. Whitehead et.al. (150) discussed the advantages and disadvantages in using each of these methods. While they criticised the work study techniques of time study and activity sampling for the quantity of data generated, our hypothesis demands a large amount of data for a statistically significant relationship between our variables to be proved or disproved. Work study is therefore more relevant to this work.

Of the work study techniques, activity or work sampling is the most appropriate in that it offers an observation and recording of what the worker is doing at regular time intervals throughout the working day. The activity sampling technique is well suited for evaluating productivity in construction operations. The use of activity sampling in construction productivity research has been justified by Duff (30,31).

Activity sampling works on statistical principles of accuracy (See Appendix E). It is possible to know the number of observations that are necessary to achieve the required confidence level in the collected data by using the formula (55):

$$N = \frac{Z^2 \times P \times (1\text{-}P)}{L^2}$$

Where N = number of observations required, P = percentage of activity observed (from pilot study), L = Limit (%) of accuracy required, and Z = value obtained from statistical tables depending upon the level of confidence required for the estimate (usually taken as 2, which corresponds to 95% confidence).

A 95% confidence level was considered adequate for this study. The main problem with using this technique is that watching a worker working in a defined pattern on a particular day does not mean that he will repeat that pattern every day. To safeguard against this, observations were taken over three days, randomly chosen, within the period the author was on that site, for every bricklayer taking part in this study. Although this does not totally remove the doubt due to the worker varying his working pattern daily, it boosts confidence in the data.

As earlier mentioned, activity sampling often presents enormous difficulties in data recording and analysis. To ease both problems, a computer program in BASIC language was written as part of a research project at Loughborough University, sponsored by the SERC (56). This programme was of great help in recording work study data. The workers were fascinated with the use of computers in their place of work and did not offer much of the expected traditional resistance to work study on sites.

Apart from the help at the data collection stage, the programme is not of much use in the data analysis stage. This is because it provides a rather narrow approach to production analysis with little avenue for statistical verification. Since there are more sophisticated statistical packages around, it would have been better if the activity sampling data collection programme had been connected to a data base from which it would be easier to use existing statistical packages for analysis.

5.4.3 Quantifying Motivation.

In chapter 3 we discussed how motivation has developed in both psychology and management. Traditionally, motivation was restricted to the study of behaviour and later emphasis was not only on understanding behaviour but on knowing the instigating forces behind behaviour. Today, emphasis in psychology is on the roles of these forces in predicting future actions in similar circumstances. The study of motivation in management is not less theoretical but more practical, pinpointing what these instigating forces/variables are. Different management theories relate these variables together. As earlier mentioned, a major omission in management literature is a proof of the relationship between these forces and performance. A combination of the theoretical formulations by psychologists and the variables identified by management form the basis of the quantifying technique used in this research.

James (68) and Freud (45), as earlier stated, recognised that an analysis of the mind of individuals is an impossible task but believed that it was possible to observe what individuals do or say. It is therefore the norm in behavioural studies to base inferences and subsequent judgement on what individuals say or do. Different subjective techniques for measuring behavioural patterns have been devised by human scientists to quantify innate human variables. The Michigan Organisational Assessment Package (103) exemplifies the subjective measurement techniques in the social sciences.

Let us now take a second look at Newman and Morganen (7) subjective equation of motivation.

$$SEU = P_1U_1 + P_2U_2 \ldots\ldots P_nU_n$$

It was earlier stated that the strength of SEU should be equivalent to the summation of the degree of probability of the different motivational tedencies in an individual. This forms the basis of the Expectancy theory. On this basis, let us interprete SEU as a measure of the total motivation content in an individual at a particular time and in an environment.

The strength of each component of motivation depends on the product of the subjective probability (P) of that variable and the subjective value (U) of that component. Our discussion of the different motivation theories gave us a broad spectrum of what these constituting variables are. Table 3 shows the list of motivating and demotivating variables identified by first asking the workers about their satisfiers and dissatisfiers and then highlighting those that can motivate or demotivate. This is explained in more detail in Chapter 7.

Borrowing a leaf from the Michigan Organisational Assessment Rating Techniques (19), P and U in the above equation were assessed in four and three rating zones respectively. For both P and U, an operative has maximum score of 12, i.e. 4 X 3. If in a particular variable an operative rated P with high value (4) and U with a medium value (2), his total score in the variable would be 8. This is converted into relative index by dividing this score by the total score obtainable; very high (4) x high (3) which is 12. The relative index for this operative will therefore be 8 divided by 12 which is 0.66.

Table 5.3 : Motivating and Demotivating Variables Used For Data Collection

Motivating Variables	Demotivating Variables
Good Relations with mates	Disrespect by Supervisor
Good Safety Programme	Little Accomplishment
The Work Itself	Discontinuity of Work
Overtime	Non-recognition
Level of Pay	Underutilisation of Skill
Recognition on the Job	Incompetent Workmate
Accurate Description of Work	Uncooperating Mate
Participation in Decision making	Poor Inspection Programme
Good Supervision	Unsafe Conditions
Promotion	Hot Weather
More Responsibility	Cold Weather
Challenging Task	Too much work
Job Security	Not enough work
Choosing Workmates	
Bonus	

A simple addition of the scores in each variable is indicative of an operative's motivation content at that time and in that environment. However, because not all the variables identified will be relevant to every operative, a relative **motivation index** was devised; in which an operative's total score is converted to a proportion of achievable score in his relevant variables, see example in Table 5.4.

Since we construe motivation not only as a function of motivating variables but also demotivating variables, a relative **demotivation index** was devised for each operative following the same quantifying procedure just described. An index of total motivation, the **total motivation index,** is derived by deducting the demotivation index from the motivation index. In mathematical terms the total motivation in an operative can be expressed as:

$$\text{Total Motivation} = \frac{\sum_{i=1}^{N_m} P_i^m U_i^m}{P_{max}^m \times U_{max}^m \times N_m} - \frac{\sum_{q=1}^{N_d} P_q^d U_q^d}{P_{max}^d \times U_{max}^d \times N_d}$$

Where:

P^m	=	Importance ratings of each motivating variable
U^m	=	Gratification ratings of each motivating variable
P^d	=	Importance ratings of each demotivating variable
U^d	=	Gratification ratings of each demotivating variable
P_{max}	=	Maximum importance rating
U_{max}	=	Maximum gratification rating
N_m	=	Number of relevant motivating variables
N_d	=	Number of relevant demotivating variables

Each of the indices above (motivating index, demotivating index and total motivation index) have values ranging from 0 to 1. Because these indices are proportions, comparative analysis becomes easy. These indices originate from an interval scale (i.e. no true zero) which have been found adequate in analysing psychological variables (89). Baker et.al. have shown that statistics used in analysing psychological variables, even, when computed on distribution of non interval data yields essentially the same decision as statistics on distribution of interval data (9).

This measuring technique is a logical extension of psychology and management literature into quantifying construction operative motivation. The technique is in-built with both the time and environmental features of motivation. To assess the validity of this model, it was tested with 123 construction operatives in Nigeria and was found to be adequate for wider

Table 5.4 Quantifying Motivation - An Example

Motivation Varaiables	Pi	Ui	PiUi	Demotivating Variables	Pq	Uq	PqUq
Good Relations with mates	3	4	12	Disrespect by Supervisor	3	1	3
Good Safety Programme	3	2	6	Little Accomplishment	3	2	6
The Work Itself	3	2	6	Discontinuity of Work	2	4	8
Overtime	1	2	2	Non recognition of Effort	2	1	2
Level of Pay	3	2	6	Underutilisation of Skill	3	3	9
Recognition on then job	3	1	3	Incompetent Workmate	3	1	3
Accurate Description	2	2	4	Uncooperating Mate	3	1	3
Participation in Decision	3	3	9	Poor Inspection Programme	3	1	3
Good Supervision	3	2	6	Unsafe Conditions	2	1	2
Promotion	-	-	-	Hot Weather	2	1	2
More Responsibility	2	2	4	Cold Weather	3	1	3
Challenging Task	3	3	9	Too much work	-	-	-
Job Security	1	1	1	Not enough work	-	-	-
Choosing Workmates	3	2	6				
Bonus	1	1	1				

$$\sum P_i U_i = 75 \qquad \sum P_q U_q = 44$$

Total Summation of PiUi attainable =
Number of Relevant Motivators x 3 x 4 = 14 x 3 x 4 = 168
Total Summation of PqUq attainable =
Number of Relevant Demotivators x 3 x 4 = 11 x 3 x 4 =132

$$\textbf{Motivation Index} = \frac{\text{Attained Summation of PiUi}}{\text{Attainable Summation PiUi}} = \frac{72}{168} = 0.43$$

$$\textbf{Demotivation Index} = \frac{\text{Attained Summation of PqUq}}{\text{Attainable Summation of PqUq}} = \frac{44}{132} = 0.33$$

Total Motivation = Motivation Index -Demotivation Index = 0.76

application in this research (109). See Table 5.4 for an example of the above described quantitative technique used to measure motivation in one hypothetical bricklayer.

5.4.4 Questionnaire Survey

While activity sampling helped to collect data on how time was spent on site, the technique used to collect data on motivation influences was a structured questionnaire survey. A questionnaire (see Appendix B) was designed to evaluate the entire construction working environment, based on the premise that though motivation factors have been well identified in literature, they are but products of the workers' immediate working environment. It was therefore necessary to evaluate them on particular sites in order to establish their relationship with the productivity. Table 5.5 shows the main question areas. Each question was structured to attract quantifiable responses.

Table 5.5 Questionnaire Survey Synopsis

Question Areas	Number of Questions
Bricklayers' Identity	4
Turnover	2
Nature of Employment	2
Working Hours and Overtime	5
Gang size, group selection and cooperation	4
Supervision	4
Remuneration	5
Motivation and Job satisfaction	3
Productivity problems	3
Increasing Productivity	3
Production output	3

5.4.5 Some Characteristics of Projects Used for Data Collection.

The investigations were carried out on twelve construction sites in England. The sites were operated by construction firms which shall be identified alphabetically for anonymity. The names of these firms are in the acknowledgement. It should be stated that the alphabetical order does not in anyway correspond to the listing of the firms in the acknowledgement. Having said this let us examine some of the significant characteristics of these construction firms and their projects.

5.4.5.1 The Construction Firms.

Eighteen construction firms were selected from the Directory of Building and Civil Engineering contractors for the above described research. They were contacted by letter explaining the aims of this research. Of the eighteen, eleven replied; five willing to participate while six wanted interviews with the investigator. Of these six, four gave final approval. Seven of the nine participating firms were randomly selected for the first part of this investigation while the remaining two were reserved for the testing of the relationship derived from investigating the seven. These firms will be identified as A,B,C,D,E,F,G,H and J respectively.

Contractor A.

Firm A is a long established construction firm with regional offices all over the nation. Quoted on the London Stock Exchange, the company has witnessed economic downturn in recent years which has necessitated an overhauling of the management system. With a workforce of 13000 in the 1970s, this construction firm now employs mainly APTC staffs with operatives' work being subcontracted to 'labour-only' subcontractors. Bricklaying is subcontracted (labour-only) with sites having a site agent, supervisor/general foreman and an office assistant each. The Midlands' regional head office is also the National Headquarters with a bonus department undertaking site measurement and preparation of payment claims for the finance office to settle. Their work-study data which was well documented when workers were directly employed is now only updated or just referenced when considering subcontractors' estimates for new projects. This firm offered a site for investigations in this research.

The site is a speculative housing project (marketed by the marketing arm of the firm). Please see Table 5.6 for details of contract sum, duration etc.. The bricklaying subcontractor had three 2:1 gangs of bricklayers. The project was self financing, i.e. money received from down-payment on sales form a substantial part of the contract sum. The location was a prime site, so there are no sales problems. However, the subcontractor claims that the management is not dynamic, i.e. does not respond quickly enough to challenges on site. Details of site opinions will be discussed in chapter 6.

Contractor B

Contractor B is a regional contractor with a steady growth record. It has grown with work orders for the next two years in Local Council housing and speculative housing in conjunction with a regional Building Society. Although there are other people in the company's board of directors, it is still largely owned by the founder and his family. It has a steady profit growth rate with the speculative arm outperforming other arms of the company. Contractor B offered this research the highest number of sites and gangs for evaluation. See Table 5.6

Contractor B largely operates the traditional construction organisation system with all the trades except joinery and bricklaying directly employed by the contractor. When asked why the company has not joined the "subcontractor craze"; the contracts manager replied that the company has enough work for the workers and is not ready to throw its people , who helped built the firm, into the unemployment market. Keeping them, he claimed, is better since they do not waste time scouting for them. The subcontracting system for bricklaying here works on a very different basis to contractors A and C since the gangs are directly in contract agreement with the contractor - no middlemen. They are normally subcontracted one house at a time at an agreed price for the whole house. On finishing, there is usually some other work for the gang. This has encouraged these gangs to stay longer with this firm.

Table 5.6 : Some Characteristics of Projects Used For Data Collection.

CONTRACTING FIRM	SITES	CONTRACT SUM (£)	CONTRACT DURATION	TYPE OF WORK	NO. OF GANGS	NUMBER OF OPERATIVES Skilled	Labour
A	A1	2500000	42	Specl. Housing	3	6	3
B	B1	1418923	34	Contr. Housing	3	6	3
	B2	1217194	29	Contr. Housing	3	6	3
	B3	687719	-	Specl. Housing	3	6	3
	B4	3073147	61	Contr. Housing	4	8	4
C	C1	4387848	43	Specl. Housing	2	10	4
	C2	1793185	35	Specl. Housing	3	8	2
D	D1	2145719	53	Contr. Housing	4	8	4
E	E1	375948	31	Contr. Sports F.	3	8	3
F	F1	6300000	12	Contr. Lab.	3	7	3
G	G1	1373694	46	Spec. Housing	6	12	6
	G2	2300000	70	Contr. Police B.	4	8	4

SUMMARY

7 Construction Organisations, 12 Sites, 41 Gangs, 157 Bricklayers, 40 Labourers.

The sites have the same structure - Site Agent, General Foreman and Office Assistant. The site agents supplies the bricklayers with all they need, calling in fixers or concretors from the head office when needed. The job sequencing on these sites is documented in form of charts but the gangs are largely on their own and they plan their work with minimum supervision from the office.

Contractor C.

This is also a national contractor with headquarters in the South East. Quoted on the London Stock Exchange, it is one of the most popular building firms in the financial press. Its financial performance in recent years reflects the boom the industry has been witnessing. This is a highly market oriented company with emphasis, not on site productivity or motivation as we have been developing in this thesis, but more on marketing. The author asked, the managing director of the 'homes' subsidiary of of this firm, a question on site productivity with him replying that " We were interested in these after the war and failed. Our emphasis now is how much the market is ready to pay and how much we are able to get our subcontractors to do it for." All work is subcontracted to two sets of subcontractors - one 'labour-only' the other to supply materials.

This firm allowed the author onto four sites for the investigations in this research. The same management pattern - one site agent co-ordinating all subcontractors with the help of an office assistant - was maintained on all the sites. The subcontractors were not gangs of skilled operatives as in contractor C, but established 'labour-only' contractors who pay a constant rate and have one foreman on each site empowered to recruit and sack as deemed necessary. The gang sizes are not 2:1 but very large 5:2, 8:1 or 10:2 varying daily with rampant absenteeism and changes in crew membership.

Contractor D

This is a national contractor with a midland regional office. The company is quoted on the stock exchange. It has a well established work study department with time estimates and prices on a computer network readily available to the regional offices. Jobs are planned from the different regional offices which charge a particular agent with recruitment of relevant operatives in each project locality. The regional office co-ordinates all projects in each region. This company offered 3 sites in East Midlands for investigations in this dissertation. The site agents employ gangs of bricklayers directly as subcontractors. The sites had general foremen who supervise the subscontractors directly as in traditional project management.

Contractor E.

This is a local but promising contractor with no speculative interest. All projects are on contract with clients around the East Midlands. By virtue of its size, it is much into traditional management with all workers 'on the books'. The sites have a site agent, general foreman and foremen for each trade. Although all are on the books, the management is ready to subcontract 'labour only' to bricklayers who are interested. Two sites were offered and investigated for this dissertation from this firm.

Contractor F.

Also local with the same description as E.

Contractor G.

This is a national contractor with a regional office in the midlands. Much like contractor D; but has particular interests in training new operatives for different trades on its sites. This interest started to wane in 1981 with the growth of subcontracting but it is being revived because of the skill shortage. Training now focusses on top management. This company offered three sites to this research. On the sites, there was the site agent, supervisor and foremen for each trade on site. These foremen supervised the subcontractor gangs with the site agent seeing to the overall smooth running of the site.

5.5 Summary

This chapter has explained the basis of the hypotheses for this research and how the experiments have been carried out in order to understand the analysis in later chapters. Productivity is measured through the scientific work study technique of activity sampling at 95% accuracy for the sites. Although motivation is quite difficult to measure - because of its nature varying with time, environment and personality - a technique to measure it has been devised. It is believed that the measuring techniques aided by statistical analysis will enhance the understanding of the interelationships between the motivation variables and the relationship between motivation and productivity in construction. Let us now go into analysis and discussion of the findings.

CHAPTER 6

CHAPTER 6

AN EVALUATION OF THE BRICKLAYING ENVIRONMENT

6.1 Introduction

Our earlier discussions have identified the working environment as a major determinant of operatives' productivity. Also, the review of motivation theory identified the genetic, formative and social environments as the main determinants of human motivation. The genetic environment is outside the scope of this research. The formative environment is relevant mainly when the operative is being trained or is acquiring the necessary skills. While skill is a major determinant of production output, its contribution depends on both the technological and social environment of the operative. Although individuals' reactions to working environments vary, it is possible from an aggregation of their responses to know their cumulative opinion about that environment in relation to their work. If the operatives' working environment is well understood, it should be possible to understand the motivation variables which that environment influences.

The construction working environment is the construction site. This environment is a product of the organisational response to needs for adequate production resources and the workers' assessment of this response. The workers' assessment of this working environment influences their motivation and consequently their productivity.

One main problem is identifying the variables in the working environment that directly or indirectly affect operatives' productivity. The usual approach is through structured questionnaires in which workers are asked to identify the variables in their working environment influencing their productivity. Borcherding and Sebastian have developed a general Craftsmen Questionnaire Survey Technique to be used in productivity studies on construction operatives (127). This technique has been attracting favourable comments in construction productivity literature (22, 64). A more scientific approach is the activity sampling technique described in the previous chapter. Both techniques were adopted in this research to evaluate the working environment of bricklayers.

Adopting both techniques is considered best because, workers know more about what inhibits them than can be learnt through activity sampling spread over a period of days, but since activity sampling is more objective, a combination of both techniques achieves better results.

6.2 Production Output, Site and Gang Size Relationship

The working environment can be broadly classified into two - the immediate and the very immediate. In the case of the bricklayer, these are the **Site** and the **Gang** in which he is working. These two factors influence operatives' immediate enthusiasm to produce.

The first step in our analysis is to determine which of these two environments influences bricklayers' productivity most. The bricklayers' output, the type of site and the gang size were statistically tested for the 'best' fit variable (i.e. which of the variables, Site or Gang Size, most significantly influenced production outputs in bricklaying). Table 6.1 shows the results of this exercise.

Table 6.1 : **Comparative Analysis of the Influence of Site and Gang Size on Production Output**

Y variate is Production output

	Estimate	S.E.	T
Constant	199.071	38.487	5.17
site 21	158.595	70.267	2.26
site 71	28.554	51.700	0.54
site 72	43.643	66.661	0.65
site 41	345.679	63.823	5.42
site 23	34.929	81.643	0.43
site 24	170.595	70.267	2.43
site 51	37.554	63.823	0.59
site 31	16.151	61.526	0.26
site 11	350.929	91.617	3.83

Analysis of Variance

	DF	SS	
MS			
Regression	10	1230969	123097
Residual	75	1555307	20737
Change	-10	-1230969	123097

Percentage variance accounted for 36.

Site alone accounted for 36.7% of the variance in the data. An F ratio of 5.94 proves that the site is a significant factor in accounting for variation in production output. Although gang size is a contributory factor to variation in output from site to site it is not a significant factor on its own. With a reduced F-ratio the graph of the residuals confirms both gang size and site as jointly significant. The reasons for the significant contribution of the site factor is often traced to the differences in type of work. Since this research tried to minimise the site influence by choosing sites with the same level of technological complexity, the main reason for the difference may have been the actual working environment.

6.3 The Bricklayers' Personality

Having established that site is the most important environmental factor in bricklaying productivity, the workers' reactions to this site environment were evaluated with a view to identifying the salient environmental variables influencing production. Since variations in personality is one of the main factors in human motivation, it is pertinent to first understand those being evaluated. We shall try to identify their personality by evaluating training, experience, age and individual assessment of the working environment and other organisational variables. The data was collected, with the 'open ended' section of the operative questionnaire (Appendix B), either by personal interviews, using the questions, or by the worker answering them at his convenience and posting them back to the author. The operatives were encouraged to give broad responses to the questionnaire.

6.3.1 Employment and Other Characteristics

53% of the operatives were directly employed by 'labour-only' subcontractors, 12% by main subcontractors, 34% by main contractor and 1% work by other arrangements. The percentage distribution varied from site to site. Workers on sites 1, 2 and 8 were all employed by 'labour -only' subcontractors while other sites, except 4 and 9, combined two or more modes of employment, see Table 6.2. In all cases, workers under 'labour-only' contracts were affiliated to the main contractors.

On average, 46% of these men had stayed for two or less years with their present employers, while the majority (54%) have stayed more than two years, reflecting a fairly stable pattern of employment. This may have been due to the high proportion employed by 'labour only' subcontractors. Bricklayers in 'labour only' gangs operated in fairly permanent crews, working together as a team. In such small 'companies', the likelihood of splitting up is low unless there is a major misunderstanding.

51% of the bricklayers were below 30 years in age, which indicates that bricklaying is a young man's trade. It would have been expected that the mean age group would have been 30 to 40 years, in line with the national working population distribution. This situation may be a reflection of, either the desertion of the industry by older men to less hazardous industries or the current drive for trainees. The age distribution on individual sites were not as normally distributed as when all the sites were taken together. Each site had a concentration of certain age groups. For example, while sites 1,2,3 and 12 had middle aged men, sites 5, 6, 7 and 10 had young men. We may therefore infer that bricklayers work on sites where they can relate to people of their own age group.

Age distribution appeared to have direct effect on stability of employment. Younger bricklayers changed gang or direct employer quite frequently. For example, site 1 operated a 'labour only' subcontracting system, 75% of its workers were above 30 years of age and have been together for 10 to 20 years. Although Site 2 operated the same 'labour only' system, 80% of the operatives were below 30 years of age, and 80% of them had been together for less than two years!.

49% of the bricklayers in this research were trained through an apprenticeship scheme. This figure corresponds to the 49% above 30 years of age. The newly skilled bricklayers were not trained through the apprenticeship training route. They were either trained by companies on YTS scheme, in companies' training schools or through CITB. The length of training under apprenticeship varied; ranging from 4 years for the younger ones to 7 years for the older bricklayers. Apparently, the apprenticeship system is gradually dying out as trainees want shorter periods and the current skill shortage in the industry necessitates shorter training periods.

Table 6.2 - Type of Employer

CLASSES	MEAN %	PERCENTAGE OF RESPONDENTS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
Labour only Sub.	53	100	100	56	0	53	63	63	100	0	25	69	50
Main Subcontractor	12	0	0	22	0	0	25	25	0	0	0	23	50
Main Contractor	34	0	0	22	100	47	12	12	0	100	75	0	0
Other arrangements	1	0	0	0	0	0	0	0	0	0	0	8	0

Table 6.3- Length of Stay With Direct Employer

CLASSES	MEAN %	PERCENTAGE OF RESPONDENTS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
0 - 2 years	46	0	80	30	20	40	50	50	100	25	25	62	100
2 - 5 years	19	0	20	20	40	13	12	12	0	38	50	15	0
5 - 10 years	18	0	0	20	0	40	38	38	0	0	0	8	0
10-20 years	11	100	0	20	20	7	0	0	0	25	0	0	0
> 20 years	7	0	0	10	20	0	0	0	0	12	25	15	0

Table 6.4 - Age Distribution of Bricklayers

CLASSES	MEAN %	PERCENTAGE OF RESPONDENTS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
15 - 20 years	16	0	0	0	20	13	38	38	0	22	33	7	0
20 - 30 years	35	25	80	30	0	40	50	50	100	22	33	14	50
30 - 40 years	15	50	20	20	20	13	0	0	0	0	0	36	25
40 - 50 years	23	0	0	20	10	33	12	12	0	33	17	36	25
> 50 years	11	25	0	30	40	0	0	0	0	22	17	7	0

Table 6.5 - An Evaluation of the Mode of Training

CLASSES	MEAN %	PERCENTAGE OF RESPONDENTS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
Apprenticeship	49	33	25	54	50	38	25	25	100	56	80	77	50
Trade School	0	0	0	0	0	0	0	0	0	0	0	0	0
C.I.T.B.	8	0	25	6	25	13	0	0	0	11	20	0	0
On site	36	0	25	39	25	44	75	75	0	22	0	23	25
Combination	7	67	25	0	0	6	0	0	0	11	0	0	25

One important problem is how to determine when a trainee becomes skilled. The CITB assumes that a trainee is skilled if he can pass an assessment test at the end of his three years training period. The basis of this assessment technique is now being questioned by a research team at the University of Salford (99). The assessment question will remain until a harmonised assessment technique is derived for measuring skill in bricklaying.

It is known that skill influences the level of production output, and from the knowledge of learning curves, we know that it improves with experience. Experience is a function of the length of time an operative has been doing a particular type of work. On the average, 81% of the bricklayers in this research had been in the trade for over 5 years; we may therefore conclude that they are well experienced. 53% were well experienced in housing jobs, 19% in public building, 20% in industrial and 8% in commercial structures. The site by site details reveal that bricklayers tend to work more on the type of construction that they had most experience at doing. For example, 77% of bricklayers on site 1 (a housing site) were well experienced in housing projects, while 50% of bricklayers on site 10 (an industrial site) were well experienced at industrial structures.

Length of time spent, or experience by type of work are not adequate measures of skill. This is because individuals perceive, learn, practice and work at different rates. The old apprenticeship schemes were based on periods of training. While a trainee may be pronounced skilled at the end of the period, it does not necessarily mean he has been exposed to **all** the necessary details for the practice of the trade. Also, because of design changes, it is not safe to assume that if an operative has been on housing jobs for 20 years consisting of high rise flats, he may be equally good in detached bungalows. Despite these criticisms, we can say that the bricklaying operatives on these sites were fairly well experienced and skilled based on the fact that the majority were engaged in the type of work they were most experienced at doing.

Table 6.6 - Experience by Type of Job Undertaken

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Housing	53	77	43	56	90	70	64	64	40	21	10	49	30
Public Building	19	14	18	17	7	15	20	20	25	33	28	12	16
industrial	20	7	7	15	3	11	10	10	25	39	50	18	36
Commercial	8	2	7	12	0	4	6	6	10	7	12	13	18

Table 6.7 - Experience in Years

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
0 - 2 years	3	0	0	0	20	7	0	0	0	0	0	7	0
2 - 5 years	16	0	40	0	0	7	38	38	0	22	50	7	0
5 - 10 years	18	0	40	30	0	33	25	25	0	11	0	7	0
10 - 20 years	23	50	20	10	20	7	25	25	100	22	0	22	75
> 20 years	40	50	0	60	60	47	12	12	0	45	50	57	25

How did these bricklayers perceive their work in terms of energy input? Accessing energy input is necessary because a worker who thinks he is giving too much without commensurate financial rewards, may quit the trade before the normal retirement age. 84% of the bricklayers were of the opinion that their work was strenuous (46% strenuous, 38% very strenuous). The fact that a 60 year old bricklayer can rarely be found on construction sites may be accounted for by the strains of the trade.

Table 6.9 shows an aggregation of bricklayers' response to the question evaluating their remunerations. On average, 42% of them considered their remuneration fair, 31% - good, 11% -bad and 17% - very bad. A large proportion seemed satisfied with the wages. Nevertheless, those dissatisfied (28%) cannot be discounted. Considering the fact that most of these workers were 'labour - only' subcontractors being paid negotiated prices, one may wonder why 28% consented to the price in the first instance if it was bad or very bad. In a market where prices are fixed by the forces of demand and supply, the workers are partly responsible for their 'reward' situations.

First, these bricklayers were possibly not aware of the much publicised skill shortage, a knowledge which they could have used to great advantage when haggling prices. Secondly, some of them found it difficult to leave a contractor with a steady stream of work "just because of some pennies off". Our earlier analysis showed that some have been with the same contractor for upwards of 20 years! Thirdly, the 'labour only' subcontractors do not have unions to bargain prices. It would have been helpful if they had a union that could either negotiate better prices for them or supply them with price-sensitive information which may help them when haggling prices.

Table 6.8 - An Evaluation of Energy Input in Bricklaying

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Very strenuous	38	33	40	20	20	50	29	29	100	37	25	46	41
Strenuous	46	67	40	80	40	36	29	29	0	50	75	46	47
Just O.K.	16	0	20	0	40	14	43	43	0	13	0	8	12

Table 6.9 - An Evaluation of Remuneration

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Excellent	0	0	0	0	0	0	0	0	0	0	0	0	0
Very good	0	0	0	0	0	0	0	0	0	0	0	0	0
Good	31	50	20	30	60	13	0	0	0	14	0	29	39
Fair	42	50	40	50	0	60	71	71	50	57	75	29	28
Bad	11	0	40	10	20	20	0	0	50	0	0	14	11
Very bad	17	0	0	10	20	7	29	29	0	29	25	29	22

Mixed responses to the remuneration question were received from sites with 'on the books' operatives. Some were very happy with the piecework rates given but would be happier had the piecework rates 'not being shoved down the neck' -as one of them put it. On the whole, the responses indicated that while the feeling that bricklaying work is strenuous, these bricklayers were fairly paid for effort expended. This position is supported by a report on remuneration levels in construction trades which shows that bricklayers are well paid relative to other trades (27).

An attempt was made to understand the levels of importance attached to some factors known in literature to influence workers' decision to remain or leave a particular place of work. See Table 6.10 for the ranking of these factors by bricklayers. Earnings related issues was the greatest factor influencing bricklayers' decision to change from a particular site to another or quit the trade altogether. Working conditions and overall management of the sites were the second and third ranked factors respectively. These findings are much in line with what may be expected from workers in other industries.

Table 6.10 - Rankings of Reasons Why Bricklayers Leave Sites

REASONS	MEAN RANK	RANK OF REASONS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
Earnings related	1st	1	1	1	1	1	1	1	1	1	1	1	1
Workmates	6th	-	3	-	-	4	-	4	-	5	-	8	-
Distance from home	4th	3	2	5	-	-	5	-	-	7	4	6	3
Better design	7th	-	4	6	1	-	-	-	-	-	2	6	-
Working conditions	2nd	2	4	2	-	3	3	4	3	3	-	4	2
Do not want to work	8th	-	-	-	-	-	3	-	-	2	-	-	-
Management / superv.	3rd	3	-	6	-	2	5	6	2	3	-	2	-
Dismissal	8th	-	-	-	-	-	-	2	-	-	-	3	-
Transfer	10th	-	-	-	-	-	-	2	-	-	3	-	-
Workmanship	4th	-	-	2	-	-	2	-	-	-	5	4	4
To other trades	11th	-	-	-	-	-	-	-	-	5	-	-	4

6.3.2. Bricklayers' Perception Of Management

The working environment is the responsibility of both the head office and site office management. Their policies and actions can positively or adversely affect operatives' enthusiasm to perform in their working environment. In this section, we shall examine bricklayers' perception of management's contribution to their working environment. This will be viewed in terms of work organisation, supervision, progress on site, and operatives' awareness of management's efforts.

The operatives were asked to assess the overall organisation of their sites in terms of site planning, control, job sequencing, materials delivery etc. Their responses are shown in Tables 6.11, 6.12 and 6.13. A question assessing their general opinion of their sites was deliberately asked in three forms to test the consistency of their response, see Appendix B.

The majority of bricklayers were of the opinion that their sites were fairly well organised. Only 12% considered their sites excellently organised - mainly sites 10 and 11. 12% of the bricklayers also rated the organisation of their work as being 'very good'. The same pattern of response was repeated when they were asked to assess overall work supervision and the general working environment. From these consistent responses, the working environment was judged to be fair by the operatives.

There were obvious leaks in production time due to management related problems. Have the bricklayers become so accustomed to certain problems that their judgement has become subjective ? If a worker has been on a site with severe managerial problems, it is possible that when he gets to another site with a comparatively better (but still bad) management, he may rate his new site as being excellent. This subjectivity problem is one of the deficiencies of opinion surveys (23). The site problems will be discussed in a later section of this chapter.

Table 6.11 - An Evaluation of Work Organisation

CLASSES	MEAN %	1	2	3	4	5	6	7	8	9	10	11	12
		PERCENTAGE OF RESPONDENTS PER SITE											
Excellent	12	0	0	0	20	7	13	13	0	13	33	21	0
Very good	12	0	0	40	40	13	0	0	0	13	0	7	0
Good	33	50	40	30	0	13	25	25	0	50	33	50	100
Fair	35	50	60	30	20	40	60	60	100	25	33	0	0
Bad	6	0	0	0	0	20	0	0	0	0	0	14	0
Very bad	3	0	0	0	20	7	0	0	0	0	0	7	0

Table 6.12 - An Evaluation of Overall Work Supervision

CLASSES	MEAN %	1	2	3	4	5	6	7	8	9	10	11	12
		PERCENTAGE OF RESPONDENTS PER SITE											
Excellent	12	33	0	10	40	7	14	14	0	0	50	14	0
Very good	15	0	0	40	20	0	14	14	0	29	25	7	25
Good	39	0	40	50	0	33	29	29	0	43	25	71	50
Fair	28	33	40	0	20	47	43	43	100	29	0	14	25
Bad	6	33	20	0	20	13	0	0	0	0	0	0	0
Very bad	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.13 - An Evaluation of Working Environment

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Excellent	5	0	0	0	40	0	0	0	0	0	25	0	25
Very good	20	0	0	30	0	0	0	0	0	43	50	36	0
Good	34	100	60	40	20	15	43	43	50	29	25	36	50
Fair	30	0	40	10	40	39	57	57	50	29	0	21	25
Bad	5	0	0	10	0	23	0	0	0	0	0	0	0
Very bad	6	0	0	10	0	23	0	0	0	0	0	7	0

Table 6.14 - Cooperation With Workmates

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Very cooperative	44	33	50	50	40	14	25	25	50	67	75	50	61
Cooperative	51	67	50	50	60	86	50	50	50	33	25	50	39
Not cooperative	4	0	0	0	0	0	25	25	0	0	0	0	0

Operatives were also asked about management's understanding of their work; in order to detect any communication gap between management and the workforce. 59% of the operatives were of the opinion that their respective site and head office management were well aware and concerned about the progress they were making on their jobs. Only 15% were of the opinion that management had no awareness of their work - an indication of a communication gap between the management and operatives. These bricklayers had aversion to being asked by management about job progress when materials or other production resources were not available. Only 25% of the bricklayers saw management as being ready to identify sources of delays and rectify them.

Since these responses showed that the management was not too detached from the operatives, more sensitive questions were asked relating to cost and profits made by the contractor. This was in order to ascertain the operatives' degree of involvement in the firms. 72% of the operatives were not very aware of the project costs and the profit being made on their project. They only knew the prices for their work and the progress rate expected from them. There is a marked absence of industrial democracy or profit sharing schemes in operative management in the construction industry.

The above discussions show that the working environment is fairly conducive for production. To decipher some of the expected subjectivity often generated in opinion surveys, a more scientific and objective technique of activity sampling was adopted to survey how production time was actually spent by these workers. This is to enable us identify problem areas and also evaluate the reliability of workers' opinions.

Table 6.15 - Management's Knowledge of Bricklayers' Work

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Progress	59	50	40	73	80	67	38	38	0	64	67	67	75
Delays	25	25	60	9	0	13	38	38	0	36	33	27	25
Nothing	15	25	0	18	20	20	25	25	100	0	0	6	0

Table 6.16 - Bricklayers' Awareness of Profit and Project Cost

CLASSES	MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
	%	1	2	3	4	5	6	7	8	9	10	11	12
Very aware	28	50	20	20	40	21	25	25	50	43	0	43	25
Aware	46	25	60	70	40	43	50	50	50	57	75	14	75
Not aware	26	25	20	10	20	36	25	25	0	0	25	43	0

6.3. How Bricklayers Spend the Working day.

The activity sampling data was analysed with reference to our earlier classification of the working day (see chapter 5). Since the official break was fixed on all the sites, it was not considered necessary in the analysis. The analysis concentrated only on the working time. Table 6.17 shows the site by site distribution of the working time.

Table 6.17 - Utilisation of The Working Time

SITE	%Extra Break	%Supervision	%Productive	%Unproductive
1.	6	1	63	30
2.*	17	1	51	31
3.*	9	3	67	21
4.*	14	3	65	18
5.*	11	1	61	27
6.**	10	1	50	39
7.**	24	2	45	29
8.	5	1	62	32
9.	12	4	56	28
10.	13	4	51	32
11.***	12	2	51	35
12.***	8	2	63	27

Note:- *The Same contractor

All percentages are in relation to the Working Time

Figure 6.1 Frequency Distribution of % Productive Time.

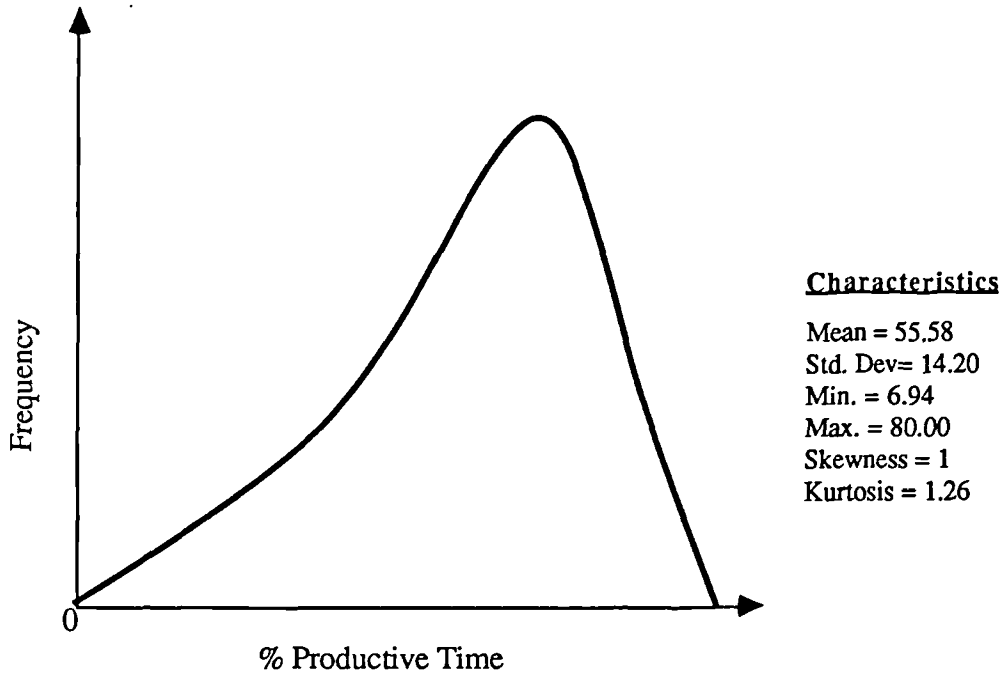


Figure 6.2 Frequency Distribution of % Unproductive Time

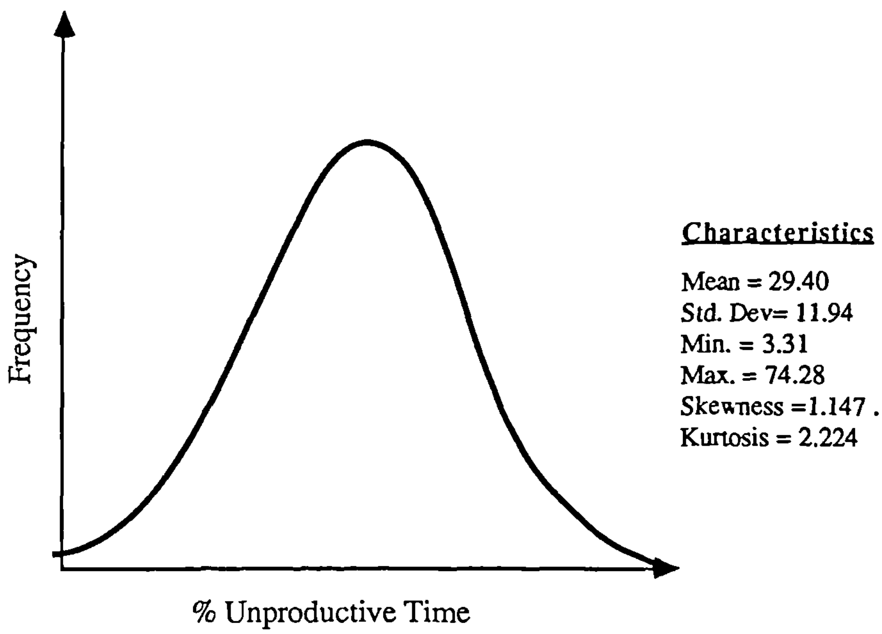


Figure 6.3 Frequency Distribution of % Extra Break

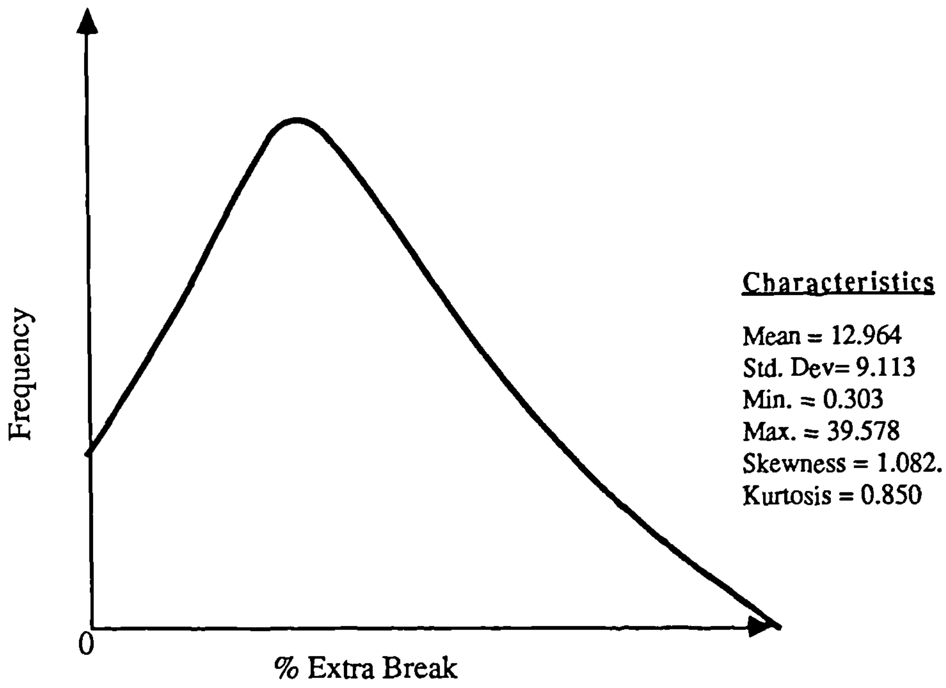


Figure 6.4 Frequency Distribution of % Supervision Time

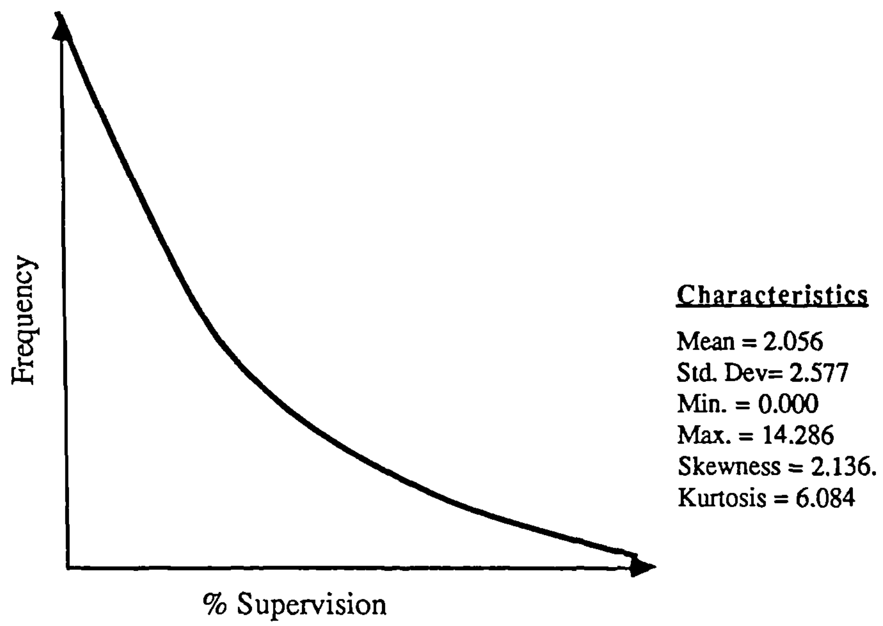


Figure 6.5 Breakdown of Working Day Utilisation by Bricklayers

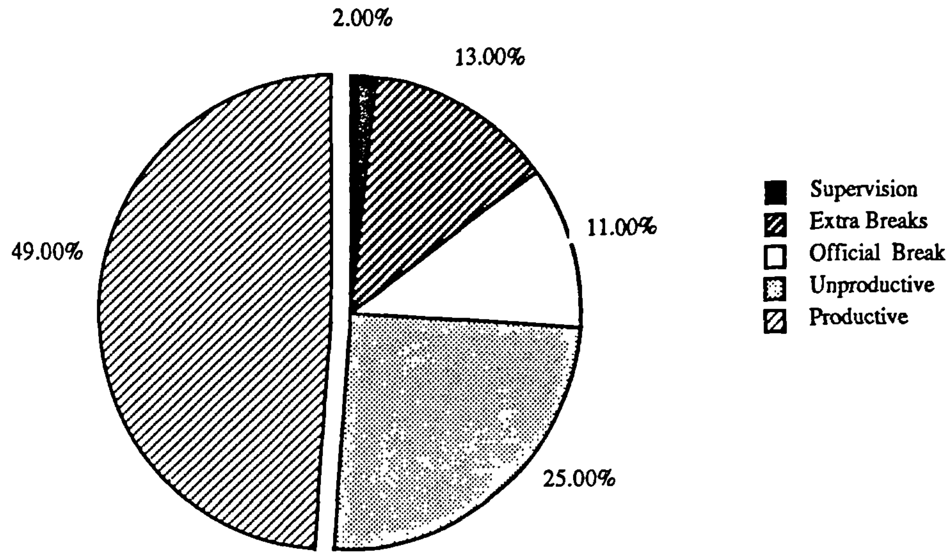
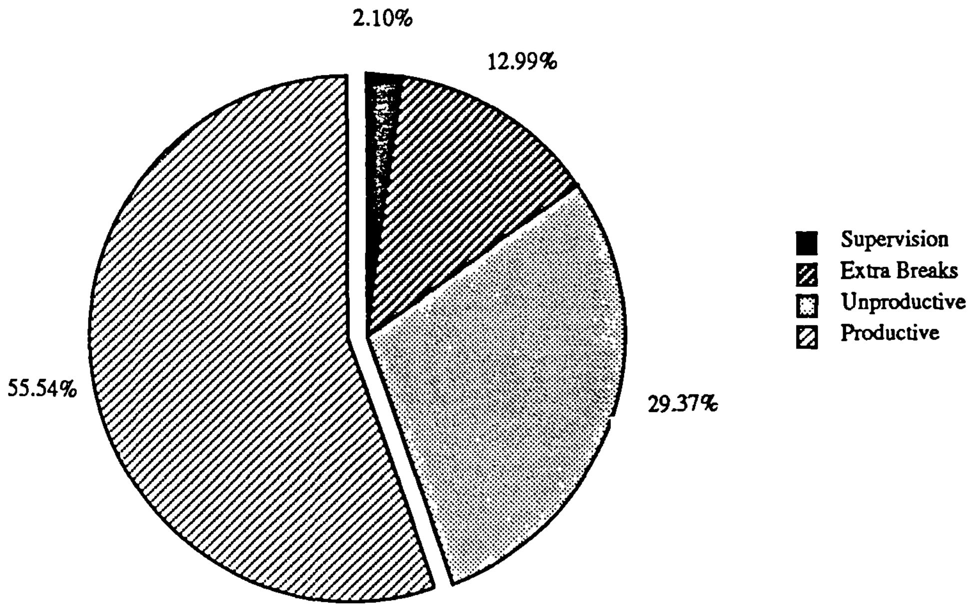


Figure 6.6 Breakdown of Working Time Utilisation by Bricklayers



At first glance, Table 6.17 shows that there was not much difference in the average percentage of time spent productively by bricklayers on different sites - a range of 50% to 63%. It would be very erroneous to use this as an indication of the level of productivity on each site. The total output on a site is the summation of what each worker does within the time he spends productively. Using these mean values however, it can be observed that the differences in percentage productive time between bricklayers is more noticeable when assessed in relation to individual companies rather than the sites. This seems contradictory to previous productivity studies in bricklaying where the emphasis has been only on site differences (43,44). It may be that the increase in subcontracting has had a neutralising effect on the differences between sites as previously reported. It can be argued that because of the growth of subcontracting, self motivation might have been improved over the years to have these neutralising effect on bricklayers' percentage productive time. Apart from the expected linear interdependency of the classifications there are not much significant deductions at this stage. Further lights would be shed on differences between production output in Chapter 8.

Overall, the distribution curves (See Figures 6.1,6.2,6.3,6.4) demonstrate that, on the average, bricklayers spent 55.6% of their working time on productive activities, 2.1% on supervision related activities, 13% on extra breaks, and 29.4% unproductively. The productive element of the working time contradicts previous studies which indicate that workers only spend 30% to 40% of the working day on productive activities (51). This may be due to definitional problems. Possibly, these earlier studies included the official break (when workers are not expected to work) in their analysis. Figures 6.5 and 6.6 demonstrate the effect of time classification on percentage productive time. When compared with Price's findings in concreting (120), the percentage productive time in this study agrees quite significantly, and baring intertrade differences the percentages for other time classes also agree. In a similar study by Olomolaiye and Price (111), the percentage productive time of Nigerian bricklayers was found to be 51%. Comparatively, bricklayers in Britain spend a larger part of their working day on productive activities. However, making international comparisons can be rather difficult. Difficulties in international comparison have been attributed to differences in technological, managerial and contractual styles, as well as the weather (2,33,105,141).

A considerably high 13% of working time was spent in the 'extra break' classification. Why did operatives, who have been largely identified as independent 'labour only' subcontractors, waste so much time idling? The answer to this question is simple. Most of these operatives did not adhere to the official hours on site. While they all came to work on time, they finished for the day at different times. It was a common practice that when a subcontract gang wasted time in 'extra breaks' during the official working day it may work beyond the official hours to make up for lost time. This is buttressed by the fact that 'on the books' bricklayers recorded lower 'extra breaks'. A small proportion of the 'labour only' operatives did not go for breaks on some days or would go at their convenience. The independence of these workers had few positive effects, but the 13% leak in production time easily outweighed these.

With observed supervision time (i.e. time spent taking instruction and inspection) ranging between 1% and 4%, we are faced with the problem on whether to classify this as unproductive or not. The time spent by various bricklayers in this classification varied considerably. It could have been expected that individuals with lower skill would have required more supervision time, but it was observed that the gang leaders often recorded higher supervision time. This was because gang leaders were often first contacted by site supervisors, and in most cases, held responsible for their colleagues' mistakes. They spent time taking instruction from the supervisor and explaining it to their colleagues.

Unproductive time constituted 29.4% of the working time. Table 5.2 shows 13 different sub-classes of this time classification. Table 6.18 shows the distribution of the overall percentage unproductive time in these subclasses. A large proportion of unproductive time on these sites was spent on unrelated works or helping labourers to transport production resources. This may be indicative of either, inadequate support from site management, or labourers not coping with the bricklayers' rate of working . The time spent on each unproductive activity is not of much use, unless the roots of the problems can be determined. Questions aimed at this were incorporated in the questionnaire, see Appendix B.

Table 6.18 - Distribution of Unproductive Time

Activity	Mean Percentage of Unproductive Time
Idle and Away	9.85
Waiting	11.94
Searching	12.36
Rework	12.90
Confused	5.00
Ancillary Works	2.70
Other Works	27.71
Drive Dumper	0.00
Operate Mixer	0.72
Climb	1.05
Distribute Brick/Mortar	7.50
Cleaning	6.42
Read drawing	1.50

Note:- See chapter 5 for the description of working day classifications.

6.5 Problems Causing Unproductive Time

The Craftsman Questionnaire Survey Technique has established that construction operatives know more about their production problems than any other individual (127). Bricklayers were approached in the second section of the operatives' questionnaire (see Appendix B) to rate a general list of potential problems as Very Important, Important and Just Important. Each of these was scored 3, 2 and 1 respectively. The total scores by all bricklayers for each problem were then converted to relative indices (see Table 6.19) using the relative rank index technique.

The operatives were again asked to estimate time losses due to each problem and the sources of these problems; see Tables 6.20, 6.21 and 6.22. These four tables form the basis of the following discussion of the problems contributing to the unproductive time.

Table 6.19 - Ranking of Problems Influencing Bricklayers Productivity

Problems Sample Size: 103 Bricklayers	Point Totals For Rank ordering	Relative Index = $\frac{\text{Point Total}}{3 \times \text{Sample size}}$	Overall Ranks
Lack of Materials	111	0.36	1st
Lack of Equipment	19	0.06	5th
Gang Interference	105	0.34	2nd
Absenteeism	6	0.02	6th
Supervision	22	0.07	4th
Repeat Work	53	0.17	3rd

Table 6.20 - Estimated Time Losses Per Problem Area in a 40-Hour Week

CLASSES	MEAN TIME	HOURS PER SITE PER WEEK 1	2	3	4	5	6	7	8	9	10	11	12
Lack of Materials	3	2	1	4	5	3	-	4	3	4	1	2	4
Lack of tools or Eqpt.	2	2	1	2	2	2	3	2	-	2	-	2	2
Rework	2.5	-	8	-	3	3	1	3	2	3	2	1	1
Change of mates	1.5	-	-	2	-	-	4	-	-	1	-	1	1
Overcrowding	2	-	-	2	-	1	-	-	-	2	2	1	3
Supervision	2	4	1	-	2	1	-	4	1	3	-	2	1
Gang interference	2	-	2	5	2	-	3	2	3	2	2	2	1

Table 6.21 - Ranks of Causes of Rework

CLASSES	MEAN RANKS	RANKS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
Poor Instructions	2nd	2	1	2	2	2	4	4	1	2	3	2	3
Change of Instr.	1st	1	2	1	1	1	2	2	2	1	1	1	1
Poor Workmanship	4th	4	4	4	4	4	1	1	4	3	4	3	4
Complex Specs.	3rd	3	3	3	3	3	3	3	3	4	3	4	1

Table 6.22: Ranks of Causes of Lack of Materials

CLASSES	MEAN RANKS	RANKS PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
Transport	2nd	1	2	1	3	1	5	5	-	1	5	1	1
Paper work	4th	3	-	5	5	5	4	4	-	5	4	5	4
Improper materials	3rd	4	1	3	2	4	2	2	-	3	2	4	4
Lack of Planning	1st	2	2	2	1	2	1	1	1	4	3	2	2
Interference	3rd	5	-	4	4	3	3	3	-	2	1	3	3

6.5.1 Lack of Materials

Taking the relative indices as a measure of importance, lack of materials ranked the greatest hinderance to operatives' productivity, with an overall index of 0.36. The sites experienced this problem in varying degrees. This is reflected in the estimated hours lost during a 40-hour week as shown in Table 6.20. Site 4 recorded the highest loss of 5 hours due to this problem. On aggregating the different reasons for the lack of materials, the bricklayers identified lack of planning as the main source of the problem. This was traced to inadequate job sequencing and site planning. This lack of adequate planning probably accounted for 'transport difficulties' coming second as a cause of the lack of materials. Bricklayers' labourers experienced difficulty on some of the sites, particularly on site 12. Delivery of wrong materials to site and interference by other gangs (e.g. using the bricks a particular gang has stacked and prepared) were jointly identified as the third ranked sources of this problem. On all sites the procedure for obtaining materials, when available, was efficient hence it was not seen as a major cause of the problem of materials shortage.

6.5.2 Gang Interference

This ranked the second most important factor influencing bricklayers' productivity, with a high relative index of 0.34. On average, bricklayers wasted up to 2 hours of the 40-hour week as a result of this problem. This problem could be solved or reduced by adequate planning of jobs on sites. Bricklayers sometimes resorted to fixing scaffolds themselves which was referred to as doing 'unrelated work' in our classification of unproductive time. It is fast becoming part of the bricklaying trade to fix scaffolding on some sites. Apart from waiting for scaffolders or fixing scaffolding, the bricklayers also had to wait for joiners, concretors or even equipment, e.g. overhead cranes.

6.5.3 Repeat Work

'Repeat work' ranked third with a relative index of 0.17. An average of 2.5 hours was estimated to be lost per week due to this problem. Repeat work was traced mainly to changes in instructions or vague instructions which are obviously related to supervision. Job complexity was the third ranked cause of rework. Poor workmanship had the least rating as a source of this problem. This is expected since individuals rarely blame themselves for problems (111).

6.5.4 Supervision Delays

While time spent taking instruction or inspection cannot be classified unproductive, there were other times the supervisor disturbed the production process. Bricklayers ranked this problem fourth with an index of 0.07. On the average they estimated that 2 hours were lost due to this problem each week. The bricklayers were of the opinion that a high proportion of inspection delays could have been avoided if clearer instructions had been given in the first instance and that, some instructions were either mere repetitions or even unnecessary. Generally, the bricklayers gave favourable comments about their direct supervisors, see Table 6.23.

Table 6.23 - **Bricklayers' Assessment of Their Direct Supervisors**

CLASSES	MEAN %	1	2	3	4	5	6	7	8	9	10	11	12
		PERCENTAGE RESPONDENT PER SITE											
Very skilled	16	13	0	22	17	15	25	25	0	14	17	15	0
Friendly and approachable	35	38	38	39	50	35	19	19	25	43	50	35	60
Around when needed	37	25	50	26	17	35	38	38	25	43	33	45	40
Does not take suggestion	5	0	12	4	17	5	6	6	50	0	0	0	0
Keeps information	5	13	0	4	0	10	6	6	0	0	0	5	0
Does not know his work	3	13	0	4	0	0	6	6	0	0	0	0	0

6.5.5 Lack of Equipment

This had a very low index of 0.06 and is the 5th ranked problem contributing to the unproductive time. An estimated two hours were lost due to this problem. Bricklayers were not happy having to share a mixer because it entailed waiting. With on-site transport difficulties, it would have been better if tower cranes were used to distribute bricks and mortar on sites such as 11 and 12.

6.5.6 Absenteeism

Absenteeism is often taken as a measure of productivity and motivation (15). Bricklayers in this study rated it very low with a relative rank index of 0.02. An attempt was made at polling the bricklayers' general opinion on absenteeism. 46% of the workers reported cases of absenteeism on their sites. The percentage varied from from site to site. When asked if the absence of their gang members mattered to them, a staggering 39% of the bricklayers did seem not mind. This is baffling as one would have expected them all to give positive response to the question. This response may be an indication that bricklayers have accepted abseenteeism as part of their relationship with one another. They are no longer bothered! Since pay is based on the number of bricks laid, they may not bother if a gang member is absent to earn his living. However, we are aware that a sudden absence of a member of a gang will disrupt production and would affect the enthusiasm of other workers to produce that particular day. A consequent reduction in output for that day may be expected.

Table 6. 24 - An Evaluation of Absenteeism

CLASSES	%MEAN	PERCENTAGE OF RESPONDENTS PER SITE											
		1	2	3	4	5	6	7	8	9	10	11	12
Are mates often Absent ?													
YES	46	50	20	50	0	38	63	63	100	13	0	69	100
NO	54	50	80	50	100	62	37	37	0	87	100	31	0
Hours lost /week ?.	4	0	0	2	0	4	5	5	8	0	3	8	8
Do you mind your mates absence ?													
YES	61	67	60	67	25	69	33	33	50	75	100	62	100
NO	39	33	40	33	75	31	67	67	50	25	0	38	0

6.6 An International Comparison of Production Problems

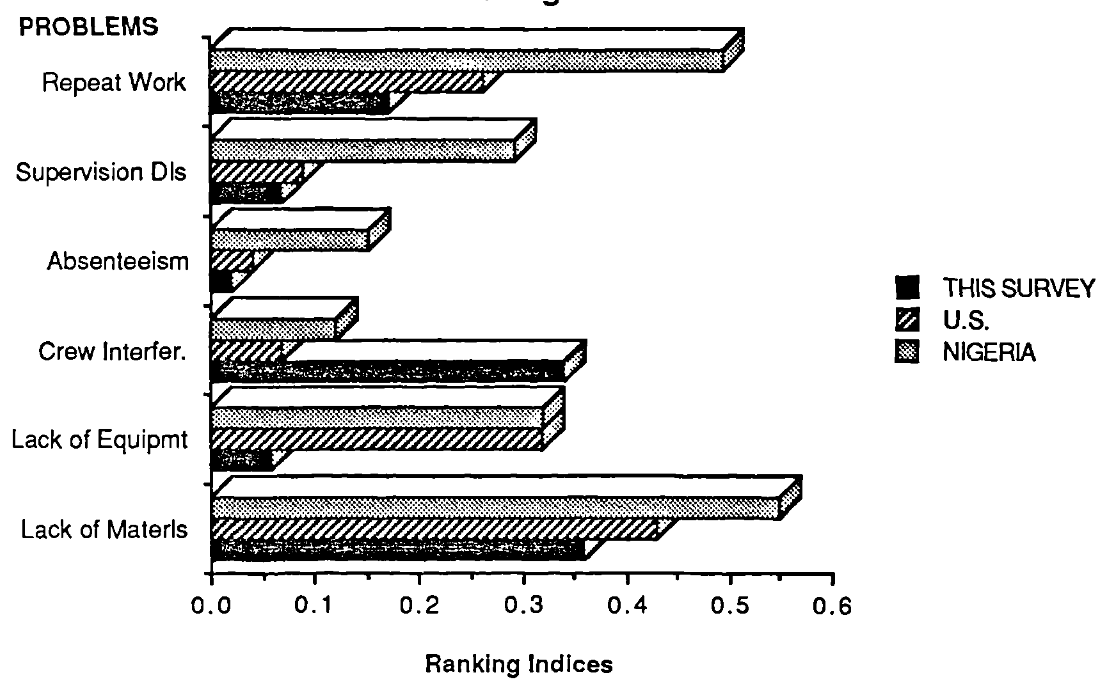
The operative questionnaire survey and activity sampling techniques have aided our appreciation of production problems in bricklaying. In the light of this, it is considered necessary to attempt an international comparison of our findings with similar findings in U.S. and Nigeria (111, 127). It is recognised that since the studies have different foci it would be risky to use them for much serious comparative analysis. Also, since the published figures for U.S. and Nigeria are only final summaries of responses of the total sample used in the other studies, they may only represent the 'tips of the iceberg'. However, it is possible to draw some inferences from these figures using the reported indices as measures of the importance attached to the problems in these other countries.

From Table 6.25 (further illusrated in Figure 6.7), it is apparent that Nigerian workers experienced more of the problems. Lack of materials was generally the worst problem to all workers in the three countries. While lack of equipment was second and third in the U.S. and Nigeria respectively, gang interference problem was second in the U.K.. Gang interference ranked very low in both and U.S. and Nigeria. Its coming second in the U.K. gives a cause for concern. The only reason that may be suggested is that the high incidence of 'labour only' subcontracting in the U.K might have aggravated the problem of job sequencing in site management. In the U.S., workers are mostly unionised while in Nigeria they are directly employed by main contractors. When workers are under one management, it is easier for the site agent to plan what his men will do without interference between the gangs.

Table 6. 25 - **Index Ranks of Production Problems in This Survey, U.S.A. and Nigeria**

Problems	**Relative Index Ranks In Each Country**		
	THIS SURVEY	U.S.	NIGERIA
Lack of Materials	0.36	0.43	0.55
Lack of Equipment	0.06	0.32	0.32
Gang Interference	0.34	0.07	0.12
Absenteeism	0.02	0.04	0.15
Supervision Delays	0.07	0.09	0.29
Repeat Work	0.17	0.26	0.49

Figure 6.7 Ranking of Problems in U.K., U.S., and Nigeria



It has been argued that where these problems exist in significant proportions, it will be useless trying to motivate or even study motivation in workers (25). The reason being that if a worker is highly motivated in an environment where basic construction resources are lacking, he will still be unproductive. But can there be a working environment free of all production problems - a construction utopia ? No !. U.K. workers demonstrably experience lower degrees of these problems and can be said to offer the best (out of these three countries) environment to study motivational impacts on construction productivity.

6.6 Summary

1. The site environment significantly affects bricklayers productivity. The gang size does not; but when combined with the site factor, it does.
2. Bricklayers work with peer group members and in fairly permanent gangs.
3. Younger bricklayers change direct employers very often.
4. Bricklayers in this study are fairly well experienced and skilled in their jobs.
5. Bricklaying is strenuous but workers are fairly paid.
6. There is a need for an assessment technique for testing bricklayers' skill.
7. Bricklayers spend 55.6% of the working time productively with rest of the time spent unproductively; largely due to lack of materials, gang interference and work repetition.
8. The U.K construction environment is more conducive for motivation study than U.S. or Nigeria.

CHAPTER 7

CHAPTER 7

AN EVALUATION OF OPERATIVE MOTIVATION IN BRICKLAYING

7.1 Introduction

It was concluded in the preceding chapter that the British construction environment is comparatively better for the study of operative motivation than those in United States and Nigeria. The main reason for this conclusion is that British workers' experience production problems in lower degrees than construction operatives in these other countries. Although production problems still exist, no utopia construction environment should be expected before attempting to study construction operative motivation. Recognising this, Olomolaiye and Ogunlana (110) approached the study of motivation on Nigerian sites from a rather hypothetical premise; asking Nigerian workers what would motivate them should the identified problems be removed or were non existent. While appreciating their resolve to study motivation in Nigeria, motivation on British sites do not demand such abstract approach since the problems experienced by workers are not so intense as to becloud the underlying motivation.

In this chapter we shall discuss in detail the results of investigations into motivational aspects of bricklaying and the relationships between motivation and productivity in the trade. The relative importance of motivating and demotivating variables in relation to production output will be statistically evaluated and discussed. This will be in line with earlier findings in general psychology, general management and in construction literature with a view to improving the understanding of construction operative motivation and prove our first hypothesis (stated in chapter 5) that motivation variables are very interdependent.

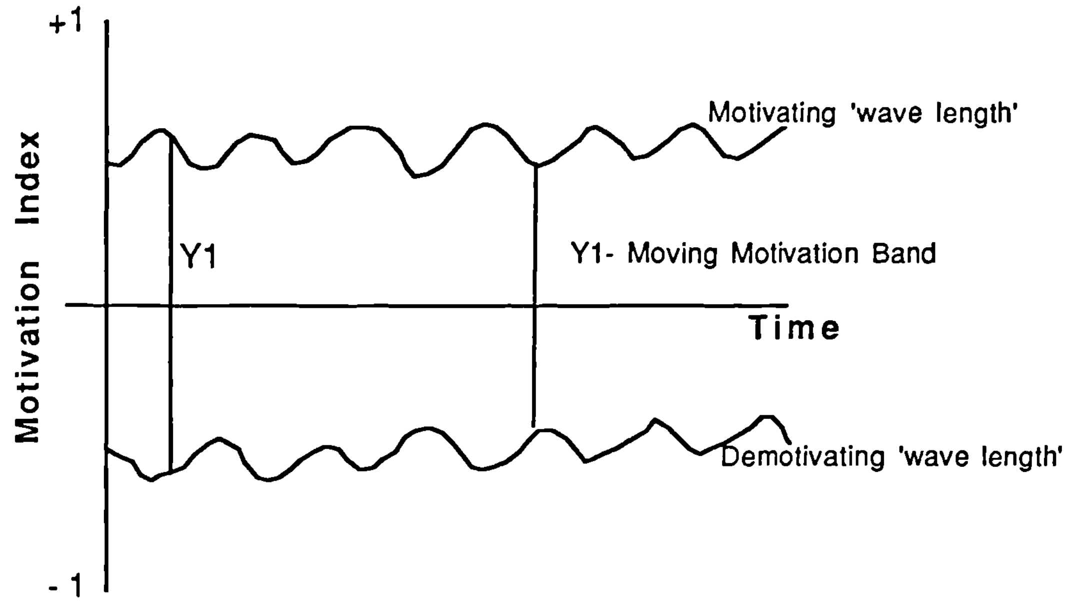
7.2 Motivational Aspects of Bricklaying

From our literature review in human motivation we observed that there is an underlying understanding of motivation as an energising element in workers and that it has a positive relationship with productivity. Despite this understanding, the absence of a generally accepted definition coupled with measurement problems have made motivation remain an abstract concept. A quantifying technique was earlier suggested to bring this concept out of abstraction and detect its actual relationship with productivity. While we have presented this technique, we are yet to see the concept behind it. Before discussing the results and findings on the relationship of motivation to productivity, let us obtain some insight into the concept behind the measurement technique used to quantify motivation in this research.

7.2.1 The Motivation Band Concept

The motivation content in an individual worker is conceived figuratively as a cup of water with two taps - one supplying, the other draining. The amount of water in the cup at a particular time depicts the motivation content of the worker at that point in time. This content is a function of both the MOTIVATING and the DEMOTIVATING variables (the two taps). The content increases when the motivating variables are satisfied or energised and reduces (the second tap is opened!) when the demotivating variables are activated. The motivation content in an individual may increase when the motivating variables are activated with a corresponding decrease or stability in the level of demotivation. It may decrease by an energisation of the demotivating content with the same or lower level of motivation. The motivation content in an individual over some length of time then resembles a band - demarcated by two alternating sinusoidal waves. These waves do not necessarily follow regular patterns, see Figure 7.1. The main point which should be borne in mind is that motivation is a function of both motivating and demotivating variables.

Figure 7:1 The Motivation Band Concept



7.2.2 Job Satisfaction and Dissatisfaction

To prevent falling into definitional complications about motivation in general management, the first step taken was to investigate satisfiers and dissatisfiers distinctly from motivating and demotivating variables. Satisfiers give satisfaction but do not necessarily motivate, while dissatisfiers cause dissatisfaction but do not necessarily demotivate. On the other hand, motivators give satisfaction as well as motivate while demotivators dissatisfy and can cause deliberate withdrawal of production ability.

Herzberg (59) presented lists of job satisfiers and dissatisfiers to workers who were required to identify their level of importance. The approach adopted in this research is different. Bricklayers were asked to describe the three most important factors that satisfy or dissatisfy them in their trade. This approach was taken in order to obtain an original set of satisfiers and dissatisfiers from bricklayers which will subsequently form the crux of investigations of motivational variables. Since not everyone believes Herzberg's notion that money is not a satisfier and therefore not a motivator, obtaining an original list from workers will help us pinpoint the role of wages in operative motivation.

Another contrast to Herzberg 's (59) and Borcherding's (16) approaches is that no special selection of highly productive workers was made from the general population - all workers were asked to respond to the question. From workers' descriptions of their satisfiers and dissatisfiers, like factors were collected under common headings and then ranked according to the total scores. Tables 7.1 and 7.2 show the rankings of satisfiers and dissatisfiers in bricklaying across the sites.

7.2.2.1 Job Satisfiers

According to the rankings "Reward related issues" is the greatest satisfier to bricklaying operatives. With comments such as "I'm here for the money" and "we all work for money" from the operatives, it is clear that money is a great satisfier to operatives. This may not be far fetched from the classical thoughts about the role of wages. A cross analysis of the responses shows that, but for its being the most frequently mentioned factor, rewards related issues could not have come tops. Despite this frequent mentioning, it only marginally beat "Doing a good Job" related factors to the second place.

Bricklayers derive much satisfaction from neat and tidy work. Some believe that the only way to distinguish themselves as bricklayers is to "do it professionally since almost everyone can lay brick". One commented that 'a job well done makes all recognise your skill'. Another commented that what satisfies him most in bricklaying is 'correct and neat job completed without comebacks'. Bricklayers detest rework - a cause of dissatisfaction on sites - with one commenting that what he detests most is "putting other gangs' work right". To bricklayers, rework due to one's own faults is more bearable than redoing other people's work.

Table 7.1 Ranks of Bricklayers' Satisfiers

SATISFIERS	MEAN RANK	RANK PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
The trade itself	7th	7	7	-	5	3	7	7	-	6	-	2	-
Type of work	4th	2	3	3	3	7	-	-	-	6	-	8	2
Good mach. and mats.	9th	7	-	-	-	-	5	5	1	4	-	5	-
Working conditions	5th	5	5	8	-	5	3	3	-	2	-	6	-
Workmates	8th	-	4	3	3	4	-	-	-	4	-	-	5
Doing a good job	2nd	4	2	2	2	2	2	2	-	2	3	3	3
Supervision related	3rd	5	5	5	6	3	4	4	3	8	-	3	5
Completing the job	6th	3	5	7	6	5	5	5	-	8	1	6	4
Remunerations	1st	1	1	1	1	1	1	1	2	1	2	1	1

The third rated factor is "supervision related issues". Bricklayers like being left alone to do the job without the supervisor doting on them. The fourth rated satisfier is "nature of work related" issues. Bricklayers love challenging tasks. One commented that, since ' the more complicated the job, the more its beauty' he liked doing complicated jobs but only when adequately rewarded. An association may be made between this fourth factor and the second factor - 'doing a job well' - to conclude that work related factors are important satisfiers. This association is reinforced by "completing the job on hand" and "the bricklaying trade itself" being the sixth and seventh rated satisfiers respectively. Comments such as 'finishing a project within schedule without problem', 'being able to see a job from start to finish' and 'being in the trade for 47 years without ever being finished by any firm', show that the actual work is the most prominent satisfying factor to the bricklayer.

Should the scores in these four classifications be combined, work related factors outshine all other factors as the most prominent job satisfier to the operatives. This is in line with Borcherding's observation on American sites (16) but contradicts Herzberg's basis for job enrichment (59) as bricklayers consider their trade already enriched.

7.2.2.2 Job Dissatisfiers.

Again, "reward" is the highest ranked job dissatisfier in bricklaying. Some detest strict piece work rates without any added bonus. One commented that what dissatisfies him most is 'no bonus for rushing around all day'. Some see bonuses more as an appreciation by management for work done and have negative view of any management that doesn't give any form of bonus. When 'labour-only' subcontractors were asked to give their opinions about bonuses, 76% of them did not expect bonuses and it did not affect their satisfaction. What affects them most is 'having a price shoved down your neck just because you have no alternative'.

Weather is another major dissatisfier. Often, no bricklaying is done when the temperature falls below 3°C. But what happens when there is an unexpected shower ? Bricklayers are generally frustrated by unfavourable weather. One commented that he is most dissatisfied on 'wet days when water rush down brickwork and washes joints out'. Subcontractors naturally ranked this factor as a higher dissatisfier than 'on the books' workers, largely because site management only pay them for what is done.

Table 7.2 Ranks of Job Dissatisfiers in Bricklaying

DISSATISFIERS	MEAN RANK	RANK PER SITE 1	2	3	4	5	6	7	8	9	10	11	12
Weather	2nd	1	1	3	1	3	1	-	1	2	3	5	4
Remuneration	1st	2	-	1	2	2	2	1	1	1	1	1	1
Management	6th	4	-	6	3	6	-	3	-	5	-	7	-
Bad mach. and mats	5th	-	4	4	-	-	4	3	-	6	3	5	3
Rework	8th	-	1	6	-	3	-	5	-	-	-	13	-
Bad working conditions.	4th	-	-	1	-	5	-	6	1	3	-	3	6
Bad workmanship	8th	-	-	4	-	-	2	-	-	7	5	7	-
Lack of work	13th	4	-	-	-	-	-	-	-	7	-	-	-
Idle / bad mates	7th	7	-	-	-	-	-	6	-	4	1	10	4
Waiting for others	10th	2	-	6	-	6	-	-	-	-	-	-	-
Work discontinuity	11th	7	4	-	-	-	-	-	-	-	-	-	-
Supervision related	3rd	4	1	9	4	1	5	1	-	-	-	2	2
Type of work	12th	-	-	-	-	-	-	-	-	-	-	4	-
Bad drawings	14th	-	-	-	-	8	-	-	-	-	-	10	-

"Supervision related comments" is the third rated dissatisfier. Comments such as 'officials on the jobs who don't know anything but try to treat you like an idiot', 'being regarded as a non person', 'take or leave it attitude of staff' etc. - all reflect the strength of opinion on this dissatisfier. From these comments it seems bricklayers do not really mind being corrected but negative human relations from their supervisors cause them much dissatisfaction with their work. The fourth rated dissatisfier is "working conditions". One complained that he is frustrated because 'in 12 years there has been no change in my status'. What change does he really want? Is it to become a supervisor? Yes. He and others in this category think there should be more room for improvement in personal status. The majority however, are contented with working just in their trade and would even resist being promoted because all they want is to remain tradesmen.

Two observations could be made from the classification of bricklayers' comments on satisfiers and dissatisfiers. First the rankings reveal that dissatisfiers are not the exact opposite of satisfiers as earlier observed by Herzberg and Borcherding - they are not on the same scale. Also, the list of dissatisfiers shows more variations than the list of satisfiers. This may be due to the fact that dissatisfying situations are more easily recognised by human beings. As job satisfaction is not our focus in this chapter no further analysis of the responses is considered necessary. The identified satisfiers and dissatisfiers helped in compiling the lists of motivators and demotivators.

7.2.3 Motivating Variables in Bricklaying.

As earlier defined, a satisfier capable of energising workers to produce is a motivator / motivating variable. From the identified satisfiers and literature citings, a list of fifteen motivating variables was drawn and presented to bricklayers. They were asked first to evaluate the degree of importance of each variable without relating them to their present site. Secondly, they were requested to evaluate the degree to which each variable was motivating them on their present sites. The relative importance index per variable were ranked and the relative motivation index of each variable were also ranked. In order to evaluate the overall motivation of the worker, the total relative motivation indices of all variables were calculated (See chapter 5) and taken as the measure of motivation in the operative (see example in Table 5.4). Table 7.3 shows the rankings by total importance scores and the relative indices of each motivation variable. The total relative motivation indices of each worker will be used to find the relationship between motivation and productivity in a later section of this chapter.

As we shall be drawing various inferences from these scores and indices it is an important statistical step to test these data for normality. The reason being that most inferential statistics is based on normal distribution characteristics (see Appendix E for explanation of the statistical approach taken in this study).

The normality tests show that the motivation scores in each variable are not normally distributed at 95% level of significance but rather at lower levels. This is buttressed by the skewness of the variables ranging from a low 0.074 in 'accurate description of work' variable to 0.948 in the 'overtime' variable. (See Table 7.4 for statistical description of each variable). However, a logarithmic transformation of the data reveals that the underlying trend is normal at 95% i.e. the data are from a normally distributed population. Based on this confirmation of normality it is possible to proceed with the analysis of the data using normal distribution statistics.

The first step taken in our analysis was to find the correlation between the levels of importance and on-site gratification of the motivation variables. This was in order to know the level of interdependency between the two influences of the motivation level. The correlation coefficients between the two were found to be significant, ranging from 0.66 in the 'bonus' variable to 0.94 in the 'good relationship with mates' variable. This significant relationship shows the tendency of bricklayers' to rank active motivation factors in their environment as being important.

The strength of dependency between motivation index scores across variables was also found by correlation analysis. Table 7.5 shows the 15 x 15 correlation matrix of all motivation variables. Each correlation coefficient was tested for significance (see Appendix E for tests of significance). The significant relationships are asterisked (*) on the correlation matrix table; and would form the basis of our discussion of the motivation variables.

The coefficient of variation (CV) which measures the strength of variation in a set of data was calculated for each variable. Since the scores in each variable are from individuals, it is logical to take these coefficients of variation as a measure of variation in personal / individual assessment of the importance of each variable. The CVs therefore indicate that there are wide differences in personality varying from 25.76% in the 'Good relations with mates' variable to 63.91% the 'Promotion' variable. On the strength of these scores, ranks and statistical analysis we shall now discuss each of these motivating variables.

7.2.3.1 Discussion of Motivating Variables

The most important variables when only the relative importance indices are considered are 'good relations with mates' and 'fairness of pay'. 'Good supervision' and 'the work itself' variables come next in importance. Using the relative motivation indices which include the level of gratification, this first of rankings change. 'Good relations with mates' distinctly came out as the most important as well as the most gratified motivating factor on bricklayers on these sites. 'Good supervision' is second and 'the work itself' third. 'Fairness of pay' slipped to the seventh in the gratification ranking.

Good relationship with mates is the primary motivating variable, regardless of the bricklayer's working environment. It recorded the highest overall importance index of 0.74 and motivation index of 0.69. While it shows some positive correlation with all other variables - except 'fairness of pay', 'promotion' and 'more responsibility' - it only has significant relationship with the 'challenging task' variable. Since most of the bricklayers are 'labour only' subcontractors, gang members seek work and do it together. Having been working together over long periods of time, it is a primary consideration in these gangs that relationships between gang members be sound. If not their output will fall. Since output determines earnings and output (amongst other things) depends on relationship amongst gang members, a somewhat circular relationship exist between these three variables.

Table 7.3 Comparative Ranking of Motivation Factors

MOTIVATORS	RELATIVE IMPORTANCE SCORE	INDEX	RANK	RELATIVE MOTIVATION MEAN INDEX	RANK
Good relations with mates	168	0.74	1st	0.69	1st
Good safety programme	148	0.69	8th	0.53	4th
The work itself	146	0.73	3rd	0.57	3rd
Overtime	78	0.45	15th	0.21	15th
Fairness of Pay	166	0.74	1st	0.50	7th
Recognition on the job	119	0.61	13th	0.37	12th
Accurate description of work	141	0.70	7th	0.53	4th
Participation in decision	130	0.66	10th	0.43	9th
Good Supervision	167	0.73	3rd	0.58	2nd
Promotion	102	0.58	14th	0.23	14th
More responsibility	113	0.60	12th	0.31	13th
Challenging task	135	0.63	11th	0.42	10th
Job security	154	0.71	6th	0.52	6th
Choosing workmates	137	0.68	9th	0.49	8th
Bonus	134	0.72	5th	0.41	11th

NOTE: - Relative importance index = $\frac{\text{Total Score}}{3 \times \text{No. of Respondents}}$

- See Chapter 5 for the calculation of Motivation Indices.

Table 7:4 Statistical Descriptions of Motivating Variables

Motivating Variables	Min.	Max.	Range	Median	Mean	Std.Err	Variance	Std.Dev.	C.V.	Skew.	Kurt.
Good Relations	0.25	1.00	0.75	0.75	0.69	0.02	0.03	0.18	25.78	-0.32	-0.49
Good Safety Prov.	0.19	1.00	0.81	0.50	0.53	0.03	0.04	0.19	36.83	0.29	-0.74
The Work Itself	0.19	1.00	0.81	0.54	0.57	0.03	0.04	0.21	36.15	0.19	-0.57
Overtime	0.08	0.50	0.42	0.17	0.21	0.01	0.01	0.10	48.27	0.95	0.31
Fairness of Pay	0.17	0.94	0.77	0.50	0.50	0.03	0.05	0.23	45.07	0.23	-0.96
Recognition	0.11	0.75	0.64	0.36	0.37	0.10	0.02	0.14	39.37	0.15	-0.49
Acc. Description	0.19	0.81	0.63	0.50	0.53	0.02	0.03	0.17	32.07	-0.07	-0.80
Participation in Dec.	0.11	0.70	0.59	0.45	0.43	0.02	0.02	0.16	36.18	-0.02	-0.62
Good Supervision	0.19	1.00	0.81	0.56	0.58	0.03	0.04	0.20	33.61	0.03	-0.53
Promotion	0.08	0.69	0.60	0.17	0.23	0.02	0.02	0.15	63.91	1.38	1.23
More Responsibility	0.08	0.75	0.67	0.30	0.31	0.02	0.03	0.16	51.63	0.50	-0.71
Challenging Task	0.14	0.72	0.58	0.43	0.42	0.02	0.03	0.18	43.14	0.12	-1.06
Job Security	0.14	1.00	0.86	0.53	0.52	0.03	0.07	0.26	49.72	0.35	-1.01
Choosing Mates	0.08	1.00	0.917	0.50	0.49	0.04	0.07	0.27	55.54	0.25	-1.08
Bonus	0.08	0.81	0.73	0.28	0.41	0.03	0.06	0.24	59.02	0.38	-1.39

Table 7: 5 Correlation Matrix of the Motivating Variables

Good Relations	1.00	0.27	0.26	0.10	-0.03	0.19	0.28	0.23	0.28	-0.00	-0.16	0.32*	0.03	0.24	0.17
Good Safety Prov.	0.27	1.00	0.37*	-0.08	-0.06	0.27	0.19	0.31*	0.44*	-0.21	0.02	-0.04	0.13	0.13	-0.11
The Work Itself	0.26	0.37*	1.00	-0.15	0.07	0.17	0.13	0.30	0.52*	0.17	0.12	0.30	0.45*	0.02	0.29
Overtime	0.10	-0.08	-0.15	1.00	-0.02	-0.14	0.03	-0.05	-0.14	0.26	-0.24	-0.04	0.23	0.15	0.06
Fairness of Pay	-0.03	-0.06	0.07	-0.02	1.00	0.35	0.43	0.04	0.19	0.08	-0.10	0.03	0.29	0.49*	0.20
Recognition	0.19	0.27	0.17	-0.14	0.35*	1.00	0.51	0.26	0.47*	0.03	0.19	0.19	0.36*	0.06	-0.11
Acc. Descrption	0.28	0.19	0.13	0.03	0.43*	0.51*	1.00	0.25	0.35*	-0.28	0.05	0.06	0.19	0.33*	0.05
Participation in Dec.	0.23	0.31*	0.30	-0.05	0.04	0.26	0.25	1.00	0.39*	0.20	0.32*	0.52*	0.25	0.15	0.51*
Good Supervision	0.28	0.44*	0.52*	-0.14	0.19	0.47*	0.35*	0.39*	1.00	0.03	0.22	0.30*	0.45*	0.08	0.30*
Promotion	-0.00	-0.21	0.17	0.26	0.08	0.03	-0.28	0.20	0.03	1.00	0.27	0.25	0.26	-0.04	0.38*
More responsibility	-0.16	0.02	0.12	-0.24	-0.10	0.19	0.05	0.32*	0.22	0.27	1.00	0.32*	0.32*	-0.22	0.10
Challenging Task	0.32*	-0.04	0.30*	-0.04	0.03	0.19	0.06	0.52*	0.30*	0.25	0.32*	1.00	0.20	0.04	0.48*
Job Security	0.03	-0.13	0.45*	0.23	0.29	0.36*	0.19	0.25	0.45*	0.26	0.32*	0.20	1.00	0.29	0.30*
Choosing Mates	0.24	0.13	0.02	0.15	0.49*	0.06	0.33*	0.15	0.08	-0.04	-0.22	0.04	0.29	1.00	0.26
Bonus	0.17	-0.11	0.29	0.06	0.20	-0.11	0.05	0.51*	0.30*	0.38*	0.10	0.48*	0.30*	0.26	1.00

N.B. (*) Denotes significant correlation coefficients. See Appendix E for Test of Correlation.

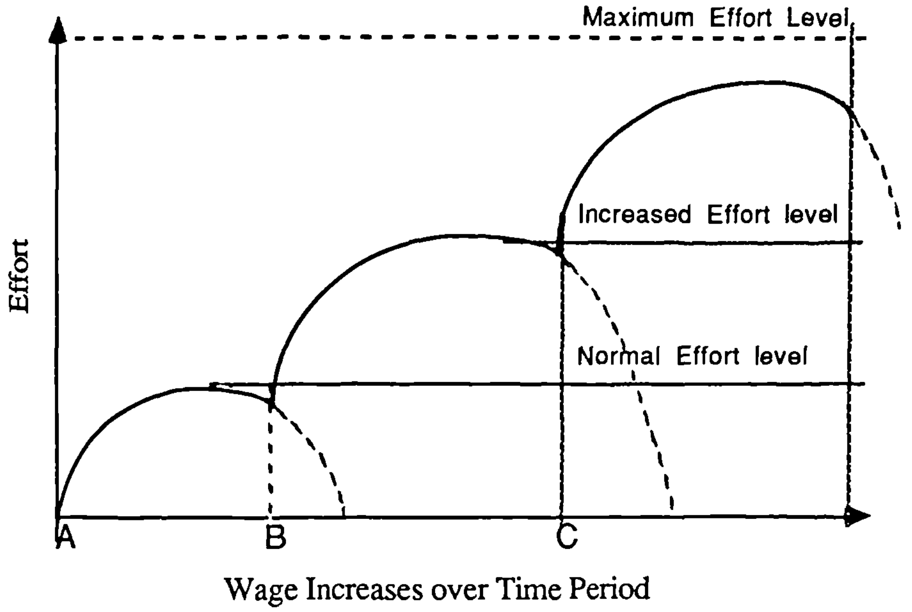
GANGS ⟷ OUTPUT ⟷ EARNINGS

Relationship with workers in other gangs can also affect their work. In chapter 6, we identified crew interference as the most significant problem on these sites. Harmonious relationships amongst all workers on site will reduce interference from other gangs and it is possible that a particular gang can have positive relationship with others resulting in using materials across gangs or obtaining advice from one another at knotty junctures. The significant relationship found between this variable and 'challenging task' may be interpreted by the fact that gang members become more united when the task is challenging. Greater productivity can be expected from gangs when both variables are present.

Fairness of Pay is another highly ranked motivating variable. Considering its 0.74 relative importance index and earlier identification as the chief satisfier, there should be no question that it is a high level motivator. From these rankings it is possible to refute Herzberg's argument that money is not a satisfier and therefore not a motivator, on the ground of possible misconception of the role of wages in human motivation.

There is much difference between Pay and Earnings. When there is parity between pay and effort, we say that the wage is fair and equitable. There is possibly a parabolic relationship between wages and effort. Let us illustrate this with Figure 7.2 below.

Figure 7:2 A Conceptual Frame of the Wage-Effort Relationship



Points A,B and C are points when there is increase in wages. Whenever there is an increase in wages, workers increase their effort. After a short time an optimum increase in effort is reached. This is sustained for a period of time before a process of conscious or unconscious withdrawal of effort commences until the next wage increase. Possibly, Herzberg believes that this can continue forever and therefore wages and wage increase can never satisfy. The truth however is that, each increase in wages before substantial withdrawal of effort (see dotted portions of each subcurve) will push effort up towards an overall optimal capacity level in the workers and that each subcurve has an optimal point.

Although effort starts to decrease at this point through a process of conscious withdrawal, a sensitive management can maintain effort at this level before the next wage increase. The argument here is that workers are motivated up to this point and that fair wage is an incontestable motivator - at least in the construction situation. Underpayment will surely lead to a conscious withdrawal of effort. While money in the very long run may not be a satisfier, commensurate monetary rewards for effort expended satisfies and motivates.

A second look at productivity literature reveals that some classical experiments (Gilbreth (50) and Smith (129)) were construction industry based. From these it is possible to see the effect of wages on effort, basically because construction projects last just for a couple of months. In modern manufacturing industry based experiments, it is possible to spread observations over longer length of time, at the end of which the influence of wages may wear out. The difference between the two schools of thought could therefore be due to the different experimental settings. A bridge may be built between the classical and modern schools of thoughts on this issue by considering the effect of time on operative motivation.

"Fairness of Pay" has a significant relationship with "recognition on the job" and "the choice of working mates" motivating variables. Since a gang's wages depends on its output, it is quite logical that bricklayers seek to work with mates which will help achieve high production output, thereby improving earning levels. The relationship between pay and "recognition on the job" variable is a bit difficult to explain. Possibly, bricklayers like most other sets of workers measure status by earnings. Status is related to ego which in turn is related to the "recognition on the job" variable.

Good supervision and **the bricklaying work itself** were rated jointly as the third most important motivating variable with relative indices of 0.73. This index is just marginally lower than the 0.74 for the first rated variables. An early indication of supervision as a high ranking motivator was given in its rating as the third most important satisfier. Why was it so highly rated? The answer to this can be found in its significant relationship with the 'actual bricklaying work itself' and 'safety' motivating variables. Without adequate supervision, production problems in the actual work will overwhelm the workers and subsequently reduce their efforts to produce. The earlier identified problems - lack of materials, repeat work and crew interference - were all direct results of inadequate planning, resource scheduling and job sequencing by the supervisor. The relevance of supervision to working patterns on site is further reinforced by the relatively high and significant correlation coefficient between the two variables. The significant relationship between "good supervision" and "good safety provision" is quite logical. When there is good supervision there is bound to be good safety on sites which will result in higher level of motivation in the workers.

The bricklaying work itself is another important motivating variable. It has significant linear relationship with "good safety provision" (0.365), "good supervision" (0.518) and "job security" (0.454). In an economy currently experiencing dire skill shortages, being a skilled bricklayer practically guarantees a job. Apart from job guarantee, being in the trade itself motivates. One commented that he purposely came into the trade to continue the family tradition and cannot imagine himself in another trade. Such loyalty or pride in a trade is a source of satisfaction and motivation. This factor also has significant link with 'good safety provision' which may mean that bricklayers consider their trade inherently safer than other trades competing for their loyalty.

Job security is the sixth ranked most important and gratified motivation influence on these twelve sites, see Table 7.3. It is significantly related to 'the work itself' (0.454), 'recognition on the job' (0.355), 'good supervision' (0.446) and 'more responsibility' (0.322). Apart from its relationship with 'the work itself' variable, which has been previously discussed, other variables indicate its significant relationship with the site management function. It is logical to expect job security when more responsibility is entrusted to the workers and workers will naturally stay longer on sites offering them more recognition - an element of good supervision. There is more inter-dependency between other motivating variables and the "job security" variable.

Accurate description of work and **good safety provision** were the seventh and eighth ranked important motivaton variables respectively. Accurate descriptions - clear, unambiguous, easy to read drawings; all point to the workers' desire to avoid repeat work. This is very important to 'labour only' subcontractors who simply cannot afford repeating work since prices for repeat work, often due to faults originating from the main contractor are not very encouraging and more because, repeat work due to supervisor's fault are often done free to maintain good relationship with the supervisor.

"Accurate description of work" has significant relationships with "recognition on the job" (0.511), "good supervision" (0.346) and "choosing work mates" (0.331). From these we can infer that if the worker had chosen good work mates (9th ranked motivator), one person in the gang will, at least, understand the instructions on drawings so that the gang can work to instructions and not be blamed for not following instructions. More recognition on the job often leads to gangs being left alone to do job with minimal supervision from site personnel. This gives bricklayers the much needed freedom to express their skill and quietly rectify mistakes when made. Such freedom reduces the tension often attached to repeat work on sites. The positive relationship between "accurate description of work" and "good supervision" is logical as both motivators have overlapping interpretation and in most situations accurate job description is a function of good supervision.

"Good safety provision" is a latent motivator until activated on risky sites. This is because of the tendency by human beings to recognise danger only when it is nearest. With a relative index 0.695 this motivator has significant relationship with 'the work itself' (0.365), 'participation in decision making' (0.306) and 'good supervision' (0.441). The higher the "participating in decision making" variable is activated the higher the "good safety provision". Workers know more than management about 'on-site' safety. For example a bricklayer standing on a scaffold should know more about its stability than management. If he can communicate this to site management or if he was consulted when the scaffold was being constructed, he will not have to stop working because of unstable scaffold. More, his ego would have been boosted for the consultation and therefore he will be more motivated.

"Participation in decision making" was the tenth ranked motivator in the 15 - variable list with a relative importance index 0.66. It relates significantly with "good safety provision" (0.306), "good supervision" (0.388), "more responsibility" (0.315), "challenging task" (0.522) and "Bonus" (0.506). The relationship with the last two variables are relatively high. When a task is challenging there is the need for an exchange of ideas between operative and site management which can often lead to the operative participating in the decision making process. In some instances the operative is left to do the job in the best possible way, probably because the supervisor is short of ideas thus bringing the recognition variable into the picture. All the variables then work together to accomplish the task.

The relative importance of the motivating variables and their inter-relationships have so far been discussed. A great inter-dependency between the variables is noticed with each variable significantly relating to at least two other variables . This indicates that total motivation in an individual is a melting pot of all these variables as earlier hypothesised. Although their relative importances have been discussed based on relative index ranking, none works in isolation. Only 'fairness of pay' changed quite significantly in ranking from the first ranked in importance to seventh gratified motivating factor on these sites. Let us now take a look at the 'other side of the coin' - the demotivating variables.

7.2.4 Demotivating Variables in Bricklaying

The same approach as in our discussions of motivating variables in the last section is taken in this section. A list of fourteen demotivating variables based on both literature and the list of dissatisfiers was presented to bricklayers on all the sites to first rank the order of importance of the variables regardless of the sites, and secondly to rank the degree of demotivation with respect to their current sites. Both the relative importance indices and relative demotivation indices ranks are shown in Table 7.6. Normality tests were conducted on the distributions of the data in each variable. This showed that the data are from a normally distributed population; as such, further statistical judgements are possible. As earlier found in motivation variables, there is significant relationships between bricklayers' ranking of the importance levels of the demotivation factors and their gratification.

The linear interdependencies between the demotivating variables were tested by correlation analysis. Each correlation coefficient was tested for significance (see Appendix E). The significant coefficients are asterisked (*) in the correlational matrix table 7.8. Table 7.7 shows the full statistical description of each variable. The coefficient of variation, which indicates the degree of variation in individual assessment of each variable ranges between 34.676% in 'mates not cooperating' to 56.262% in 'work not enough' variables - a closer range than our observation in motivating variables. This indicates a closer agreement in the assessment of demotivating variables than the motivating variables. Tables 7.6, 7.7 and 7.8 form the basis of our discussion of demotivating variables in bricklaying.

7.2.4.1 Discussion of Demotivating Variables

Disrespect by site management was the most important demotivator, while cold weather was the worst demotivator on the sites investigated. Disrespect is not only in direct abuse to the workers (which may readily come to mind) but in the totality of the supervisory attitude towards operatives. The significant relationship between this demotivator and 'discontinuity of work' (0.317), 'urging but not caring' (0.585), 'cold weather' (0.338) and 'no enough work' (0.430) give some insight to what the bricklayers regard as disrespect. Uncaring or non-chalant attitude by the supervisor is apparent in work allotment and the way the supervisor treats workers' requests on site. If the supervisor is not concerned about how the worker progresses (work and earnings wise) and does not provide the resources needed for continuity of work, urging the workers to meet deadline will only be an exercise in hypocrisy - salt on injury for an alienated worker !

The relationship between this variable and 'cold weather' is explained by the lack of provision of warm clothing on most of the sites to 'labour only' workers - a privilege they used to enjoy when 'on the books' was the norm. Whether contractors should continue to make basic welfare provision for workers on their sites is a question of morality which the industry needs to examine in its continuing evolution.

Figure 7.6 Comparative Ranking of Demotivating Influences

DEMOTIVATORS	RELATIVE IMPORTANCE SCORE	INDEX	RANK	RELATIVE MOTIVATION MEAN INDEX	RANK
Disrespect	153	0.81	1st	0.42	1st
Little accomplishment	126	0.70	10th	0.34	12th
Discontinuity of work	138	0.74	5th	0.44	3rd
Non recognition	113	0.62	12th	0.36	12th
Underutilisation of skill	127	0.71	9th	0.38	6th
Incompetent workmate	127	0.73	6th	0.35	11th
Mates not cooperating	140	0.80	2nd	0.37	7th
Poor inspection programme	97	0.57	13th	0.25	14th
Unsafe conditions	143	0.79	3rd	0.47	2nd
Urging but no one caring	101	0.64	11th	0.36	9th
Hot weather	121	0.72	8th	0.39	5th
Cold weather	142	0.79	3rd	0.57	1st
Too much work	90	0.53	14th	0.30	13th
Not enough work	124	0.73	6th	0.37	7th

NOTE:
- Relative importance index = $\frac{\text{Total Score}}{3 \times \text{No. of Respondents}}$
- See Chapter 5 for the calculation of Demotivation Indices.

Table 7:7 Statistical Descriptions of Demotivating Variables

Demotivators	Min.	Max.	Range	Median	Mean	Std.Err	Variance	Std.Dev.	C.V.	Skew.	Kurt.
Disrespect	0.08	0.75	0.67	0.38	0.42	0.02	0.03	0.18	42.81	0.20	-0.84
Little Accomplishment	0.08	0.67	0.58	0.33	0.34	0.02	0.02	0.15	43.32	0.35	-0.47
Work Discontinuity	0.11	0.88	0.76	0.37	0.44	0.03	0.04	0.21	47.41	0.45	-0.61
Non Recognition	0.13	0.64	0.52	0.37	0.36	0.02	0.03	0.17	46.69	0.15	-1.39
Skill Underutilised	0.08	0.70	0.61	0.39	0.38	0.02	0.03	0.18	46.46	0.19	-1.02
Incompetent Mate	0.08	0.75	0.67	0.35	0.35	0.02	0.02	0.15	42.49	0.06	-0.56
Uncooperaing Mate	0.08	0.50	0.42	0.40	0.37	0.02	0.02	0.13	34.68	-0.63	-0.71
Poor Inspection	0.08	0.50	0.42	0.26	0.25	0.02	0.01	0.12	45.90	0.56	-0.57
Unsafe Conditions	0.13	0.80	0.68	0.50	0.47	0.03	0.04	0.19	40.65	0.02	-0.77
Urging but Uncaring	0.13	1.00	0.88	0.33	0.36	0.03	0.04	0.19	52.63	0.81	0.51
Hot Weather	0.13	0.75	0.63	0.38	0.39	0.02	0.03	0.16	42.48	0.41	-0.32
Cold Weather	0.15	0.88	0.73	0.57	0.57	0.03	0.06	0.24	42.05	-0.22	-1.47
Too Much Work	0.13	0.82	0.70	0.25	0.30	0.02	0.03	0.17	55.33	1.55	2.20
Work not Enough	0.08	0.75	0.68	0.37	0.37	0.03	0.04	0.21	56.26	0.46	-0.91

Table 7: 8 Correlation Matrix of Demotivating Variables

Disrespect	1.00	0.20	0.32*	0.19	0.06	-0.12	-0.26	0.24	-0.13	0.59*	0.19	0.34*	0.25	0.43*
Little Accomplishmt.	0.20	1.00	0.57*	0.38*	0.36*	0.29	0.27	0.54	0.03	0.28	-0.09	0.54*	-0.01	0.34*
Work Discontinuity	0.32*	0.57*	1.00	-0.05	-0.04	0.12	0.15	0.54*	0.10	0.51*	0.12	0.54*	0.04	0.68*
Non recognition	0.19	0.38*	-0.05	1.00	0.69*	0.25	0.20	0.35*	0.20	0.30*	-0.03	0.40*	0.34*	0.14
Skill Underutilised	0.06	0.36*	-0.04	0.69*	1.00	0.30*	0.04	0.23	0.12	0.20	-0.18	0.21	0.40*	0.11
Incompetent Mate	-0.12	0.29	0.12	0.25	0.30*	1.00	0.59*	0.24	0.28	0.04	0.19	0.28	0.08	0.16
Uncooperating Mate	-0.26	0.27	0.15	0.20	0.04	0.60*	1.00	0.10	0.48*	-0.14	0.14	0.43*	-0.17	0.19
Poor Inspection	0.24	0.54*	0.54*	0.35*	0.23	0.24	0.10	1.00	0.18	0.51*	0.04	0.47*	0.17	0.55*
Unsafe Conditions	-0.13	0.03	0.10	0.20	0.12	0.28	0.48*	0.12	1.00	-0.02	-0.36*	0.25	0.03	0.10
Urging but uncaring	0.59*	0.28	0.51*	0.30*	0.20	0.04	-0.14	0.51*	-0.02	1.00	0.17	0.44*	0.15	0.50*
Hot Weather	0.19	-0.09	0.12	-0.03	-0.18	0.19	0.14	0.04	-0.36*	0.17	1.00	0.07	0.11	0.25
Cold Weather	0.34*	0.54*	0.54*	0.40*	0.21	0.28	0.43*	0.47*	0.25	0.44*	0.07	1.00	0.12	0.46*
Too Much Work	0.25	-0.01	0.04	0.34*	0.40*	0.08	-0.17	0.17	0.03	0.15	0.11	0.12	1.00	0.07
Wirk not Enough	0.43*	0.34*	0.68*	0.14	0.11	0.16	0.19	0.55*	0.10	0.50*	0.25	0.46*	0.07	1.00

N.B. (*) Denotes significant correlation coefficients. See Appendix E for Test of Correlation.

The second ranked demotivator was **"lack of cooperation amongst workmates"** with a relative importance index 0.80. On the gratification scale it is seventh. This means that, although it was generally the second most important demotivator, it was only seventh in the rank of demotivating influence on these sites. This corroborates our earlier observation of good relationship between gang members on these sites. Where the positive side of relationship is well activated, the negative is suppressed. This variable has significant relationship with "incompetent workmate" (0.594), "unsafe conditions" (0.479) and "cold weather" (0.432). The relationship with incompetency of workmate is the most significant. It is logical to expect a reduction in the enthusiasm to produce when working with an incompetent mate. Incompetency often leads to repeat work which will demotivate the innocent worker and may lead to a feeling of frustration, reduced earnings and subsequent break up of the gang. The level of seriousness amongst gang members differs with individuals. The labourer may listen to the weather man's forecast of 'doom' for the second day and decide to take a rest at home while the bricklayers may come, meet good weather but no labourer to serve them ! It is difficult to explain the relationship between 'safety' and 'lack of cooperation amongst mates'. Not all site accidents are caused by the laxity of site management. Some are caused by the workmen themselves.

Cold weather was ranked the third most important demotivating variable on the sites investigated with a relative importance index of 0.79. It was the worst offending demotivator with a demotivating index of 0.57. It has significant relationships with 8 other variables - an indication of its importance as the most active underlying influence on other variables. These relationships indicate that there is much frustration with both site management and work mates when it is cold. Site management are less enthusiastic to encourage production when it is cold because the temperature may fall below the allowable 3^{o}C which will give the finished brickwork some efflorescense. Also, mates are not enthusiastic to work because it is cold and materials may be covered by snow or sudden rain may wash the mortar off the joints with resultant repeat work. The apathy from the management side may be attributable to the fact that most contractors plan for drops in production output during the cold months.

Discontinuity of work was the next rated demotivating variable with a relative importance index 0.74. It is significantly related to 'no enough work' (0.682), 'little accomplishment' (0.571), 'poor inspection programme' (0.537), 'urging but not caring' (0.506) and disrespect (0.317). This variable demonstrates the great interdependency between the demotivating variables. In light of the earlier identified production problems, it is not surprising that not having enough work to do is so highly related to work discontinuity. In fact this variable summarises the main elements of site management as partners to demotivation. When there is discontinuity of work, little will be accomplished and this is often caused by the non chalant attitude of management to the provision of resources needed for bricklaying on the sites.

Although each demotivating variable is distinct in the psychological sense, they show much interdependency, which confirms our hypothesis of interdependency. They may be re-classified into three broad groups- Management demotivators, Workmates demotivators and External demotivators, e.g weather. When the data was disaggregated along these new classes, management demotivators were found to be the worst on these sites. But what is the relationship between these motivating and demotivating variables and productivity really like?

7.3. Relationships Between Motivation and Productivity.

The relationship between motivation and productivity is one of the fundamental issues addressed in this thesis. While it has long been assumed that there is a significant positive relationship between these two, it has not been empirically confirmed. The actual shape of the relationship has remained a conception waiting for empirical confirmation or rejection. This section tries to fill this gap in motivation - productivity studies. Before proceeding into analysis and discussion of the findings, it should be remembered, as earlier stated in the literature review, that efficiency is generally regarded as the measure of productivity and it is defined by the relationship:

$$\textbf{Efficiency} = \frac{\textbf{Output}}{\textbf{Input}}$$

Output in this investigation is the number of bricks laid and input is the time spent by the bricklayer to produce this output. The time input as earlier explained is classified under four main sub-headings (Productive Time, Unproductive Time, Supervision Time and Extra Break). Unproductive time is subdivided into pure idleness and time spent in auxillary activities. The productivity equation can have any of these time classifications as the denominator but the most reasonable denominator is productive time. The reason for this being that it is the actual time spent working that influences output. This will measure the ability of the worker to convert this portion of the day into physical outputs. For the purpose of our investigation we shall relate each time classification to motivation and use the total time spent working and the productive portion of this as different denominators of the productivity equation above.

The concept earlier discussed in this chapter was followed in deriving the total motivation content in the worker. The demotivating indices were deducted from the motivating indices to obtain a measure of what remains in the motivation cup - the motivation content. This is rather simplistic but was a good starting point in the interpretation of the relationships between motivation and productivity.

7.3.1 The Relationships.

Correlation analysis was done to test the strength of linear dependency between the different working day classifications, the measures of productivity, the motivating indices, demotivating indices and the total motivation content indices. Table 7.9 shows the correlation matrix with the significant relationships asterisked (*) as the basis of our discussion.

TABLE 7:9 Correlation Matrix of Motivation and Productivity Indices

Productive Time Index	**1.00**	-0.27	0.10	-0.46	0.30	0.25	0.41	0.19	0.36	0.44	-0.12
Motivating Index	-0.27	**1.00**	0.13	0.46*	-0.51*	-0.07	-0.10	-0.48*	-0.46*	0.07	0.78
Demotivating Index	0.10	0.13	**1.00**	0.09	-0.06	-0.08	-0.01	-0.08	-0.02	-0.10	-0.73
% Productive Time	-0.46	0.46*	0.09	**1.00**	-0.79	-0.54	-0.37	-0.70	-0.75	0.21	0.38*
% Unproductive Time	0.30	-0.51*	-0.06	-0.79	**1.00**	-0.05	0.23	0.91	0.92	-0.24	-0.39*
% Extra Break Time	0.25	-0.07	-0.08	-0.54	-0.05	**1.00**	-0.00	-0.04	-0.05	0.03	-0.10
% Supervision Time	0.41	-0.10	-0.01	-0.37	0.23	-0.00	**1.00**	0.11	0.31	-0.20	-0.08
% Unproductive-IDLE	0.19	-0.48*	-0.08	-0.70	0.91	-0.04	0.11	**1.00**	0.67	-0.19	-0.39*
% Unproductive-AUXILLARY	0.36	-0.46*	-0.02	-0.75	0.92	-0.05	0.31	0.67	**1.00**	-0.25	-0.33*
Total Time Productivity Index	0.44	0.07	0.10	0.21	-0.24	0.03	-0.20	-0.19	-0.25	**1.00**	0.11
Motivation Band	-0.12	0.78	0.73	0.38*	-0.39*	-0.10	-0.08	-0.39*	-0.33*	0.11	**1.00**

N.B. (*) Denotes significant correlation coefficients. See Appendix E for Test of Correlation.

Figure 7.3 Relationship Between Motivation and % Productive Time

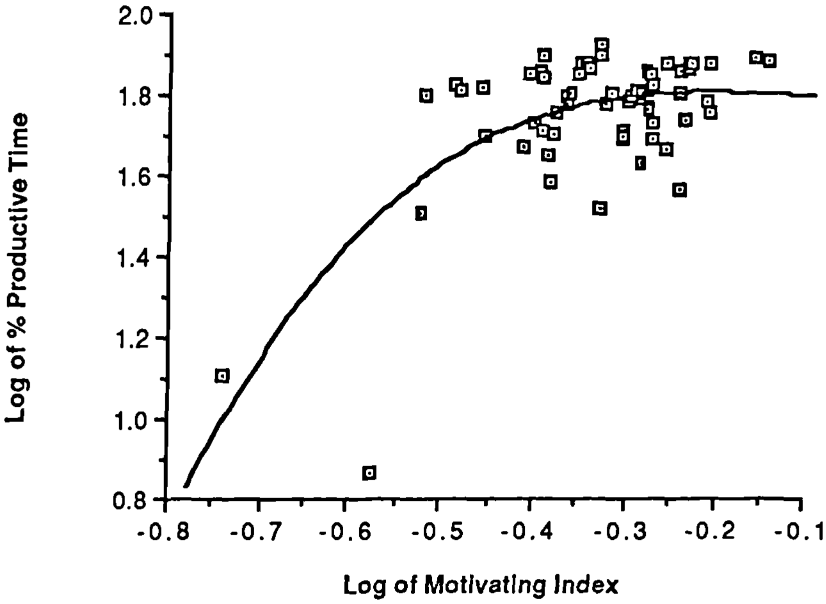


Figure 7.4 Relationship Between Motivation and % Unproductive Time

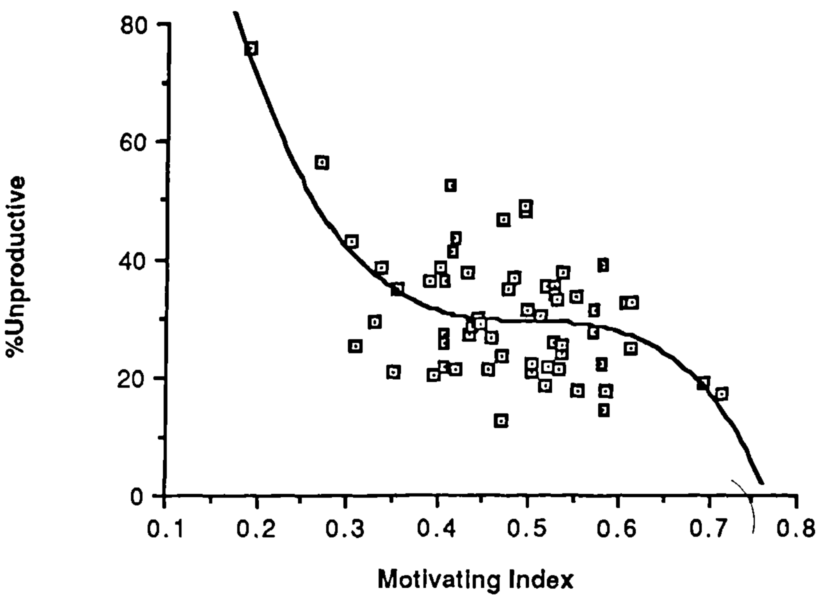


Figure 7.5 Relationship Between Motivation and % Idle Time

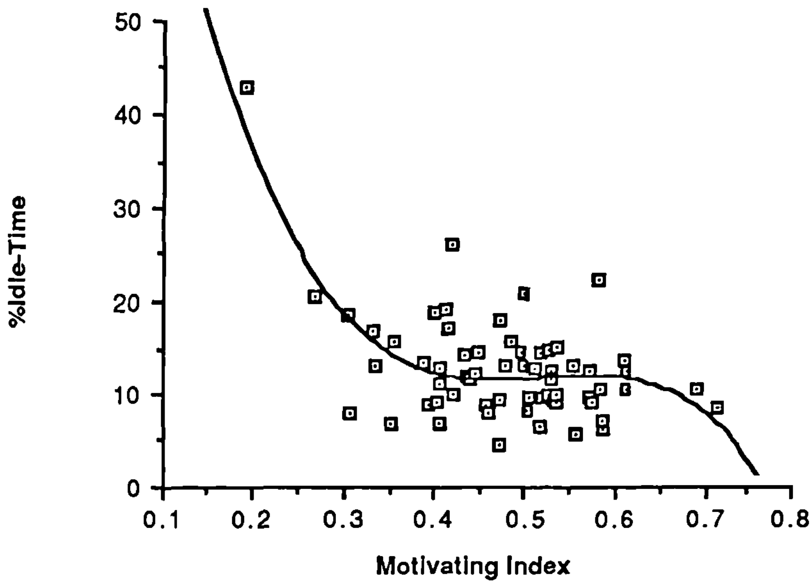


Figure 7.6 Relationship Between Motivation and % Auxillary Time

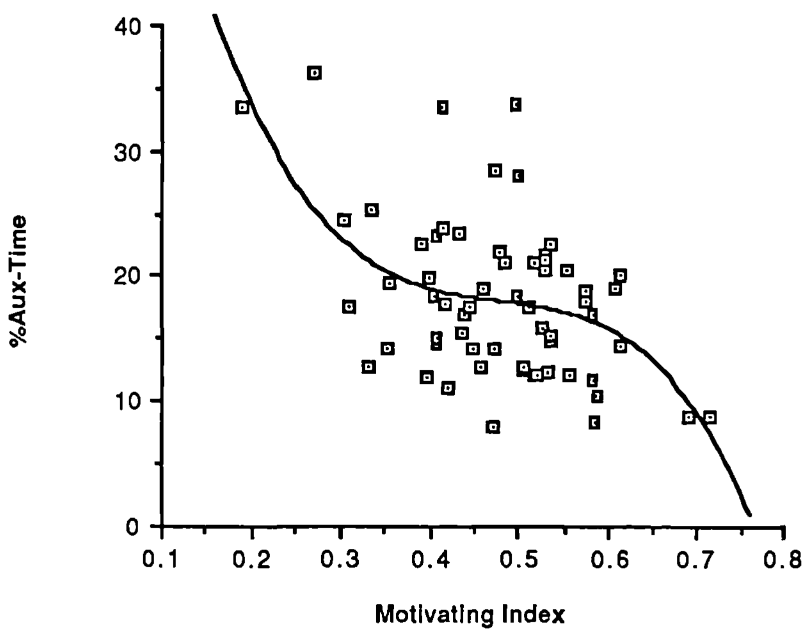


Figure 7.7 The Motivation Band

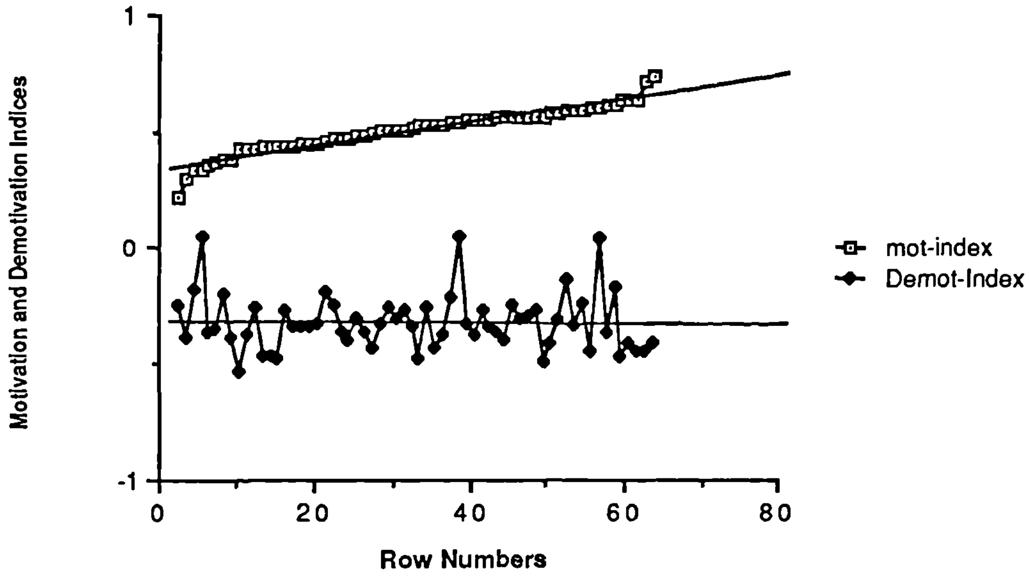
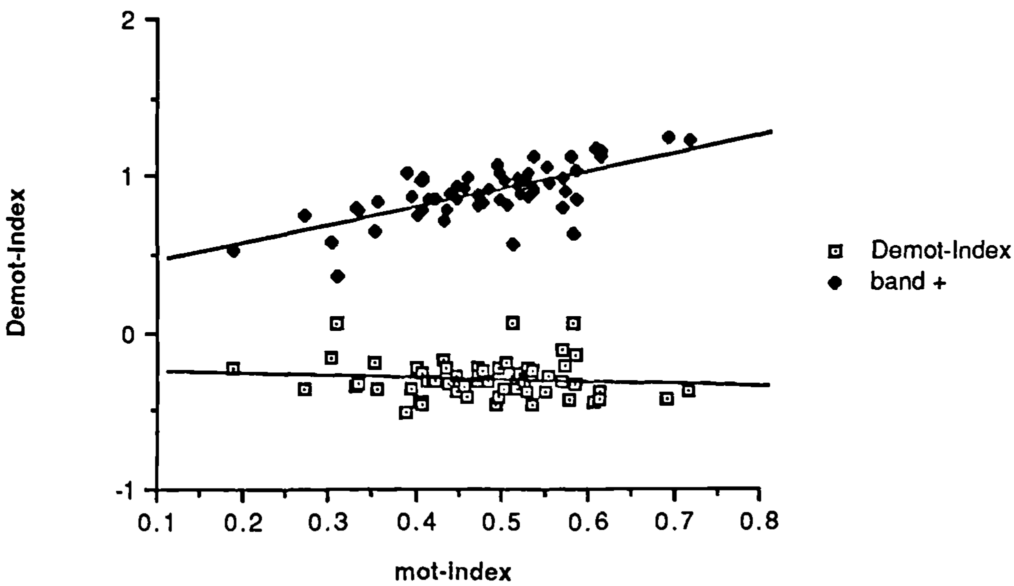


Figure 7.8 Relationship Between Motivation, Demotivation and Band



There is no significant relationship between any of the two productivity measures and any of the motivation related indices (see Table 7.9). This is rather astonishing. The measure of productivity using the total time spent as the denominator is less related to the motivation indices than the second measure which uses only the productive time as the denominator.

An inference can be drawn about the nature of these two measures that they are simply measures of the rate of production, i.e. bricks per minute. Motivation does not influence the rate of working. What influences or determines how fast a worker produces is more a function of his skill and equipment. This will be examined in more detail in chapter 8.

The most significant positive relationship is between motivating indices and percentage productive time with a correlation coefficient of 0.455 and a logical negative relationship (-0.513) with percentage unproductive time. The higher significant relationship with unproductive time may signify that, motivation has higher bearing in reducing percentage unproductive time than it does with increasing percentage productive time. Its relationship with the two classes of unproductive time logically follow the general relationship with unproductive time. With polynomial and logarithmic transformations, the strength of these relationships become firmer, reinforcing the base of the relationships. See figures 7.3 to 7.8. for these relationships. The third order polynomial relationship between percentage productive time and motivation is of the form:

$$\mathbf{Y = 198.4241 - 1045.3372X + 2139.7287X^2 - 1464.7369X^3} \quad \textit{R = 0.63}$$

where Y = Percentage Productive Time

X = Motivation Index

The coefficient of correlation **R** improves with a normal logarithmic transformation of the entire data to 0.68. The equation of the relationships then becomes:

$$\mathbf{LogY = 1.7583 - 0.797(LogX) + 0.8606(LogX)^2 + 3.1537(LogX)^3}$$

From Figures 7.3 and 7.4 it is clear that there is an amount of motivation in the workers regardless of the situation on any of the site. Based on this observation it can be said that every bricklayer has a little amount of motivation in him regardless of site. This is in order with literature, especially with Macgregor's theory Y proposition that human beings like to work (102). As motivation rises from this base the percentage productive time rises steeply before optimising on a plateau; confirming the earlier discussed Yerkes and Dodson (153) 19th century conception of optimal motivation in bricklaying operatives.

There is no significant relationship between the demotivation indices and percentage productive time or percentage unproductive time. Our total motivation content is only barely significantly related to productive and unproductive time which shows that motivation is not simply a straight forward deduction of demotivation from motivation. The relationship is more complex than that.

From the correlation matrix in Table 7.9, it is clear that the main variable of real and consistent significance to production is the motivating index. Where the motivating variables are positively activated, they override the influence of the demotivating variables. This is demonstrated in Figure 7.8, with the demotivating index declining as the motivating index increases. This observation contradicts the norm in construction operative motivation literature (25) where emphasis has been on first removing the demotivators before applying motivators.

As revealed by the analysis above, motivation is not directly related to the rate of production. It first influences the percentage productive time and then the output. It is skill that influences the rate of production. A 70% motivated but 60% skilled bricklayer may not necessarily produce as much as another 60% motivated but 70% skilled worker. How much influence does motivation really have on percentage productive time?

7.3.2 . Predicting % Productive Time With Motivators

In light of the significant relationship found between percentage productive time and motivation, the dependencies between percentage productive time and individual motivators was assessed by correlation analysis. Significant individual relationships exist between percentage productive time and 'fairness of pay' with correlation coefficient 0.302, 'accurate description' 0.399, 'participation in decision making' 0.330, 'challenging task' 0.367, and 'bonus' 0.354.

Collectively, a stepwise regression analysis was conducted on the motivating variables to predict percentage productive time. This was done in order to know how much a knowledge of these motivating variables can help in predicting percentage productive time, i.e. the percentage variance that will be accounted for by motivating variables in predicting percentage productive time. This analysis also helped in pinpoint which of the motivating variables had the most significantly influence on percentage productive time. Table 7.10 shows the result of the stepwise regression.

Table 7.10 Predicting % Productive Time With Motivators

Y - variate = % Productive Time	**ESTIMATE**	**S.E.**	**T**	**% Variance**
Constant	9.9394	9.5845	1.04	-
Good Supervision	5.0400	3.3057	1.52	14.70
Job Security	2.9997	2.4930	1.20	20.80
Accurate Description	4.8737	3.0292	1.61	22.80
Challenging Task	4.0440	2.6874	1.50	25.30

The F statistic was tested for significance at each subsequent addition of "job security" "accurate description of work" and "challenging task" to the most significant motivating variable - "good supervision". Though they increased the percentage variance that can be explained by motivation in percentage productive time they were not significant. Because of this increase in percentage variance and the randomness of the graph of residuals at this point, it can be rationalised that these are the variables which most influence percentage productive time. If we limit ourselves to the significant variable - Good Supervision - we will only be able to explain 14.7% of the variation in percentage productive time. The four variables collectively account for 25.3% of the variance in percentage productive time. It is thus clear that motivation level is not the only variable influencing percentage productive time. Other factors, such as the identified problems in the last chapter, possibly account for the remaining 74.7%.

7.4. Summary

1. Work related factors are the most prominent job satisfiers to bricklaying operatives.
2. Dissatisfiers are not exact opposite of satisfiers (as earlier observed by Herzberg and Borcherding).
3. Significant relationships exist in the rankings of the levels of importance and gratification of motivation variables by bricklayers.
4. Inter personal relationships between workmates is the greatest primary motivator to bricklayers.
5. Fairness of wage is an incontestible motivator to bricklayers. The relationship between wages and efforts is conceptually parabolic.
6. As earlier hypothesised in chapter 5 there is great inter-dependency between motivating variables which indicates that the total motivation in an individual may be a melting pot of all these variables and none should be treated in isolation.
7. Disrespect as reflected by the totality of supervisory attitude towards operatives is the greatest demotivator.
8. Motivation does not influence the rate of working. Rather it influences the percentage of working time spent productively.
9. There is a basic motivation to work in every bricklayer.

10. Good supervision is the only significant variable influencing percentage productive time. The other variables contributing, though not significantly, to percentage variance explained by motivating variables in percentage productive time are: 'Job Security', 'Accurate Description of Work' and 'Challenging Task'.

11 Motivation is not the only variable influencing percentage productive time. It accounts for 25.3% of the variations in percentage productive time.

CHAPTER 8

CHAPTER 8

A MODEL OF PRODUCTION OUTPUT AND MOTIVATION

8.1 Introduction

It was demonstrated in Chapter 7 that there is apparently no significant relationship between motivation and the rate of production. However, a significant relationship exists between motivation and percentage productive time. The pattern of this relationship was also discussed. It was suggested that the principal contributor to the rate of production, i.e. how much a worker achieves in a unit of time, is SKILL (the ability to combine all necessary productive motions to achieve a standard output). Skill determines the difference in output between two bricklayers over the same period of productive time. While motivation will contribute to this, the skill element is the over-riding factor.

Motivation influences the percentage productive time quite significantly; but its influence stops there! After giving a kick to the percentage productive time, it then gives way to the domineering influence of skill. From this relationship the model of production output can be expressed as:

Production Output = F(Skill + Motivation)

The true form of this model will be determined in this chapter. Four main steps were taken in building the model. The first step was to evaluate production output in relation to the rhythm with which operatives go through the 25 activities in the working day (see chapter 5). Then, all the 25 activities in the working day were taken to predict production output regardless of site. The critical activities to production output in bricklaying were determined with the help of a series of statistical tests and deductions. The critical activities were then statistically modelled to predict production output. The model was tested for sensitivity to variations in the critical activities. The motivation element was later introduced into the model equation as a 'practically' significant factor; to assess its influence on the percentage variance in the prediction of bricklayers' output . Let us proceed with the first step.

8.2. A General Overview of Production Output in Bricklaying.

Price (120) at Loughborough University in conjuction with the Science and Engineering Research Council (SERC) established a technique for measuring and developing activity sampling data into suitable synthesis for calculating standard and planning times for estimating purposes. Emsley (56) on the same research team developed a viable computer programme for collecting work study data on construction sites. She also developed another program for analysing the collected data. Her analysis program is rather laborious and cannot stand the necessary statistical scrutiny needed for an indepth analysis of production patterns in bricklaying. A straight forward analysis approach was taken in this research by transferring the data collected with the help of Emsley's program into three versatile statistical packages - MINITAB, GENSTAT and STATWORKS for comprehensive statistical analysis.

In this section we shall concentrate on 'global' issues which will help us establish the relationship between production output, skill and motivation; not on standard and planning times which have been comprehensively examined by Price (120). Appendix F shows detailed analysis of basic time, planning time and site factors in bricklaying based on the techniques developed by Price (120).

8.2.1 Rhythm of Production

It was earlier established that it is the **site** rather than **gang size** that has greater influence on production output in bricklaying. However, when both site and gang size were taken together as joint controlling factors they have significant relationship with production output. Having discussed the working environment in Chapter 6, we shall now consider the gang size factor in more detail as a necessary prelude to an examination of the impact of skill on production output. The first question to answer is 'do bricklayers work in the same manner regardless of the site they are employed and is there an underlying trend in the way they work?' For bricklaying to be a distinct skilled trade, there should be an underlying rhythm in the way bricklayers work (a regular pattern in the way they go through the critical activities). Detecting this rhythm is a necessary prelude to building any model of the system. To do this, observations in each of the 25 activities were converted to percentages of total observations taken. These were then tested for correlations between gangs of the same size and individuals working in gangs of equal sizes, irrespective of site. Each correlation coefficient was tested using the appropriate correlation test (Appendix E).

Correlation coefficients ranging between 0.603 and 0.977, were found between 2 member gangs, 0.703 to 0.939 between 3 member gangs, 0.198 to 0.865 between 4 member gangs, 0.417 to 0.865 between 5 members gangs, and 0.029 to 0.996 between 6 member gangs. When these correlation coefficients were tested for significance, it was found that all the coefficients in the 2 men gangs (2 operatives + 1 labourer) were significant; leading us to infer that bricklayers in this gang size work more or less in the same pattern. In 3 men gangs the test revealed that all but 2 of the coefficients were significant holding up our earlier inference though not as cohesive as in 2 men gangs. The inference holds also for 4 and 5 men gangs but with lower T values. With 6 men, the picture becomes confusing. It seems the larger gangs have sub groups consisting 2 or 3 men working in the same pattern while others follow another pattern. Cummulatively these results signify that bricklayers largely work in rhythm with their workmates.

Although individuals may generally approach bricklaying in the same manner as shown above, it may not be generally true for the inter-relationships between gangs as the labourer and the mode of employment factors may disrupt the relationship. For a clearer picture, correlation tests were conducted on bricklaying gangs of the same size and then between gangs of different sizes. In two and three men gangs it was found that, irrespective of sites, there is a significant trend in the proportion of time spent in various activities. The same pattern holds in 4 and 5-men gangs.

If proportions of time spent in different activities relate across board as demonstrated above, why then do outputs differ? Outputs differ largely because of the lateral combinations of time spent in activities critical to production outputs. Let us now determine these critical activities.

8.3 Critical Activities in Bricklaying

One of the most important steps in model building is to first have a general model of all conceivable parameters and thereafter do a backward elimination of the insignificant parameters. This approach is adopted in this research. The development of a general model of bricklaying in 25 activities for all the sites is the first step. Regressing production output against the 25 activities gives us the model of the form in Table 8. 1.

One particular problem with this general model is that predicting output with it can be quite tedious and still leads to the familiar but arduous data management problem associated with work study. There is therefore the need to have a model that will predict output with fewer number of variables. Even the graph of standard residuals reveals the need for further adjustments to stabilise the model. The Principal Component Analysis method is one of the most recognised techniques for detecting principal variables. This technique was used to detect the critical activities. See Appendix G for some programs.

A Principal Component Analysis (PCA) of the data reveals the first Principal Component (PC), which is a clear measure of the overall size of data for all bricklayers, accounts for 51% of the total variation in output. The second PC for the bricklayers contrasts 'spread mortar', 'fetch mortar', 'fetch brick', 'lay brick' and 'set brick' variables with one another, implying that, after taking account of the overall size of the data, the main source of variation in output is the amount of time spent in these five activities. This accounts for 23.5% of the total variation. The third PC contrasts 'raking and pointing' with 'fetch brick', 'fill joints', and 'distribute'. This means the main source of variation in output between individual variables after the first 5 activities, is 'raking and pointing' relative to time spent on 'fetch brick', 'fill joints' and 'distribute'. This accounts for 5.5% of the total variation in the data. It should be noted that the critical variables are all productive activities buttressing the commonly held view that output actually depends on the amount of time spent working. Conversely, it is true that the amount of time spent in unproductive activities determine output; the relationship in this case being inverse.

To confirm these principal components as the controlling activities, it is necessary to plot the data in a 'best fitting' 9 - dimensional subspace ($9<p$) to minimise the sum of squared perpendicular distances of $X1, X2......Xn$ from the subspace, such that the appropriate subspaces can be defined by the first 3 PCs. Two dimensional plots will enable us detect patterns in the data. The rule is that if the data does not lie close to a 2 (or 3) dimensional subspace, then no two (or 3) dimensional plot of the data will give an adequate representation. However, if the data is close to 2 dimensional subspace, then most of the variation in the data will be accounted for by the first 2 (or 3) PCs. A plot of the observation with respect to these PCs will give a realistic picture of what the data look like, unless important aspects of the data structure are concentrated in the direction of low variance PCs (69).

Table 8.1 A General Model of Production Output

Y variate is Production Output

	Coefficient	S.E	T
Constant	90.061047	31.782845	2.83
Spread Mortar	-0.324638	2.086452	-0.16
Fetch Mortar	9.272331	2.737406	3.39
Fetch Brick	4.283432	1.823371	2.35
Cut Brick	-6.514058	2.515951	-2.59
Lay Brick	3.355408	1.776394	1.89
Fill Joints	-1.557774	2.892205	-0.54
Measure	-4.771728	4.654127	-1.03
Set Brick	-5.446043	1.681426	-3.24
Rake and Point	0.148850	1.129449	0.13
Supervision	-3.171542	1.594184	-1.99
Idle and Away	0.042769	0.313994	0.14
Relaxation	4.438384	2.768243	1.60
Waiting	6.018495	4.470101	1.35
Searching	-9.758707	4.100843	-2.38
Rework	-0.389757	3.697797	-0.11
Confused	-4.294746	8.693163	-0.49
Ancillaries	9.061485	5.030039	1.80
Other Works	4.365187	1.646983	2.65
Drive Dumper	89.581149	42.113122	2.13
Operate Mixer	31.550074	15.592216	2.02
Climb	-6.683525	5.581287	-1.20
Distribute	-29.357787	13.186960	-2.23
Fetching (L)	-2.526673	2.724904	-0.93
Cleaning	6.704224	6.157322	1.09
Read Drawing	-5.977917	9.467134	-0.63

Analysis of Variance

	DF	SS	MS
Regression	25	2342403	93696
Residual	60	443873	7398
Total	85	2786276	32780
Change	-25	-2342403	93696

Percentage variance accounted for 77.4

*The percentage variance accounted improves to 81.1% when the sites are included in the model.

Figure 8.1 First Principal Component Against Second PC

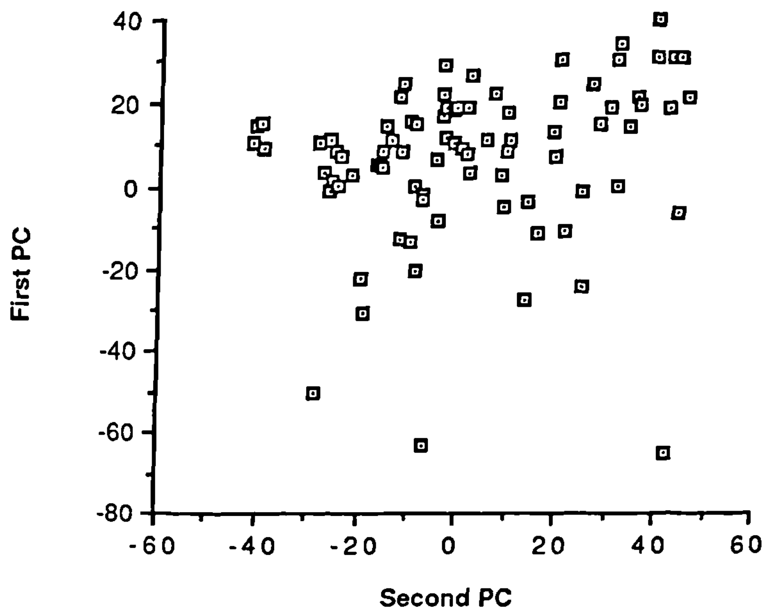
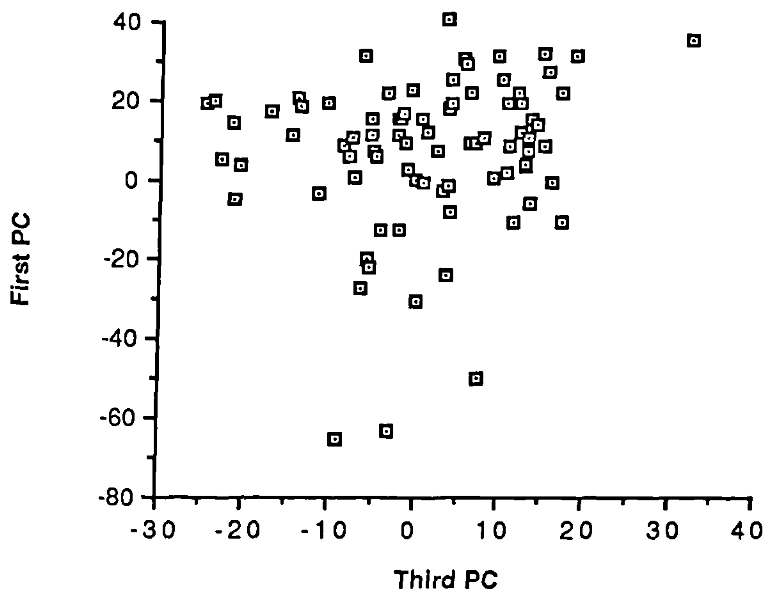


Figure 8.2 First Principal Component Against Third PC



Figures 8.1 and 8.2 show plots of the bricklaying observations with respect to the first 2 PCs. These figures confirm that the data lies close to the 2 dimensional subspace and would therefore represent the whole data and thereby reduce any laborious concentration on other none principal components of the data.
This principal component analysis gives us an insight into the main controlling variables, but these variables become very interdependent from the third principal component onward. This makes the determination of their levels of importance impossible and further analysis therefore requires more statistical assistance. The 'best' (a stepwise regression approach) statistical approach was adopted to assist in pinpointing the critical activities.

Table 8.2 shows the revised model of production output using the 'best' stepwise regression approach on the 'Genstat' statistical package (see Appendix G for programs). The graph of the residuals shows that the data has an underlying triangular pattern signifying the need for transforming the whole data values. It is statistically accepted that if these best values can produce a graph of residuals with no definite pattern, the model is acceptably stabilised for prediction. If there is a definite pattern after this, it will be necessary to proceed with transformed data values. The graph of the residuals of the variables in the revised model shows no clear pattern. It is therefore an acceptable model for predicting productivity in bricklaying. It should be noted that the first variable is not considered to be one of the main variables by this technique in contrast to our previous principal component analysis. To verify, the first variable was added to this model but did not give any significant addition to the percentage variance accounted for by the revised model.

This model contains non principal variables and a mixture of productive and unproductive activities which may be confusing to work study personnel. Since productive activities were dominant under principal component analysis, it would be better to concentrate only on the productive activities.

Table 8.2 Revised Model of Production Output.

Y-variate = Production Output

	Coefficients	Standard Error	T
Constant	89.61	24.30	3.69
Fetch Mortar	9.87	2.32	4.25
Cut Brick	-6.80	1.96	-3.45
Lay Brick	3.72	1.18	3.14
Setting and Checking	-6.65	1.44	-4.63
Searching	-10.89	3.45	-3.16
Other works	4.10	1.50	2.74
Measuring	-7.08	3.59	-1.97
Fetch Brick	4.03	1.53	2.64
Cleaning	8.71	5.12	1.70
Supervision	-3.21	1.48	-2.17
Climbing	-7.33	4.83	-1.52
Relaxation	3.87	2.38	1.62
Distribute	-1.49	1.23	-1.21

Analysis of Variance

	DF	SS	MS
Regression	13	2291329	176256
Residual	72	494947	6874
Total	85	2786276	32780
Change	0	0	*

Percentage Variance Accounted for 79.0

Concentrating on the activities featured in both techniques the new model would be as in Table 8.3.

Table 8:3 **The Critical Model of Production Output**

Y variate: Production Output

	Coefficients	**S.E**	**T**
CONSTANT	83.38	26.19	3.18
Fetch Mortar	9.27	2.54	3.66
Cut Brick	-8.10	2.07	-3.92
Lay Brick	6.32	1.08	5.86
Setting and Checking	-7.31	1.55	-4.71
Measuring	-7.40	3.98	-1.86
Fetch Brick	2.53	1.60	1.58

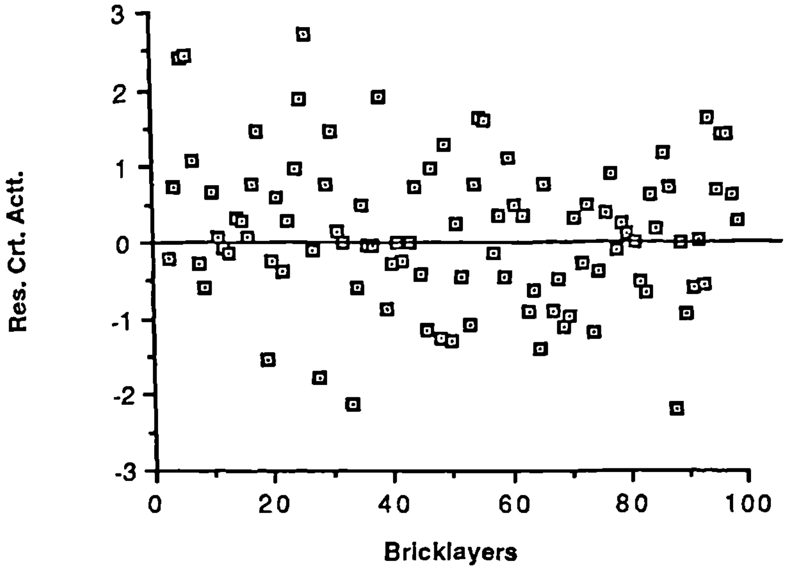
Analysis of Variance

	DF	**SS**	**MS**
Regression	6	2090778	348463
Residual	79	695498	8804
Total	85	2786276	32780
Change	-1	-21958	21958

Percentage variance accounted for 73.1

There are other models that could significantly predict bricklayers' output should we be content with lower percentage variances. While a fewer number of variables would be of much time saving value to an estimator or planner there is the need for rationalisation in determining the number of variables. We shall therefore stick to these 6 variables in the model above. The graph of residuals confirms that this is a workable model (see figure 8.3). It should be recognised that the variables with negative coefficients, though important in predicting production outputs in bricklaying, do not contribute positively to the actual number of bricks layed.

Figure 8.3 Graph of Residuals of the 'Critical' Model



8.4 Sensitivity of Production Output to the Critical Activities

A great deal of interest is generated by these 6 variables identified in section 8.3. If they are the controlling variables within the productive time, time spent on them by the bricklayers would determine output at the end of a production period. The distribution patterns in them would also reveal the variability (defined as the rate at which a bricklayer is able to finish with these controlling variables in his productive time). To determine this variability, the time spent by each bricklayer to produce 1000 bricks was worked out. A square root or logarithm transformation of each element revealed that the underlying distribution pattern was normal for the main elements. Normal Probability Density Functions (PDF) were therefore generated with the data for a clearer picture of the distributions and for prediction purposes (see figures 8.4 to 8.9).

"What characterises probability density is the fact that the area under the curve between two values (a) and (b) is equal to the probability that a random variable having this continuous distribution will assume value between (a) and (b)" (48). To calculate area under a specific value under the PDF we need the cumulative distribution function (CDF) values which can be obtained from most statistics books and softwares. Let us illustrate this with an example in the 'lay brick' activity . (See figure 8.7 for the PDF of the 'lay brick' variable).

Should we wish to know the proportion of bricklayers with basic times between 25 and 100 minutes (5 and 10 respectively on the distribution curve) per thousand bricks all we need do is to find the area of the shaded portion under the PDF. This will be given by *Area below 100* minus *Area below 25* (0.4649 - 0.1084) which is equal to 0.3565. The values of areas under 100 and 25 correspond to the CDF values at these two points. The proportion of bricklayers with basic times between 25 and 100 is therefore 35.65%. Using the distribution curves it is possible to predict the proportions of the bricklaying population with values desired by an interested investigator. These distributions can change from time to time depending on the aggregate skill levels in the bricklaying trade. It can shift to the right if there is a fall in skill levels or left if skill improves.

Figure 8. 4 Probability Distribution Of 'Fetch Mortar'

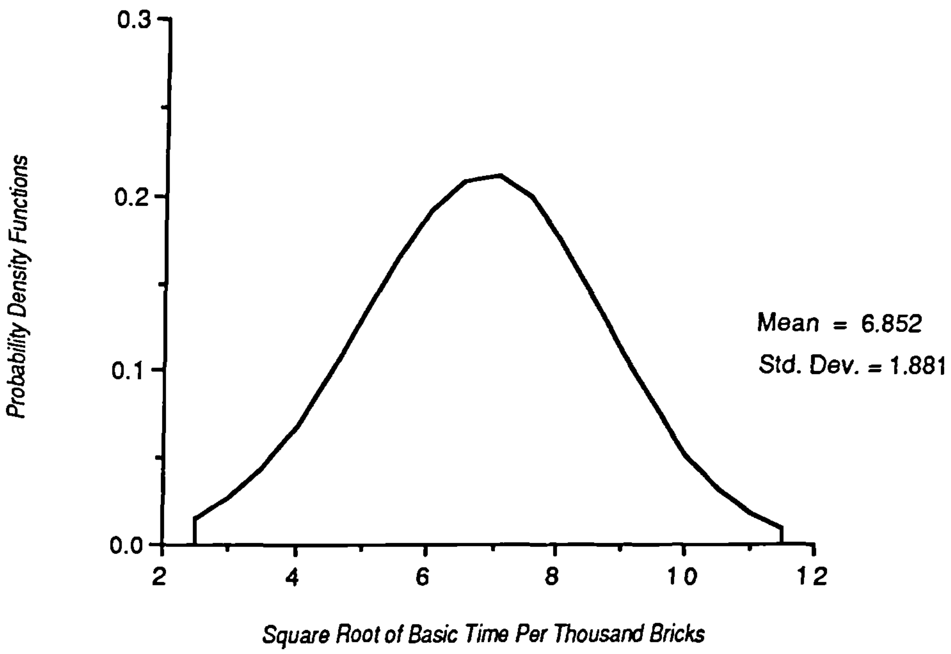


Figure 8.5 Probability Distribution of 'Fetch Brick'

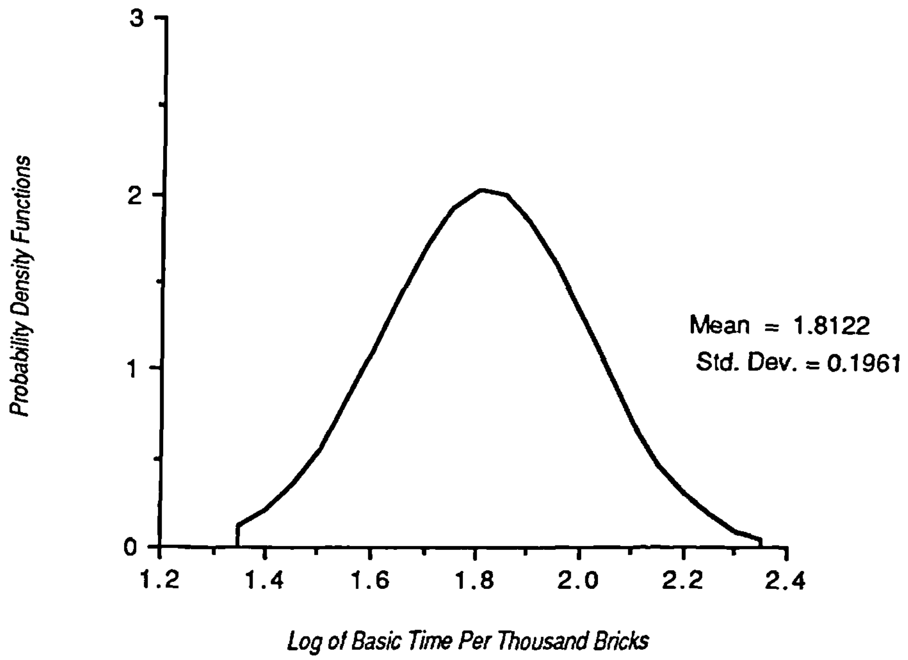


Figure 8.6 Probability Distribution of 'Cut Brick'

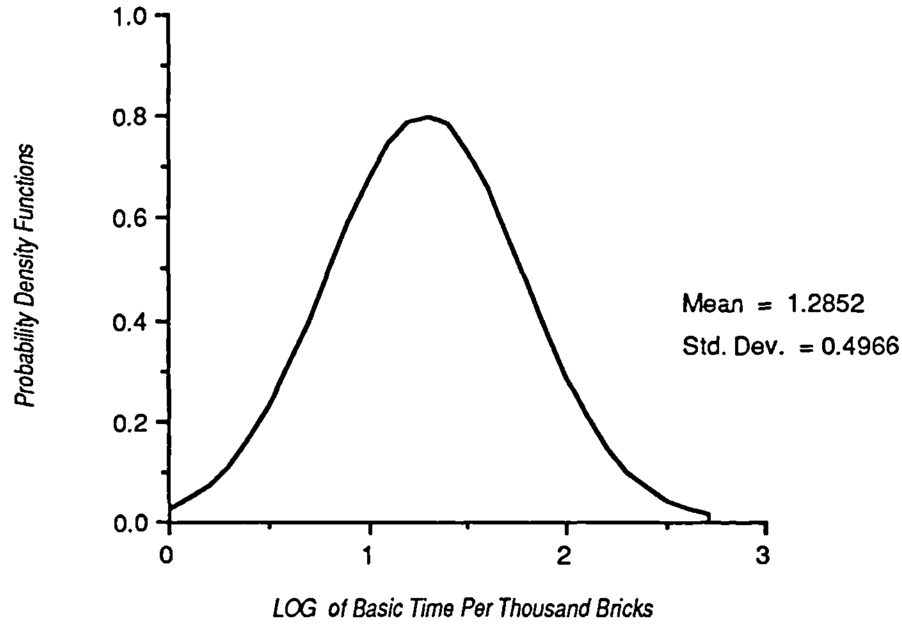


Figure 8.7 Probability Distribution Of 'Lay Brick'

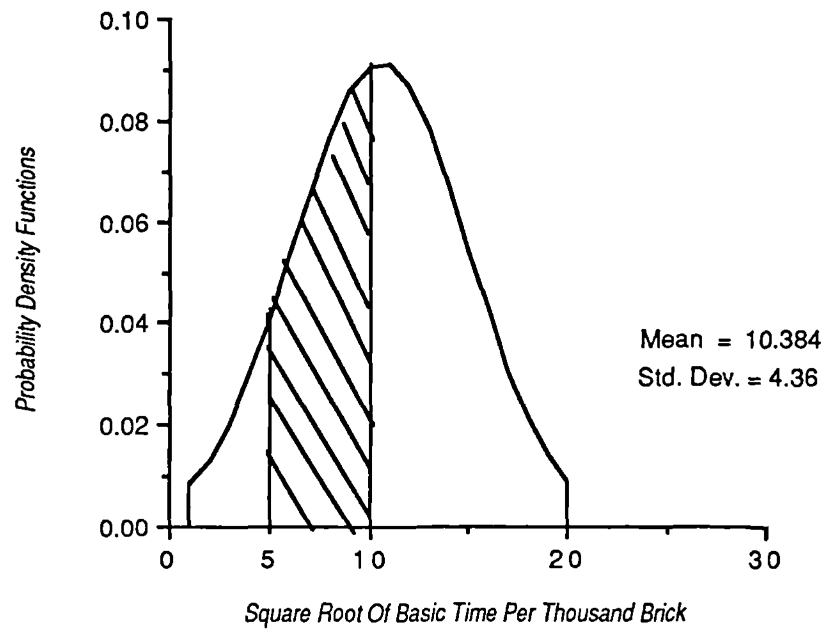


Figure 8.8 Probability Distribution of 'Measuring'

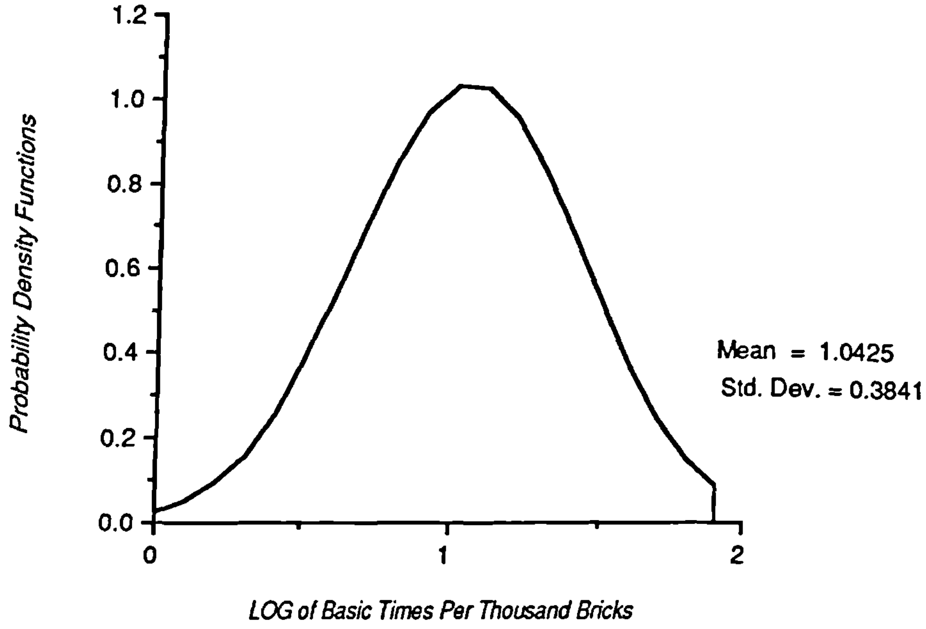
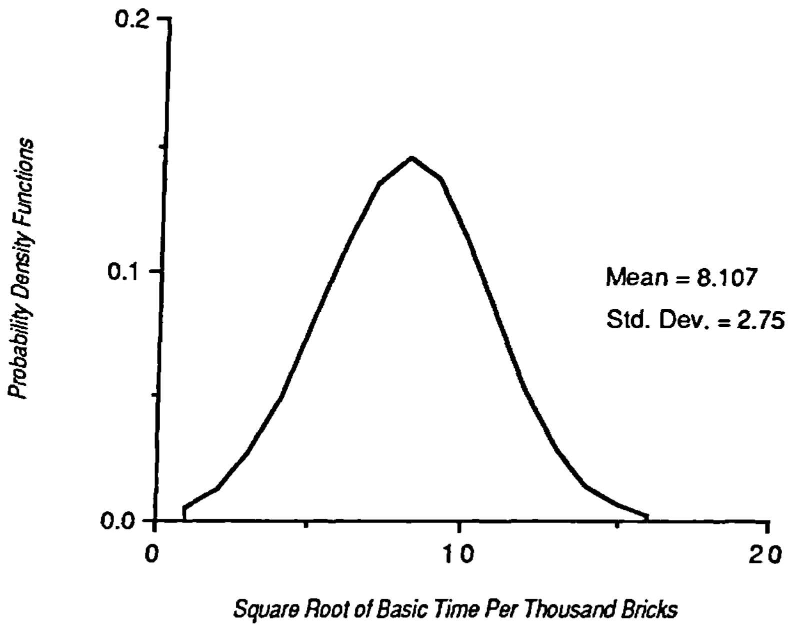


Figure 8.9 Probability Distribution Of 'Setting'



Should we want to predict the mean of the total bricklaying population in the Midlands in each significant variable, we use the **Zinterval** command on the 'Minitab' package which in equation form is an approximation of:

$$\textbf{Mean} \pm \textbf{1.96(Standard Deviation)}$$

95% confidence limits of the mean in each variable is as shown in Table 8.4. From this table we can say that with 95% assurance, the mean of the total population of bricklayers in 'fetch mortar' activity is between 35.89 and 59.75 minutes per thousand bricks.

Table 8.4. 95% Confidence Intervals of the Critical Activities.

Activities	Lower Limit	Upper limit
Fetch Mortar	5.9910	7.7310
Fetch Brick	1.7661	1.9339
Cut Brick	1.1645	1.5355
Lay Brick	8.5860	12.4140
Measuring	0.7815	1.1185
Setting and Checking	7.1510	9.8490

Note - These are transformed values. Convert before use.

8.4.1 Changes in Skill

A bricklayer's output within a production period is a function of his skill in the critical activities both collectively and individually. Since we now have a model equation of the relationship between output and these activities, it should be possible to determine the effect of variation in skill on output. This can only be achieved by bringing the equation to a common time base.

We should remember that the basic times used for the above distributions are for 1000 bricks **not per brick.** This was done to aid comprehension of these distributions as values per unit are too small for easy comprehension. To arrive at the distributions of basic times per

brick laid the values may be divided by 1000 for an approximate answer. An appropriate approach would be to derive basic time per brick from the raw data, transform it to normality, calculate the probability density functions and then draw the distribution. Although this approach is the correct one, the approach first highlighted gave reasonably close figures. Basic times per unit were calculated using the second method to determine the effect of skill variation in each of the critical activities on production output. Output per minute per operative were also calculated for this purpose. With these steps, Production Output was brought to a common base of one minute, and the basic times of each critical activity to a common unit base. Our modified regression equation is shown in Table 8.5.

Table 8.5 Model of Production Output Per Minute.

Y Variate = Output Per Minute	**Coefficient**	**S.E.**	**T**
Constant	4.062	0.144	28.185
Fetch Mortar	-2.066	3.007	-0.687
Fetch Brick	-4.596	1.988	-2.312
Cut Brick	-1.639	1.229	-1.334
Lay Brick	-6.794	1.257	-5.407
Measuring	1.106	3.956	0.280
Setting and Checking	-5.720	1.538	-3.718

This Equation predicts output per minute. Using this equation, output at say the second minute of a productive period would be equal to output in the first minute plus output in the second minute i.e.

Output at time t = **accumulated output before time t plus the new addition generated by application of the critical activities in time dt.**

With this equation we can predict output at any time t. We should be able to know how each of the critical components of skill will be stimulated by dt (i.e. time interval). For the purpose of our investigation we take 'dt' to be one minute.

8.4.1.1 Simulation

In order to investigate the response of output to changes in skill, the 'STELLA' (122) simulation package was acquired. Being a mathematical package which is able to perform 'econometric' behavioural studies in a continuous time related simulation, it is most suitable for investigating the influence of variations in each of the critical activities on production output.

First, our model was converted into a 'Stella' model of the form in Figure 8.10. Production output is represented by the 'Stock' format. The content of the Stock is determined by what flows into it from the product of the 6 critical activities. This product is combined into one single 'converter' which is then carried into the stock by the flow line. The equation of the 'stock' (i.e. production output) is of the form:

Production Output = Initial Value + dt(SKILL)

which is essentially the same as our earlier illustration above.

Numerical information - based on the mean, standard deviation and the values of the coefficients of each critical activity above - were then supplied to this model for animation. Figure 8.11 shows the result of the overall animation about the mean (at 95 % confidence limits) for four hours at a minute interval. It is variations to this mean output, based on some assumptions, that we are more interested in.

Figure 8.10 'Stella' Version of Model of Production Output

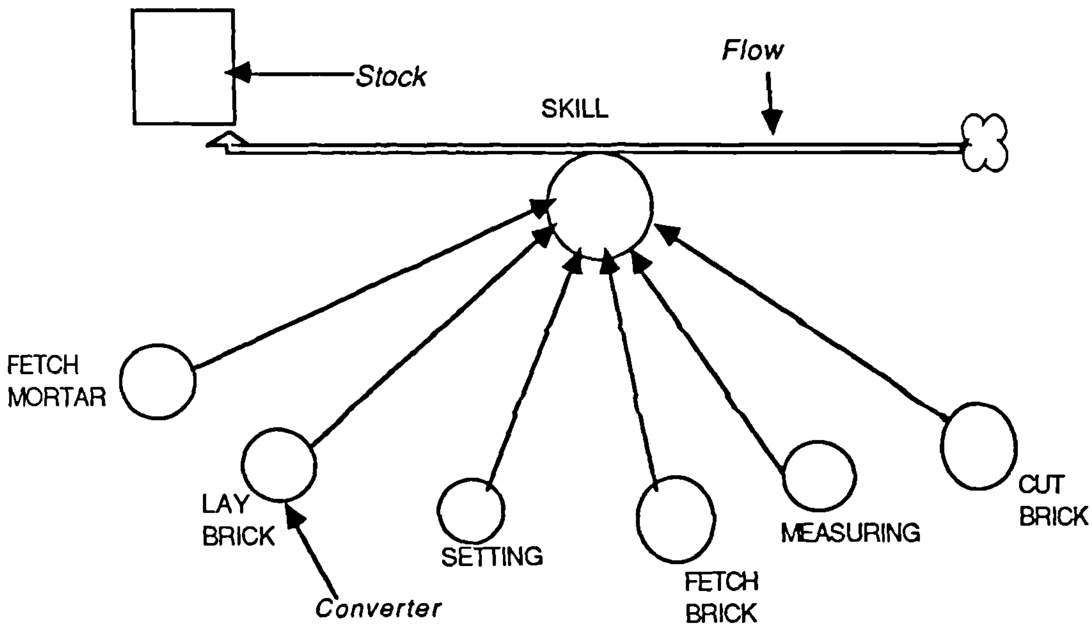


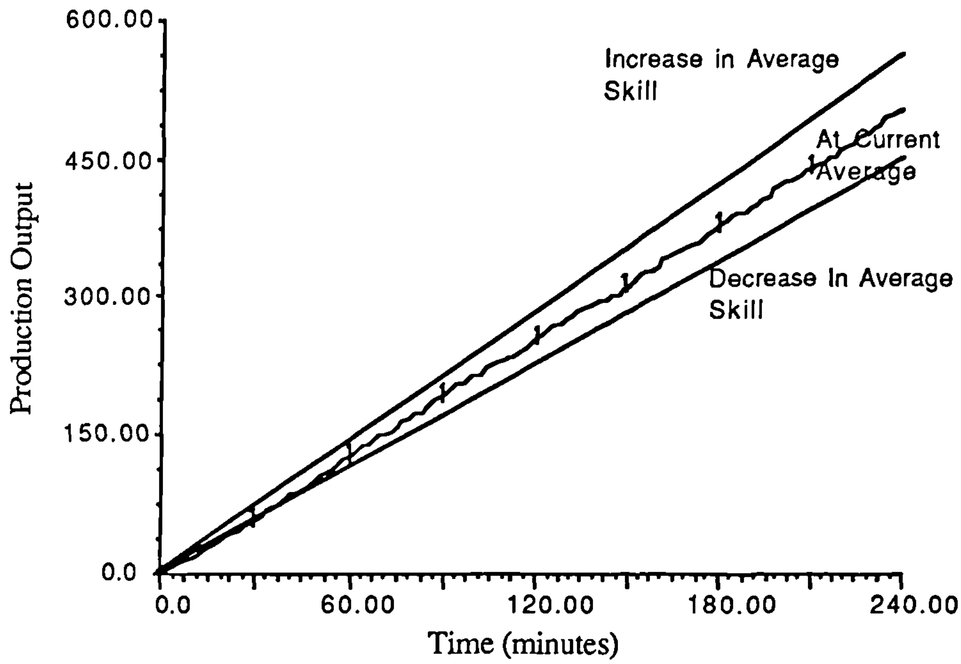
Table 8.6 Numerical Information For Simulation

OUTPUT = OUTPUT + dt * (SKILL)
INITIAL OUTPUT = 0

FETCH MORTAR	= 0.053+0.029*NORMAL(12)
FETCH BRICK	= 0.076+0.034*NORMAL(12)
CUT BRICK	= 0.035+0.05*NORMAL(12)
LAY BRICK	= 0.142+0.068*NORMAL(12)
MEASURING	= 0.013+0.017*NORMAL(12)

SETTING = 0.078+0.051*NORMAL(12)
SKILL = 4. -2.066*FETCH MORTAR-4.596*FETCH BRICK-1.639*CUT BRICK -6.794*LAY BRICK+1.106*MEASURING-5.72*SETTING
The seed for randomisation is 12

Figure 8.11. Animation of the Model Over Four Productive Hours



Assumption A

Let us say there is an incremental change of $\pm 10\%$ to $\pm 100\%$ in each of the critical activities. Table 8.7 and Figures 8.12 to 8.17 show the influence of these variations on output. The overall animation showed that, at random values around the mean, an average bricklayer will lay 130 common bricks in a productive hour. On the basis of our first assumption a 10% increase in the bricklayer's skill will cause an overall 2.9% increase in output, i.e. an increase of 4 bricks per hour. A 10% increase in skill in other activities except 'measuring' will increase output. A 10% increase in the bricklayer's skill to 'measure' will have no effect on his output per hour.

Table 8.7 Percentage Change in Skill and Resultant Percentage Change in Output

% CHANGE IN SKILL	PERCENTAGE CHANGE IN OUTPUT IF SKILLS IN THESE ACTIVITIES ARE VARIED						
	FETCH MORTAR	FETCH BRICK	CUT BRICK	LAY BRICK	MEASURE	SETTING	OVERALL
100	4.90	15.60	2.40	43.10	-0.602	19.70	85.10
90	4.40	14.00	2.10	38.70	-0.532	17.60	76.80
80	3.90	12.40	1.90	34.20	-0.463	15.60	67.40
70	3.40	10.80	1.60	29.70	-0.401	13.50	58.50
60	2.80	9.20	1.30	25.30	-0.332	11.40	49.70
50	2.30	7.60	1.10	20.80	-0.270	9.40	40.80
40	1.80	6.00	0.79	16.30	-0.200	7.30	32.00
30	1.30	4.30	0.53	11.90	-0.131	5.20	23.10
20	0.82	2.70	0.26	7.40	-0.069	3.20	14.30
10	0.32	1.10	0.00	2.90	0.000	1.10	5.40
0	0.00	0.00	0.00	0.00	0.000	0.00	0.00
-10	-0.70	-2.10	-0.53	-6.00	0.131	-3.00	-12.30
-20	-1.20	-3.70	-0.79	-10.50	0.200	-5.10	-21.10
-30	-1.70	-5.40	-1.10	-14.90	0.262	-7.20	-29.90
-40	-2.20	-7.00	-1.30	-19.40	0.332	-9.20	-38.80
-50	-2.70	-8.60	-1.60	-23.80	0.401	-11.30	-47.60
-60	-3.20	-10.20	-1.90	-28.30	0.463	-13.40	-56.50
-70	-3.70	-11.80	-2.10	-32.80	0.532	-15.40	-65.30
-80	-4.20	-13.40	-2.40	-37.20	0.602	-17.50	-74.20
-90	-4.70	-15.10	-2.70	-41.70	0.663	-19.50	-83.00
-100	-5.20	-16.70	-2.90	-46.20	0.733	-21.60	-91.90

Figure 8.12 Change in Output Vs Change in 'Fetch Mortar'

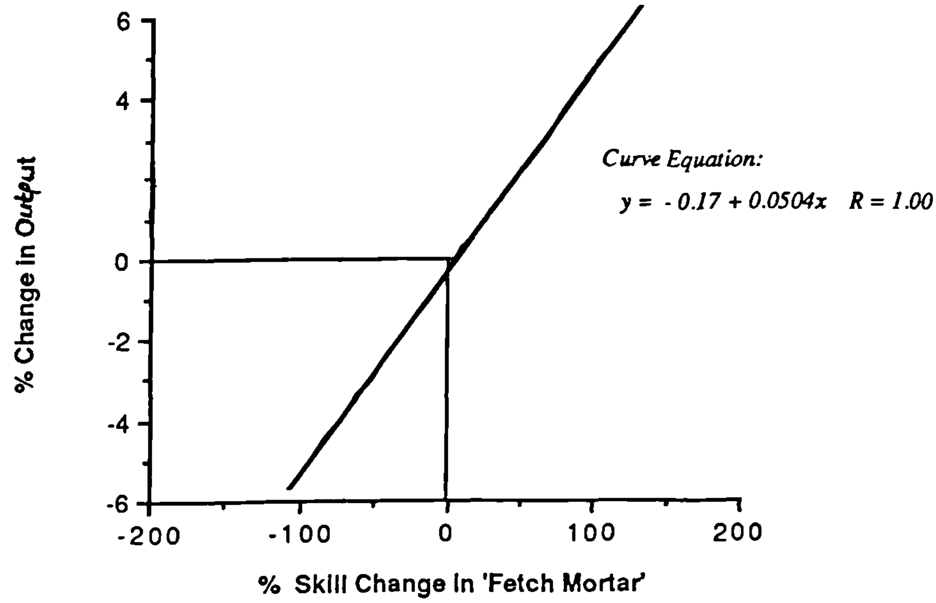


Figure 8.13 Change in Output Vs. Change in 'Fetch Brick'

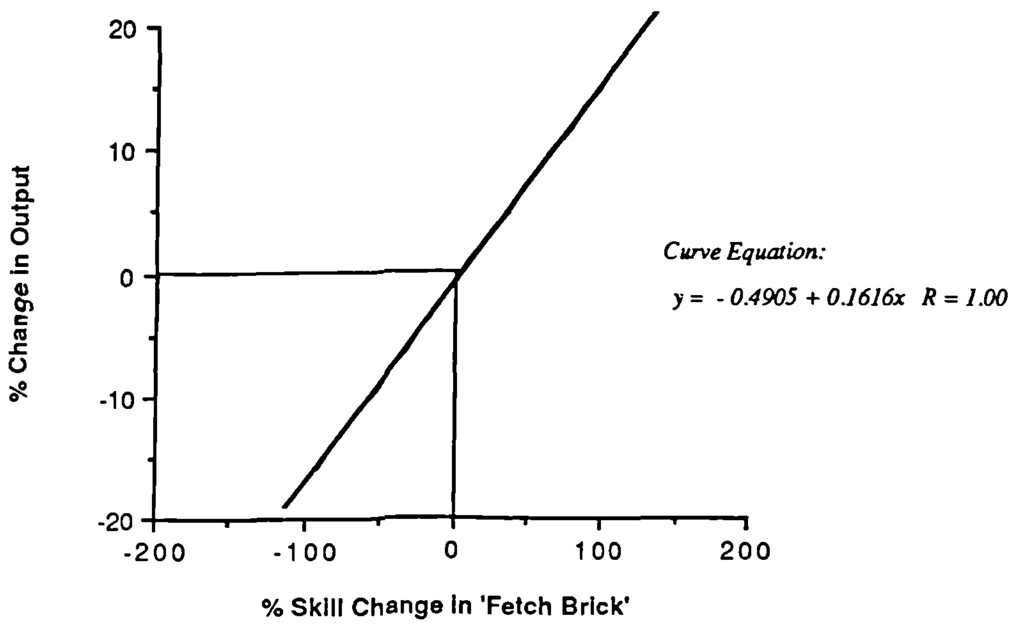


Figure 8.14 Change in Output Vs. Change in 'Cut Brick"

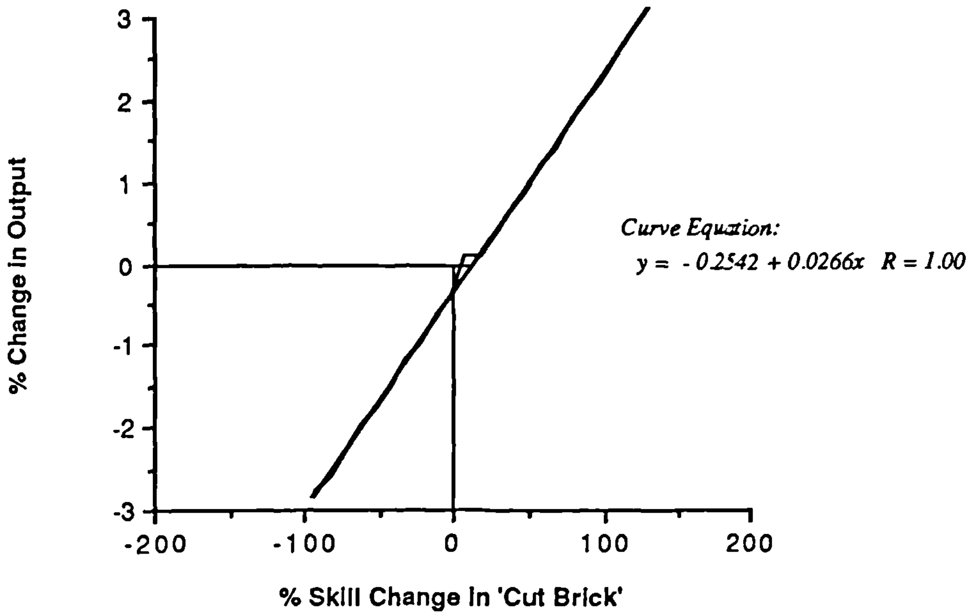


Figure 8.15 Change in Output Vs. Change in 'Lay Brick'

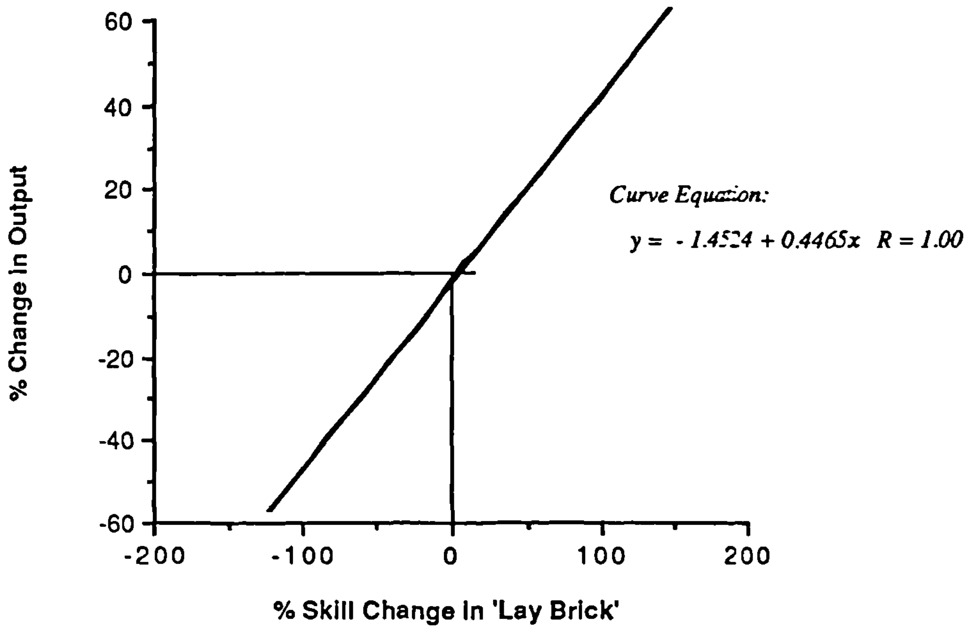


Figure 8.16 Change in Output Vs. Change in 'Measuring'

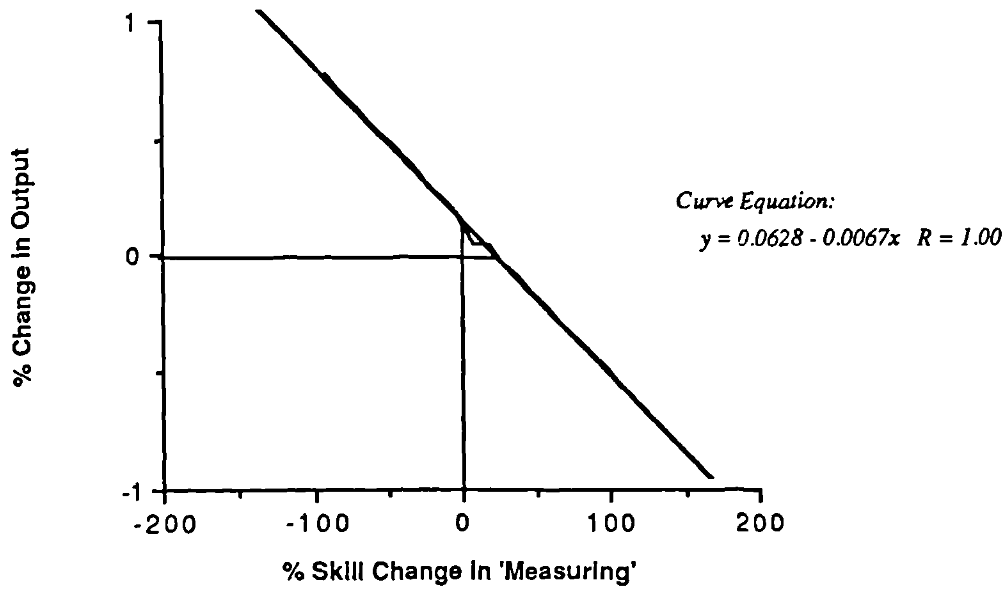
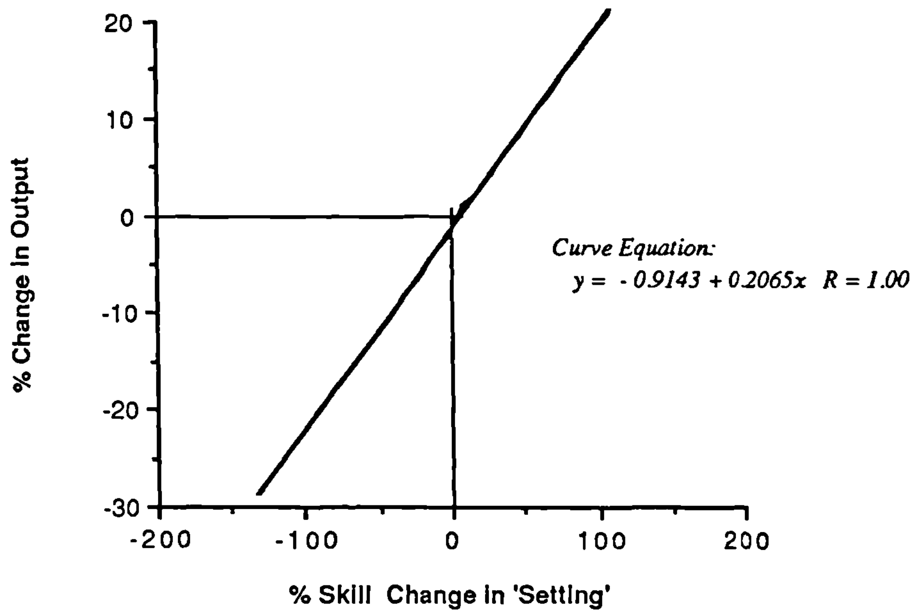


Figure 8.17 Change in Output Vs. Change in 'Setting'



The comparative influence of changes in skill in each of these activities is shown in Figure 8.18. The steeper the gradient of the lines the greater the influence of the activity with changes in skill. From the gradients it is clear that the 'lay brick' activity has more influence on output. A training instructor will therefore need to concentrate on the 'lay brick' motion more than any other motions in training new men for the industry. A skilled bricklayer needs to place more emphasis on his ability to 'lay brick' for better results in his skill development continuum.

Assumption B:

Let us say that there are simultaneous ±10 to ±100 increase or decrease in **all** the critical activities. Figure 8.19 shows this. A 10% increase in skill across board will result in output increasing by 5.4 %, see Table 8.7. Aggregating the increases from 0 to 100% gave a 1 to 0.785 relationship between overall changes in skill and output. The relationship is different in the negative axes. A 10% decrease in skill will result in a 12.3% decrease in output (Table 8.7) with 1 to 0.985 relationship in the negative axes. Overall the relationship between output and changes in skill is 1 to 0.885 (see equation of the curve). Other combination of variations in the critical activities can be assumed to give other curves.

Figure 8.18 - Comparative Output-Skill Changes

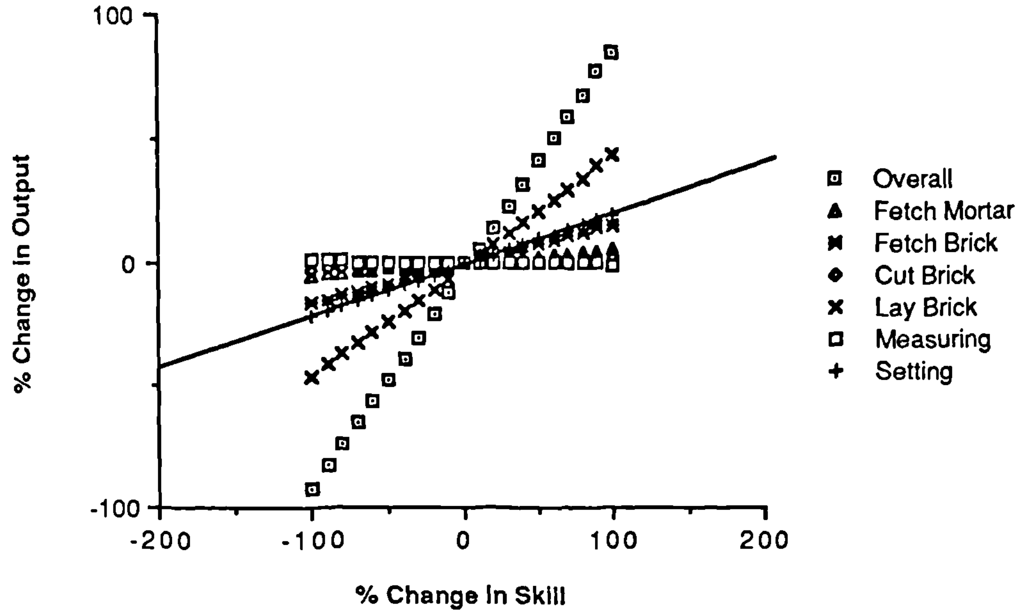
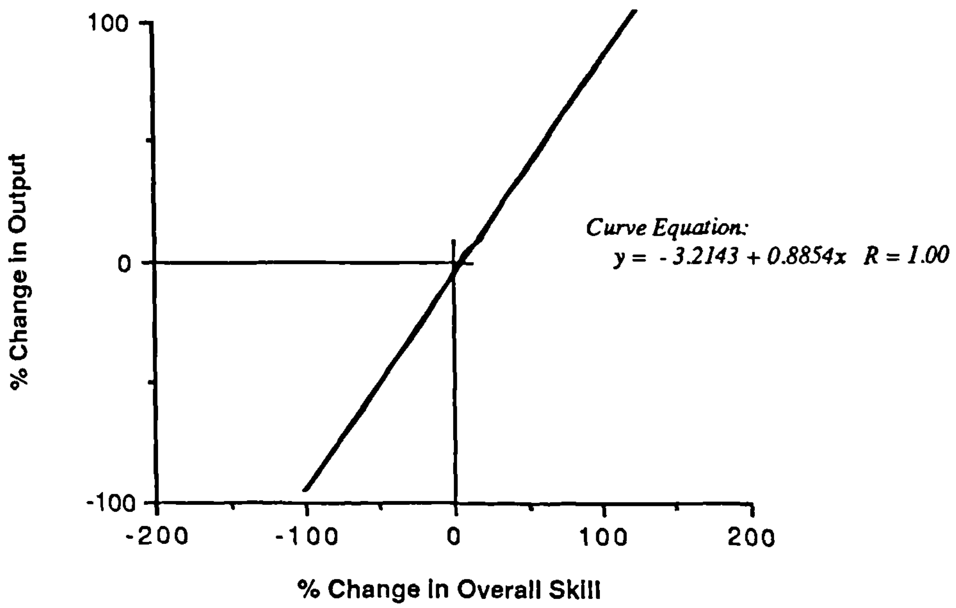


Figure 8.19 Change in Output Vs. Change in Overall Skill



8.5 The Production Output and Motivation Model

Having shown that there is a significant relationship between motivation and percentage productive time in chapter 7, it stands to reason that motivation must be an essential part of any predictive model of production output in bricklaying. Although motivation does not relate to rate of production output statistically, it may be added to the model as a 'practically' significant variable. Motivation was therefore added to the set of critical variables to give us the model in Table 8.8.

Table 8.8 Critical Model Including Motivation

Y variate is production output

	Coefficient	S.E.	T
Constant	184.1355	86.8182	2.12
Fetch Mortar	12.9405	3.3476	3.87
Fetch Brick	1.7410	2.3996	0.73
Cut Brick	-13.1184	3.4389	-3.81
Lay Brick	5.9523	1.5444	3.85
Measuring	-6.0635	4.0860	-1.48
Setting and Checking	-6.9490	1.9684	-3.53
Motivation	-132.8414	131.1418	1.01

Analysis of Variance

	DF	SS	MS
Regression	7	1234015	176288
Residual	43	328735	7645
Total	50	1562750	31255
Change	-7	-1234015	176288

Percentage Variance Accounted for 75.5

The addition of 2.4 % to the percentage variance by the inclusion of motivation in the model, though not significant, is worth noting. This shows that motivation, like the site and gang size, is definitely one of the variables influencing production output in bricklaying. Its influence is indirect. It influences the percentage productive time more significantly as earlier established.

8.6. Summary

1. A rhythm has been found in the way bricklayers work. They work in much the same way with more cohesion in smaller gang sizes than in larger ones.
2. The critical activities affecting production output in bricklaying are 'fetch mortar' 'fetch brick', 'cut brick', lay brick' 'measuring' and 'setting and checking'. They collectively account for 73.1% of the variation in outputs between bricklayers. Any skill acquisition programme in bricklaying should focus on these activities
3. A model for predicting production output in bricklaying was developed with the critical activities. This model would be tested for validation in chapter 9.
4. Production output is most sensitive to changes in the skill to 'lay brick'. There is an overall 1 to 0.885 relationship between changes in skill and output.
5. Although minimal, motivation affects the rate of production in bricklaying. It accounts for an additional 2.4% of the variation in production output.
6. The site factor accounts for 3.7% of variations in production outputs between bricklayers.

CHAPTER 9

CHAPTER 9
VALIDATION OF MODELS

9.1 Introduction

A model of the relationship between motivation and percentage productive time and a predictive model of production output in bricklaying have been developed. Several other relationships were earlier established between motivation and construction environment variables. The sensitivity of production output to the identified critical activities have also been determined as we tried to establish these two models in the last three chapters. But is it really true that at 95% confidence level these models will be representative of the situation they describe ? Of what use can these models be put? These questions are answered in this chapter. The chapter also describes the procedure taken to validate these models and discusses the results of the validation exercise.

9.2 Procedure for Validation

In chapter 7 a model of the relationship between motivation (X) and percentage productive time (Y) was established. From the equation which is of the form:

$$\log Y = 1.7583 - 0.797 (\log X) + 0.8606 (\log X)^2 + 3.1537 (\log X)^3$$

it should be possible to predict percentage productive time from the knowledge of motivation levels and vice versa. Since motivation explains only 25% of the variance in percentage productive time, we know that other factors within the site environment influence percentage productive time but the deviation of predicted values from actuals should still be reasonable. This is based on the fact that the equation above produced an 0.68 coefficient of correlation between the two variables which is considerably high when dealing with behavioural variables. Unless the other environmental variables become unduely influential the relationship should hold.

The second model is predictive. It forecasts output from the knowledge of performance in the identified critical activities. If observed values of the critical activities are substituted in the model equation:

Production Output = 83.38 + 9.27(Fetch Mortar) - 8.10(Cut Brick) + 6.32(LayBrick) - 7.31(Set and Check) - 7.40(Measuring) + 2.53(Fetch Brick)

we should have a dependable approximation of production output at 95% confidence level. This model explained 73.1% of the variation in production output across the sites. This is quite high considering the fact that we are predicting with 6 out of a possible list of 25 and the differences in site, mode of employment, variation in supervision styles and other previously identified variables can not be totally subdued.

Validating these models required going through the same experimental and analysis procedures as we did when establishing them. It is a basic rule in science that experiments should be repoduceable. Although it is not possible to follow this rule to the letter as all the projects we first studied have now been completed with the operatives engaged in new projects, serious effort was devoted to choosing new projects which closely resemble the previously studied projects. Three building projects, being constructed by two Loughborough contractors, which resemble the previous projects in terms of the type of contract, contract sum, contract duration, type of contracting firm, and the mode of employing 'labour only ' or 'on the books' operatives were chosen for the validation exercise. The same bricklaying operation - laying common bricks to walls - was being undertaken on these sites at the time of taking activity sampling observations. Only the six critical activities were observed using the computer aided activity sampling program. The operative questionnaire was reframed to only include questions relating to operatives' motivation. This made it easier to get a higher proportion of the operatives to respond to the questions. Despite this reduction in the number of questions, 6 of the 26 observed bricklayers did not respond. As such, the analysis was limited to the 20 bricklayers who were activity sampled and responded to the motivation survey. The collected data was processed and analysed using the same statistical packages.

9.3 Analysis and Discussion.

While developing the models we have used the residuals (Observation - Expectation) to check the stability of the models. This process is rather simple - check for pattern or non-randomness in the residuals. Any pattern is an evidence that the observations are not independent, or have a trend in time (147). The problem with this test of stability is that both expected and observed values are from the same set of data. In this validation exercise we use the models developed with the first set of data to predict values for the new set of data and then compare these predicted values with the actual values in the new set of data, to see if the previous models are really good for prediction.

Table 9.1 shows the basic times in the critical activities. Table 9.2 shows the actual production output, actual percentage productive times and the actual motivation index per bricklayer. The basic times in the critical activities were substituted into the production output model to predict production output. The motivation indices were also substituted into the motivation model to predict Percentage Productive Time. Both the predicted ouput and predicted percentage productive time figures are shown in Table 9.3.

Table 9.1 Basic Times in Critical Activities

Operative Number	Fetch Mortar	Cut Brick	Lay Brick	Set & Check	Measure	Fetch Brick
	Basic Times					
1	5.7	7.0	17.0	2.6	0.0	6.7
2	7.8	1.0	19.0	6.8	0.0	7.0
3	11.7	3.0	32.9	1.0	0.0	17.8
4	26.7	5.9	65.8	6.2	1.0	25.8
5	6.6	6.6	9.3	1.8	0.0	7.6
6	26.8	13.2	88.0	20.8	5.6	63.9
7	17.1	10.3	16.0	6.0	0.0	20.3
8	6.6	5.7	20.3	1.8	0.0	7.6
9	15.0	4.6	29.2	10.8	1.8	30.7
10	7.0	6.6	26.6	8.2	2.0	13.6
11	4.8	2.0	32.2	1.8	1.8	19.6
12	3.0	4.6	9.5	2.6	10.0	3.0
13	3.7	8.5	2.8	1.0	1.7	1.8
14	12.7	1.5	20.1	6.0	0.0	16.5
15	4.4	8.8	5.9	0.0	0.0	3.8
16	2.8	3.0	10.1	1.9	0.0	5.8
17	2.9	4.0	6.9	1.0	0.0	0.9
18	24.4	1.0	57.8	13.6	3.0	28.8
19	12.7	2.0	80.2	11.7	2.0	15.7
20	3.9	2.0	13.9	5.0	0.0	10.8

Table 9.2 - Actual Values

Operative No. Number	Actual Production Output	Actual Percentage Productive Time	Actual Motivation Index
1	178	69.00	0.57
2	245	58.00	0.51
3	402	53.00	0.42
4	779	50.44	0.32
5	157	79.77	0.73
6	738	72.34	0.56
7	259	60.17	0.52
8	257	74.32	0.67
9	371	64.03	0.54
10	237	56.26	0.46
11	318	73.13	0.44
12	53	65.39	0.53
13	48	49.37	0.45
14	286	72.31	0.65
15	101	53.00	0.54
16	146	76.00	0.42
17	147	75.20	0.68
18	632	73.82	0.70
19	609	74.60	0.75
20	195	52.18	0.56

Table 9.3 **Predicted and Actual Values**

Operative Number	Actual % Productive Times	Predicted % Productive T ime	Actual Output	Predicted Output
1	69.00	70.78	178	184.904
2	58.00	72.79	245	235.668
3	53.00	74.63	402	413.191
4	50.44	72.57	779	711.507
5	79.77	65.21	157	155.948
6	72.34	71.28	738	749.235
7	60.17	72.50	259	267.086
8	74.32	67.26	257	232.758
9	64.03	71.99	371	355.117
10	56.26	74.26	237	222.588
11	73.13	74.63	318	338.290
12	65.39	72.21	53	48.534
13	49.37	74.34	48	51.189
14	72.31	67.94	286	313.876
15	53.00	71.99	101	99.790
16	76.00	74.63	146	149.653
17	75.20	66.86	147	116.438
18	73.82	66.26	632	618.012
19	74.60	64.62	609	631.167
20	52.18	71.28	195	181.955

Figures 9.1 and 9.2 show the graph of residuals in both the production output and the motivation / percentage productive time models. Both figures reveal no pattern in the residuals which confirm that the models are valid; but we should be a little cautious with the the model of percentage productive time since most of the residuals are negative even though random. On ordering the observation values of percentage productive time and plotting them against their residuals, a tendency for large negative residuals on the lower end and positive residuals on the higher end was noticed. This signifies non linearity in the relationship between motivation and percentage productive time which the model had earlier brought to light. Since motivation explains only 25% of the variation in percentage productive time, this model is undoubtedly a very good representation of the relationship between these two variables.

Figure 9.1 Residuals of Predicted Production Output

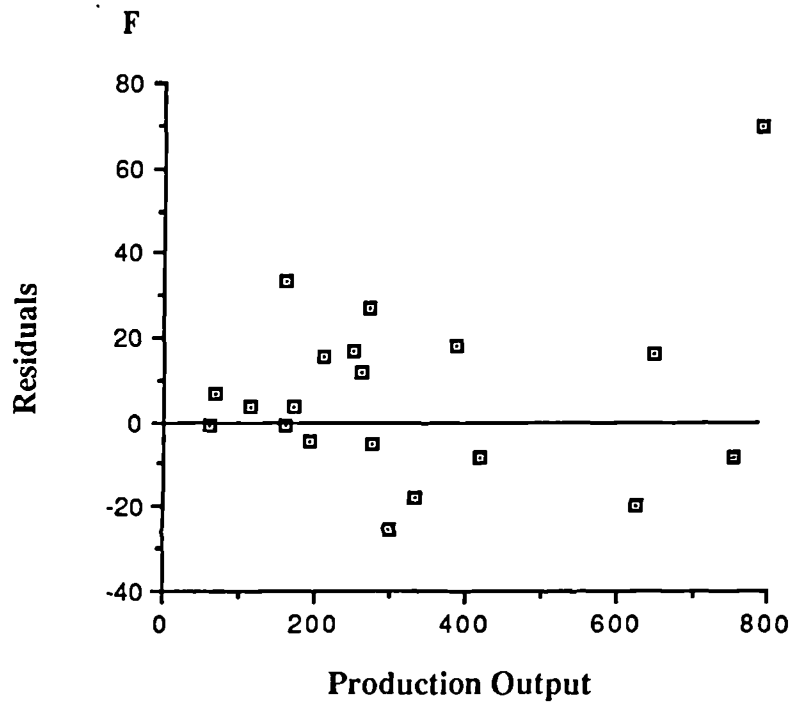
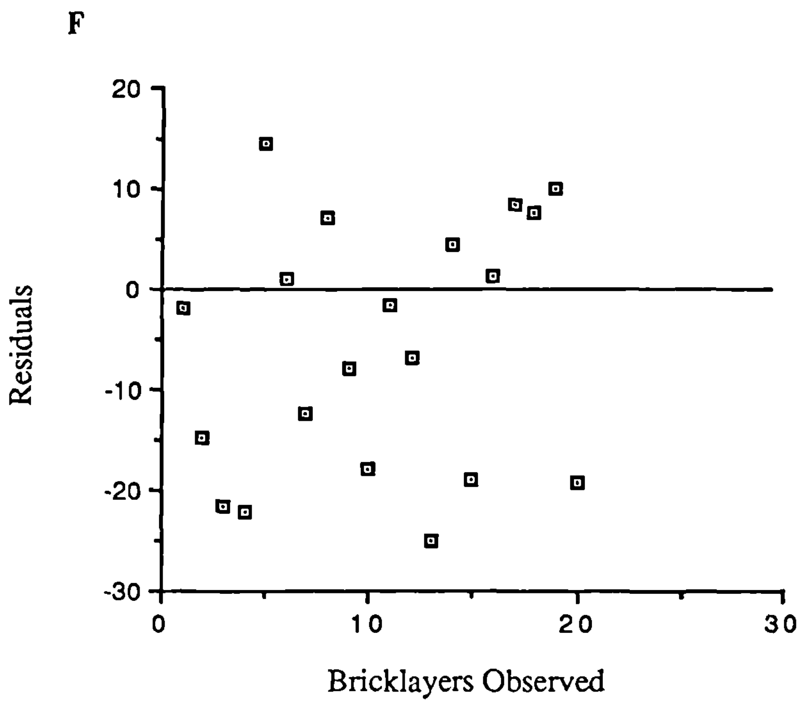


Figure 9.2 Residuals of Predicted Percentage Productive Time



The data of basic times in the six critical activities above were added to the original set of data to see whether this additional data will influence the percentage variance and the regression coefficients. Most models improve with more data and additional data may even change the criticality of the variables. The model for predicting production output is no exception. There is a noticeable improvement in the percentage variance from 73.1% to 79.4% with the t - ratios for all the variables found to be significant, see Table 9.4.

Table 9.4. Model of Production Output with Additional Data

Y variate: Production Output

	Coefficients	S.E	T
CONSTANT	74.77	18.920	3.95
Fetch Mortar	7.89	2.035	3.88
Cut Brick	-6.63	1.628	-4.07
Lay Brick	6.43	0.802	8.03
Setting and Checking	-7.48	1.197	-6.25
Measuring	-7.15	3.302	-2.16
Fetch Brick	3.58	1.226	2.92

Analysis of Variance

	DF	SS	MS
Regression	6	3309807	551635
Residual	110	856732	7788
Total	116	4166539	

Percentage variance accounted for 79.4

9.4 Uses of The Models

The model of the relationship between motivation and percentage productive time has illuminated the understanding of the nature of these motivation and productivity concepts. While it has been shown that motivation in the construction operative is a 'melting pot' of very interdependent variables the relational model provides an empirical proof of the optimal motivation concept. It is now very clear that there is an amount of motivation in every construction worker regardless of his construction situation and motivation wields greatest influence on productivity between 35% and 60% motivation level. After this range its influence is minimal.

The model of production output can be a tremendous estimating tool. It clearly reduces the burden of having to collect and analyse data on many bricklaying activities which have little influence on production output by concentrating on the critical activities. The author observed a 41% gain in time spent collecting and analysing data for this validation exercise. This percentage gain in time definitely reflect expertise gained during the course of the main investigation by the author. Giving some discount for this expertise or familiarity factor the author will estimate that there may be as much as 30% gain in work study time using this model. Apart from this, how this model could help in training new bricklayers through the results of the sensitivity analysis was demonstrated in Chapter 8 . With this model the training instructor knows which activities should take priority in his training programme.

CHAPTER 10

CHAPTER 10

CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

10.1 Conclusions

This thesis set out to evaluate the relationship between motivation and productivity in bricklaying. To achieve this the whole premise of the motivation concept and its evolution as a distinct subject was first reviewed.

From its deep psychological and physiological roots, motivation has developed into one of the most researched topics in general mangement where management practitioners are looking for ways of obtaining the best from operatives. The motivation concepts in psychology are highly theoretical but do form meaningful bases for goal oriented and motives pinpointing management theories. Unfortunately, however, these theories are all manufacturing industry based. They give conflicting explanations of worker motivation with emphases on different motivators. Attempts by construction researchers to apply these theories to the construction setting have led to conflicting interpretations of the construction operatives' motivation. This thesis approached bricklayers on a number of sites, evaluated their motivation and related this to their productivity in order to establish the relevance of motivation to productivity in construction; a necessary step towards formulating a theory of construction operative motivation.

From conceptual explanation of motivation in literature it was recognised that the environment and personality of the worker are paramount determinants of his motivation. The bricklayer's working environment is his site and the gang in which he works - the immediate environment. Of these two the site environment was found to be more important to bricklayers' productivity.

On examining the site environment through activity sampling and an operatives' questionnaire survey, the reasons for its importance to productivity became more apparent. The problems causing delays and loss of productive time were pinpointed as lack of materials, lack of equipment, crew interference, absenteeism, supervision delays and repeat work. These problems affect production in varying degrees on sites studied. On comparing the magnitude of these problems with that of the U.S.A. and Nigeria, it was found that British sites are relatively 'problem free'. This provided a good premise for evaluating motivation on these sites as the influence of motivation on production is more apparent *when* there are little or no production problems.

Evaluating bricklayers' motivation entailed the development of a quantifying technique based of the Subjective Expected Utility Theory. The theory conceives motivation as a multivariate function with different motivating variables contributing to the overall motivation content. This was modified to include demotivating variables in a new concept named the 'band' concept. This new concept is based on the assumption that total motivation is dependent not only on motivating but also on demotivating conditions.

There was a problem knowing what the motivating and demotivating variables were. This was resolved in the thesis by first asking bricklayers what satisfies or dissatisfies them in both their work and working environment. Motivators were defined as satisfiers capable of increasing production when gratified, and demotivators were defined as dissatisfiers capable of leading to a conscious withdrawal of effort. The workers were again approached to rank the level of importance of each variable to them and to assess how far it is gratified on their sites. The scores were then converted into indices which were later used to evaluate the relationship between motivation and productivity.

From investigations into satisfaction and dissatisfation in bricklayers, it was found that the greatest job satisfiers are reward related. This agrees with the classical thoughts on the role of wages in workers' productivity. However, when all satisfiers were aggregated, work related factors were found to be collectively the greatest satisfier to bricklayers. This is in line with Borcherding's observation on American sites (16) but contradicts Herzberg's (59) basis for job enrichment. Bricklayers consider their work adequately enriched.

Reward related issues is also the greatest dissatisfier. Overall however, dissatisfiers are not exact opposite of satisfiers as earlier observed by Herzberg and Borcherding even though they concentrated only on 'highly productive' workers whilst all workers on site, regardless of their productive capacities were studied in this research. An additional observation from this study is that dissatisfying conditions are more easily identifyable to the workers than satisfying conditions. They can describe unfavourable conditions in more detail than favourable ones!

A general evaluation of the importance of motivating variables revealed that the greatest motivator is "interelationship between workmates". This is not very surprising considering the fact that most bricklayers now work as subcontractor labour in fairly permanent gangs. From the consistent high ranking of "fairness of pay" first as a satisfier and then as a motivator, wages is undoubtedly a motivator to bricklayers. The thesis offered explanation for the misplaced emphasis by the classical school on the role of wages and on the 'non-motivating' rating of this variable by the modern school of thought. It was established that there is a parabolic relationship between wages and effort, depending on the level of expectation by the operative for effort expended. Wages do not predominate as suggested by the classical school, but does motivate in contrast to the now vacillating Herzberg's school of thought (60).

Significant interdependency was found between the different motivating variables. It is suggested in the thesis that this is an indication that total motivation in a construction operative is a complex interplay of all these variables and, none should be treated in isolation of the other. This forms the basis of the wholistic view of motivation expressed in latter section of this chapter. "Disrespect", as reflected in the totality of supervisory attitude towards operatives is the greatest demotivator to bricklayers. Wide variations in the personality of the bricklayers were noticed by the high coefficient of variations (25 to 69%). They were also found to be peer-group conscious.

The motivation content in individual bricklayers and their productivity were related through various statistical steps to establish that there is no sginificant relationship between any of the motivation indices (Band, motivation and demotivation) and the rate of production. Rather, significant relationships were found between these indices and the proportion of time spent productively or unproductively. It is thus concluded that motivation only influences the proportion of time spent working. The rate of working or the quantity produced within this proportion of time is more dependent on SKILL - the **ability** to produce standard quality in a period of time. Motivation provided 25.3% explanation of the variation in percentage productive time while other factors such as the problems earlier highlighted determine the remaining 74.7%. By relating the different motivating variables to the percentage productive time in a best fit exercise, it was found that the only motivator of significance to productivity is 'good supervision'.

This study established that the relationship between percentage productive time (Y) and motivation (X) is a cubic relationship of the form:

$$\mathrm{Log}Y = 1.7583 - 0.797(\mathrm{Log}X) + 0.8606(\mathrm{Log}X)^2 + 3.1537(\mathrm{Log}X)^3$$

This relationship was found to be valid on further tests in Chapter 9. The shape of the relationship and further simulations provide an empirical proof for the 19th century optimal motivation hypothesis (153). From the curve (see chapter 7) it is clear that there is a basic motivation (about 33% of the scale) in every worker regardless of his working environment.

Employing the Principal Component Analysis and the Stepwise Regression techniques, six productive and skill related activities were found to be critical to the productivity of bricklayers. These activities are: 'fetch mortar', 'fetch brick', 'cut brick', 'lay brick', 'measure' and 'set and check'. These were modelled into a multivariate equation which was found to represent 73% of the variation in productivity in bricklaying.

After defining skill as being measurable by the number of bricks laid over a unit of time, this model was animated over a four-hour period on the 'STELLA' simulation package. To the basic simulation were added variations about the mean between -100% to100% range to test the sensitivity of the model to changes in average skill. It was found that there was a 1 to 0.8854 relationship between changes in skill and productivity. Output in bricklaying was most sensitive to changes in skill in the 'lay brick' element.

Motivation was added to the critical model as a 'practically' significant variable to reflect a further 2.4% explanation of the variation in productivity. The relationship between productivity is indirect. Motivation has a significant influence on the percentage of time spent productiviely but gives way to the dominance of skill when it comes to actual production achievement within the productive time. The basic question to be answered by any management executive wanting to improve productivity in bricklaying would then be "how do I increase the time spent productivily by my workers in the working day ?"

10.2 Recommendations

The central importance of productivity to any construction firm is the main catalyst for the investigations in this thesis. Based on the findings above, a scheme to monitor production outputs, identify production and motivation problems on construction sites with a view to improving operative productivity is proposed.

10.2.1 A Productivity Improvement System

The evolution of several contracting systems is changing the mode of operative management in the construction industry. The traditional 'one roof' system of direct employment of operatives is gradually giving way to a new 'labour only' culture. This is shifting operative management from the main contractor to the labour subcontractor. The main contractor, however, remains directly responsible to the client for work completed.

The main contractor has brought complications to operative management, by subcontracting almost every construction operation. He has to learn new management techniques to manage the increasingly 'out of control' subcontractors and can no more determine the actual length of his project as he has to rely on subcontractors' performance. Main contractors have neglected training new operatives and the subcontractors are not training new ones - hence the skill shortage being witnessed in the industry today.

The question may be asked - 'who cares for the operative nowadays?' Is he to care for himself? No. The main contractor is still responsible, though indirectly. The author is of the opinion that the role of the traditional trades foreman is being taken up by the subcontractors - the organisational chain still remaining essentially the same. Under the new system the subcontractor is responsible for the productivity drive but the main contractor still pays. An operative productivity drive must be pursued by either the subcontractor or the main contractor.

10.2.1.1. Operative Productivity Drive

Resources in the construction process are interdependent. Attempts to improve productivity by motivating or training without removing production bottle necks will fail. The construction organisation's drive to improve operatives' productivity should recognise a prepotential hierarchy of necessary management actions in approaching productivity. Simply put, it is essential that management removes the 'boulder' in its own eyes before the 'dust' in the operative's.

With motivation explaining only 25% of the percentage productive time it seems that the identified 'on-site' problems are more prepotential than motivation influences and without their being removed it will be fruitless pursuing any productivity drive. If production output is taken as the focus of a productivity drive, a system of inter-relationships between the main management function will emerge. Figure 10.1 shows the flow chart of the suggested system of these inter-relationships. This system is contingent on the following assumptions:

i) the operatives are employed directly by either the subcontractor labour only or the main contractor;

ii) they are qualified operatives needing no undue length of further training; and

iii) work study principles are applied with periodic in-house productivity review by the management.

The system has the following features.

10.2.1.2 Standard Output and Capacity Determination.

It is suggested that the construction industry should have a central data bank of standard times for various construction operatives under different local conditions in the country. Centrally conducted workstudy would reduce the cost of separate workstudy by different organisations and the hoarding of scientific data by larger firms (56). Stored on a computer, the data could be accessed 'on line' by subscribing firms.

Should this be done, each (sub or main) contracting firm could observe its workers' output on sites suspected to be unproductive and then compare with standard outputs to determine excess capacity. This should be done in full consideration of design implications, method and the effectiveness of supervision. The Science and Engineering Research Council's (U.K.) funded research into the use of the activity sampling technique in the construction industry proved that it is probably the best technique for observing operatives' output. Simple computer software has been developed to make both data collection and analysis easier (56). This can be commercialised at affordable costs to interested organisations.

10.2.1.3 Tapping Excess Capacity

The first stage in tapping identified excess capacity (i.e. standard output - observed output) is to check time utilisation by the operatives using activity sampling. This will help identify percentage unproductive time. Allowances should be given for physiological rest. Identified unproductive time must be greater than rest allowances for there to be excess capacity. The next stage is to make use of the unproductive time by the removal of production problems.

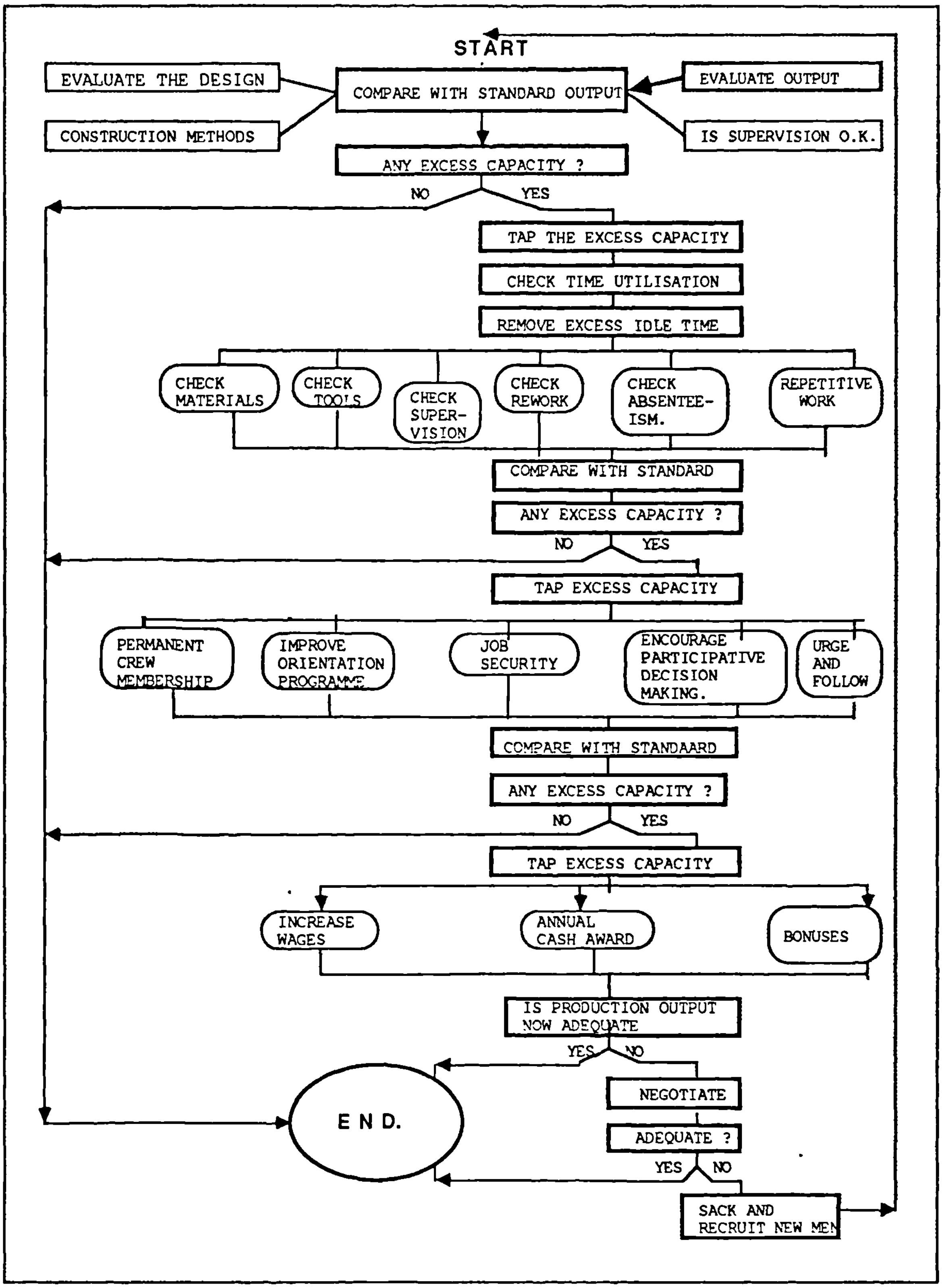
The identified production problems are within the sphere of what management can resolve by being conscious of their existence and directing specific managerial actions at them. The study has revealed the sources of these problems.

Lack of materials results from management's neglect of some of her basic functions. These are lack of proper financial planning and inadequate work scheduling. Making material available involves materials planning with adequate scheduling of deliveries, checking all deliveries to ensure that improper materials are not delivered, maintaining good storage space to ensure the safekeeping of materials and a requisitioning system devoid of bottlenecks in getting materials to the workers. On-site transportation is yet another area worth looking into. Vertical transportation of materials present more problems than horizontal transportation. This can be reduced (where practicable) by having materials depot on each level of construction.

Making proper tools available will involve a good maintenance programme for existing tools, purchase and safe keeping of adequate number of good quality tools for the operatives. Repeat work is entirely unproductive. Poor instructions from supervisors, mis-interpretation of plans and design changes have been identified as the causes of this problem. If supervisors are warned about repetition of jobs and penalised for repetition due to their fault, this situation could improve. Reducing design changes is not directly within the builder's control. The only way the builder can reduce this (should the contract clauses permit) is by claiming high variation rates to counter all the losses in output that may result from these changes. Absenteeism can be controlled by relating it to employment. The workers should be made conscious of the possibility of dismissal in cases of unjustifiable absenteeism. This measure was found to be an effective check on three of the sites studied. After these management 'corrections' have been effected, a check should be made on the output of workers vis-a-vis established standards. Should all excess capacities have been removed, the system should be maintained by periodic productivity reviews. If there is still any excess capacity, then the drive can proceed to its second stage.

At this stage, all the motivators in Table 7.3 should be employed taking their order of importance into consideration. The demotivators in Table 7.6 should be systematically removed by a concerted management effort, but emphases should be on motivators as they have been conclusively shown in this research to have overriding importance over demotivators. Some of the motivators can be easily harnessed for increased productivity

Figure 10.1 The Suggested System



while some demotivating conditions can be easily corrected. Provision of enough labourers, good safety standards and regular payment of wages can be easily corrected since they are easily discernible. However, other issues such as making tasks interesting, encouraging participative decision making, good relationship with other workers, require some management ingenuity.

Workers are generally interested in jobs that test their skill and imagination. This interest can be exploited by supervisors in work allotment. When a task challenges, worker's concentration is bound to increase. Overcoming challenging tasks by workers should always attract commendation from supervisors. A feeling of recognition will thereby be aroused in the workers. Workers should be taken as part of the business and not just instruments to be used and discarded after the project. They should be allowed some participation in the decision making process. Their views should be sought on different tasks to be done but not to the extent of giving them the upper hand which may create the feeling that they are indispensable. Morse and Reiner (104) suggested along this line that workers should only be consulted in 'safe' areas of decision making. Relationship amongst workers can be improved by reducing changing crew members. If workers stay together regularly in a crew for different tasks, they are bound to understand themselves. When management urges higher productivity, it should be backed up with positive action rather than maintaining a nonchalant attitude.

This thesis has shown the overriding importance of motivators over demotivators. Management needs to concentrate effort on the motivators as they have greater influence on productivity than demotivators. When the motivation situation has been rectified, another check should be conducted on output. If no excess capacity is apparent, then maintain by regular productivity reviews. If there is excess capacity, the drive continues to its final stage.

At this stage, financial incentives should be introduced to boost workers' output. It should be emphasised that these financial incentives should mean no more than a reasonable wage for a fair day's work. For excess capacity to remain to this stage may mean that workers are being underpaid. Efforts should be made to give them the fair price for their input. Some care is necessary at this stage as an increase without a corresponding increase in output will definitely lower existing productivity. It may therefore be necessary for some bargaining to be done before any increase in wages or bonuses is effected.

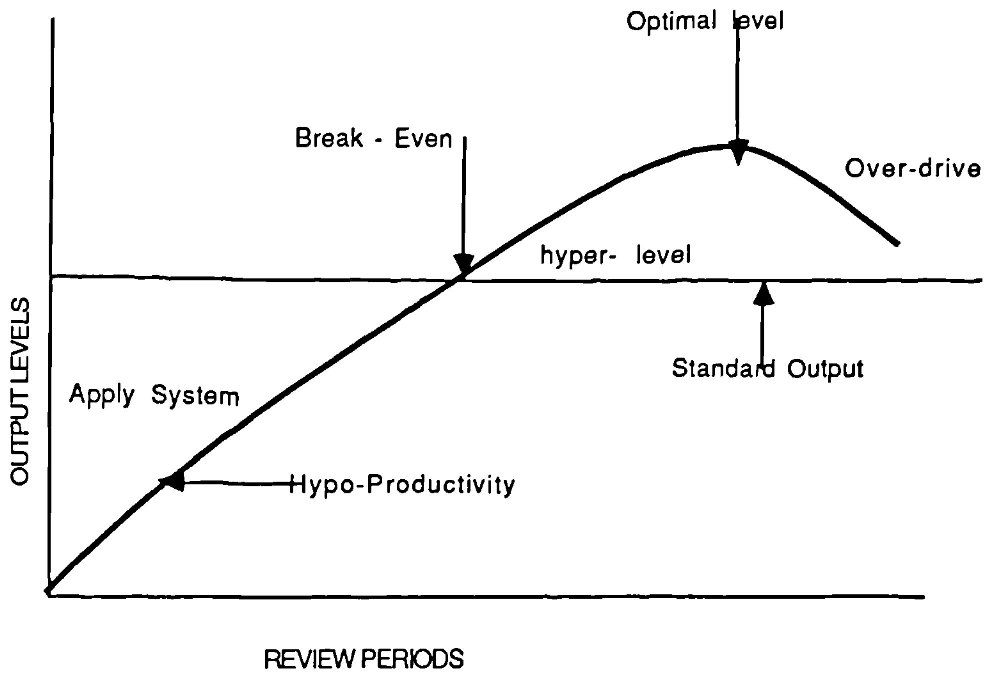
After increasing remuneration, another check of output levels should be conducted to check whether production is adequate. If it is not, there should be re-negotiation and if there is no increase, it may be assumed that workers are restricting output. In this case, a staggered system of dismissal should be adopted while new workers are being recruited. This will ensure continuity of work at the same time as a much needed reorganisation. For this system to work, the sequential order of tests and analysis should be followed.

10.2.1.4 The Concept of Break-Even and Hyper Productivity.

When there is no excess capacity noticed after a check is made between observed output and the established standard output; there are two other possibilities. First, observed output may be equal to standard output. Secondly, observed output may be greater than standard output.

If standard output and observed output are equal, then there is a break even relationship between the site and the industry and both the site and worker can be described as 'break-even' or typical site/worker. One question may be asked at this stage: Is management satisfied with this output? If it is, then management should maintain

Fig 10.2: **A Conceptual Frame of Construction Hyperproductivity.**



that productivity level - the break even productivity. Otherwise management should resort to the realm of positive variance, i.e. when observed output is greater than the industry's figure. This will mean getting more from the tradesmen than what the industry expects them to give. This is construed as hyper productivity. See figure10.2 for the conceptual frame. It may be counter productive if not carefully applied. However, as a cup is not full until it is filled to overflowing, productivity will not be optimised until this realm of hyper-productivity is reached. After the optimal level is reached there is the need for management to be careful that the 'over-drive' level is not reached as this will be counter productive. This concept evolved from this thesis in relation to the Midlands region where main contractors still exercise considerable influence on labour only subcontractors with not much difference in prices offered for work done for the main contractor.

What happens if the subcontractors exercise the freedom of their self employment to the fullest? This is not expected unless skill shortage becomes more acute than it is now. Under that situation, workers can virtually take control of how much they produce and even push up the price. Contractors would then be at their mercy and the system above would be meaningless. This is quite an extreme, though not an impossible imagination.

To forestall this the industry and individual firms need take some precautions now. Training new men for the industry should not be left only to the Government's YTS scheme or the CITB. Some construction firms used to have their own training schools for training their own personnel. This was a ready source of loyal and committed operatives. With the depression of the 1970s some of these schools were closed, the source dried up and now the same firms now 'beg' their subcontractors to take on some apprentices to reduce the impact of the skill shortage (38). Can these firms reopen these schools? Can the industry revert back the subcontractor culture to a forward looking, operative conscious past ?

10.3 Further Research

Many myths and assumptions exist in various academic fields that need be verified before application in real life. These myths abound mostly in the social sciences from which construction managers borrow some of their management tools. Construction managers however, are practically minded individuals who would not gullibly accept some of these myths without empirical tests. (Often, there are measurement problems that need be overcome). Attempts should be made to identify such myths and see their relevance to actual on-site situation. One of such myths is motivation which this thesis has addressed. Another is the relationship between productivity and profitability.

A theory of construction operative motivation could have been proposed in this thesis but for the need to have a time tested set of propositions before proposing a theory. Motivation needs be studied over a time continuum because external variables influence it. For example, the heirarchy of operatives' need in a developing economy are different from developed ones (5, 110) , and the relative importance of motivating variables in the now bouyant British economy is different from what was found by Wesley-Lees (146) in the 1970s. Herzberg (60) is now changing the premise of his motivation theory merely 20 years after it was first proposed. It is suggested that any future theory of construction operative motivation should recognise the following propositions based on the findings in this thesis:

1. That the Bricklayer is peer conscious.
2. There is an amount of motivation normally present in him.
3. He is motivated by a range of largely interdependent variables.
4. He is more satisfied with work related factors.
5. His site environment as reflected in the provision of necessary resources to perform influence his motivation.
6. The optimal percentage productive time is obtained at about 72% motivation level, see Figure 7.3.
7. There are wide variations in individual personality of bricklayers.

These propositions should be confirmed on more bricklayers and operatives in other trades in the construction industry before pronouncing a theory which would be generally applicable to the industry as whole.

The domineering impact of skill on operative productivity has been demonstrated in this thesis. The critical activities have also been identified. But how do you train workers concentrating on the critical activities? How do you assess the level of skill ? Is the traditional apprenticeship scheme so faulty that it has to completely be replaced? Has anyone bothered to evaluate the skills of the the new YTS trainees? Can projection about skill development be made into the future, i.e. can a skill forecasting model be developed to predict future shortages so that the industry would not be caught napping again? These questions should be answered in the near future.

Another area of research is that of supervision. Most site managers used to have trade background which made it possible for them to appreciate operatives' problems. The new site managers are graduates having just a few years experience in the industry and very defficient in operative management. This area need be explored to seek ways of equiping new graduates with enough managerial skills before entrusting them with managing people.

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APPENDIX A

Appendix A
Contractors' Questionnaire

Introduction

This questionnaire was designed to evaluate the characteristic features of different construction organisations participating in this research. It is the basis of our description of the participating construction firms in chapter five.

The Questionnaire

The Department of Civil Engineering of the Loughborough University is currently conducting a series of studies into construction operative productivity. The aim of these studies is to evaluate operatives' productivity now that the industry is bouyant and devise ways of maintaining it. This questionnaire is designed in a way that you can make suggestions thereby making your invaluable contributions to this work. All answers will be treated in absolute confidence and used only for academic purposes. You are however free to skip any question. Your cooperation is appreciated.

Thank You.

Response: √ Positive X Negative

SECTION 1

1. Trade of Firm:
   (a) Building and Civil Engineering
   (b) General Builder
   (c) Civil Engineering
   (d) Subcontractor

2. Firm's Catchment Area

   ....

3. Approximate Work Load at Present

Type of Work	Number of Contracts	Average Contract Sum	Average Duration	Average Distance	Average % Completion
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______

4. Estimates of Firm's Turnover , Profit or Loss

Years	Turnover	Profit/Loss
1981	________	________
1982	________	________
1983	________	________
1984	________	________
1985	________	________
1986	________	________
1987	________	________

5. Do you consider your performance above a consolidation, expansion or recession phase (Tick as applicable).

6. Are you satisfied with this ? YES............... NO...............

7. How do you normally cope with shortage of work?
   (a) Diversify from traditional areas of operation
   (b) Concentrate on your traditional areas of operation
   (c) Re-adjusting the workforce
   (d) Plough back profits from previous years?
   (e)...
   (f) ....

8. What Percentage of your expenditure in a year goes into the following:
   (a) Maintenance of company overheads ....%
   (b) Labour ....%
   (c) Management ....%
   (d) Equipments ....%
   (e) Materials ....%

SECTION 2

1. How many of these people do you have in your firm?

	Number	Average Annual Income
Managing Directors	....	....
Project/Construction Managers	....	....
Site Managers	....	....
Site Agents	....	....
Site Engineers	....	....
General Foremen	....	....
Trades Formen	....	....
Office/Clerical Staff	....	....
Operatives	....	....
Labourers	....	....

2. Some factors considered in employing workers are listed below. Please rank them and others you may add in order of importance (1st., 2nd.,......).

Factors	Management Staff (Ranks)	Technical Staff (Ranks)	Operatives (Ranks)
Experience	....	....	....
Qualification	....	....	....
Age	....	....	....
Personality	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

SECTION 3

1. What percentage of your contracts are completed on time?

(a) 10-30% (b) 30-50% (c) 50-70% (d) 70-100%

2. If not all your contracts are completed on time, can you please list the main causes in order of importance?

1st.____

2nd.____

3rd.____

4th.____

5th.____

3. Have you experienced cost over-runs i.e. over running the targetted cost of projects? ....YES ....NO

If YES, list the causes in order of importance?

1st.____

2nd.____

3rd.____

4th.____

4. Do you pre-determine the output expected from your operatives in specifc operations?

.................YES ....NO

If YES, how?

.____

.____

.____

5. How do you monitor the productivity of your workers?

.____

.____

6. What incentive scheme(s) do you operate on your sites?

(a) Bonus Scheme

(b) Target Scheme

(c) Piece work rates

(d) None

(e) ....

7. Please explain how this scheme(s) works on your sites?

.______________________________

.______________________________

.______________________________

.______________________________

8. Do you think this scheme(s) has been effective in optimising your workers' output?

.....................YES ....No

9. What other efforts do you make to optimise the productivity of your operatives?

.______________________________

.______________________________

.______________________________

10. Kindly explain your firm's labour relations policy e.g. Promotions, Retirement, Redundancy, Dismissal.

____

.______________________________

.______________________________

.______________________________

.______________________________

SECTION 4

1. How often do you experience stoppages in the construction process due to internal cash flow problems?

   (a) Very Often (b) Often (c) Seldom (d) Never

2. When cash flow problems arise, how do you cope with them?

   (a) Stop the work until the situation improves

   (b) Reduce the site labour force

   (c) Explain the situation to your workers to allow you delay payment of their wages

   (d) Short term loan from the bank

   (e) ....

   (f) ....

3. How often do you have the problem of validated certificates not being paid on time by the client?

   (a) Very often (b) Often (c) Seldom (d) Never

4. List the forms of delays you think disturb your workers from achieving their optimum production capacity.

   .____

   .____

   .____

   .____

   .____

   .____

5. When there are delays (externally or internally generated) how do you employ the services of your workers? (Please tick only the most likely thing you will do)

(a) Shift them to other jobs/departments

(b) Excuse them from duty with minimum pay

(c) Dismiss them

(d) ....

(e) ....

6. What problems do you often encounter with the client in the execution of projects?

(a) Inadequate drawings

(b) Variations

(c) Late payment

(d) ....

(e) ....

(f) ....

7. How do you cope with these problems?

- ____
- ____
- ____
- ____

SECTION 5

1. Do you employ domestic subcontractors for some of your operations?

...................YES ....NO

If YES, do the following correspond to your reasons for using them?

(a) Reduce Workload

(b) Increase profit

(c) Workers are more productive under them

(d) Reduces financial risk

(e) Do not have suitable staff

(f) ....

(g) ....

2. What form of contract do you employ with these domestic subcontractors?

(a) Your company's form

(d) The J.C.T. form

(c) His resources

(d) ....

(e) ....

3. What are your basic considerations in the choise of subcontractors for your work?

(a) Work Programme

(b) Efficiency in previous work

(c) His resources

(d) ....

4. Have there been cases of subcontractors defaulting i.e. not turning up when he's supposed oor leaving before completion of work?

..............................YES ....NO

If YES, how do you adjust in such situations?

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APPENDIX B

Appendix B
Operatives' Questionnaire

Introduction

This questionnaire was designed to evaluate bricklayers' working environment, their perception of production problems, and their motivation. With an identifying label on each questionnaire, everyone of the 157 bricklayers studied by activity sampling was requested to respond to the questions. Their responses form the basis of the discussions in Chapters 6 and 7.

The Questionnaire

The Department of Civil Engineering at Loughborough University is currently engaged in a number of research projects aimed at improving construction productivty. Having realised the paramount importance of the construction operative in the construction process, this research aims at knowing the different variables affecting productivity especially those related to operative motivation. This questionnaire is designed towards this end. Your sincere and frank answers to the questions will be much appreciated. All answers will be treated in absolute confidence and used **only** for academic purposes. You are free to skip any question considered 'nosy' by putting a line across it. Extra space is provided to enable you expand your answers to the questions where necessary.
Thank You.

Response: √ positive X negative

PERSONAL DATA

1. Name and Location of your present site...

....

2. What is your age group in years?

(a) 15 - 20 (b) 20 -30 (c) 30 - 40 (d) 40 - 50 (e) above 50

3. What is your construction experience in years?

(a) 0 - 2 (b) 2 - 5 (c) 5 - 10 (d) 10 - 20 (e) above 20 years

4. How were you trained?

   (a) Apprenticeship (b) Trade School (c) Combination of (a) and (b)

   (d) C.I.T.B. (e) On-site Experience

5. Taking into consideration all projects you have participated in, what percentage of them have you done under the following classifications:

CLASSIFICATIONS	PERCENTAGES
Housing	____
Public Building	____
Industrial	____
Commercial	____

OPERATIVE / EMPLOYER RELATIONSHIP

1. Under which of these are you currently employed?

   (a) Subcontractor (Labour only)

   (b) Main subcontractor

   (c) Main contractor

   (d) ....

2. How long have you been with your present employer?

   (a) 0-2 years (b) 2-5 years (c) 5-10 years (d)10-20 years (e) over 20 years

3. How long have you been on this present site?

   (a) 0-3months (b) 3-6 months (c) 6-12 months (d) over 12 months

4. How would you classify the following on your site? (tick (√) appropriate columns)

SUBJECTS	Excellent	V. Good	Good	Fair	Bad	V. Bad
Work Organisation						
Supervision						
Level of Pay						
Working Environment						

5. What does the management know about your work?

   (a) Its Progress (b) Its delays (c) Nothing

6. How aware are you of how your work fits into the programme and profit being made by your employer on this project?

   (a) Very aware (b) aware (c) not aware

7. If you are aware what efforts do you make to ensure your employer's progress?

   (a) Advice your direct supervisor on best methods to adopt

   (b) Adopt or devise better methods

   (c) ....

   (d) ....

8. Which of the following charactersistics are present in your direct supervisor?

   (a) Around when needed

   (b) Friendly and approachable

   (c) Does not know his work

   (d) Very skilled

   (e) Keeps all project information to himself

   (f) Does not listen to suggestions

9. How cooperative are your workmates?

   (a) Very cooperative (b) Cooperative (c) Not cooperative

OUTPUTS AND METHODS

1. Briefly describe your current task:..

   ....

2. What is your normal gang size? (First figure indicates the craftsman and the second represents the labour)

   (a) 2:1 (b) 3:1 (c) 4:1 (d) 5:1 (e) 5:2 (f) ....

3. What do you think the ideal gang size should be? ....

4. What is the normal output per day in your current task?

   Gang ....per day

   You as an individual ....per day

5. Are you satisfied with this output level?

   ....YES ....NO

6. Given all favourable condition, what do you think is the highest output you can acheive in this task?

   ....per day

7. How would you classify your energy input into bricklaying?

   (a) Very strenuous

   (b) Strenuous

   (c) Just O.K.

8. In a typical working day, what percentage of your time would you estimate is spent in the following classifications:

CLASSES	% of TYPICAL WORKING DAY
Working	....
Official Breaks	....
Waiting (e.g.materials)	....
Recovery	....
Unaccountable	....

9. Would you really like to change your current method of laying bricks should a new and better method be devised ?

   ....YES ....NO

PRODUCTIVITY

1. Underlisted are some of the problems which may be influencing your productivity. Kindly tick ( ) if it is a problem on your present site in column 2 and give an estimate (in hours) of how much time is lost per week traceable to this problem in the third column.

   Example:

Problems	Response	Estimated time lost /week
Lack of Materials		10Hrs

Problems	Response	Estimated time lost /week
Lack of Materials		
Lack of tools		
Equipment breakdown		
Repeat work		
Changing crew members		
Interference		
Absenteeism		
Supervision		
Inspection delays		
Overcrowding		
....		
....		
....		
....		

2. Underlisted are some of the probable causes of non availablity of materails when needed by bricklayers on site. If they correspond to the causes of this problem on your site tick ( ) the cause and rank them in order of importance i.e. 1st., 2nd.,...........

   (a) On-site transporting difficulties ....
   (b) Excessive paper work for requisitions ....
   (c) Improper materials delivered to site ....
   (d) Lack of proper planning ....
   (e) Other workers ....
   (f) ....

3. How much influence does your having to stop work, wait or move to a different spot because of lack of materials or tools have on your daily outptut?

   (a) Great Influence (b) Average Influence (c) No Influence

4. Just as in question 2 above, probable causes of repeat work are underlisted. Please tick ( ) and rank in order of importance.

	Ranks
(a) Poor Instructions	....
(b) Change of Instruction	....
(c) Poor workmanship	....
(d) Complex Specification	....
(e)	....

5. Does repeat work make you less enthusiastic to increasing your output?

   ....YES ....NO

6. Do you really mind having to stop work or change areas because of other gangs, overcrowding and inspections?

   ....YES ....NO

TURNOVER

1. How many men in your gang have left this site since you started working here?

   ....men

2. Please list the three most important reasons why people leave.

   1st. ....

   2nd. ....

   3rd. ....

3. Is your gang slowed down by men joining or leaving it?

.................................YES ....NO

4. How many hours in a week would you estimate are lost adjusting to new work mates?

....hour(s) in a week

5. Do you know of many people who have not shown up for one or more days but have come back to this site?

.................................YES ....NO

6. How many hours per week would you estimate are lost by your gang because men don't show up?

....................................hour(s) per week

7. Do you really mind having men from your gang missing work?

.................................YES ....NO

MOTIVATION.

1. List in order of importance the first three things that give you job satisfaction in bricklaying trade.

   1st. ....

   2nd. ....

   3rd. ....

2. List in order of importance the first three things that give you most dissatisfaction in your trade?

   1st. ....

   2nd. ....

   3rd. ....

3. Below is a table of construction situations that can motivate you to higher productivity. You are requested to indicate the level of importance (Very Important (VI), Important (I), Just Important (JI) and Very Low Importance (VLI)) of each to you in column 2. In column 3 you are to indicate the level (3 - High, 2 - Average, 1- Low) to which each variable is present on this site. The list is not exhaustive. It would be appreciated if you could add to the list.

MOTIVATORS	IMPORTANCE	LEVEL ON THIS SITE
Example: **My wife's kiss before leaving Home for work**	**VI**	**3**
Good relations with work mates		
Good safety Programme		
The work itself		
Overtime		
Fairness of Pay		
Recognition on the Job		
Accurate description of work to be done		
Participation in decision making		
Good Supervision		
Promotion		
More Responsibility		
Challenging Task		
Job Security		
Choosing workmates		
Bonus		
....		

4. As above, you are requested to rank the level of importance of the following factors which are capable of causing a loss of your enthusiasm to work and the levels to which they are met on your present site.

DEMOTIVATORS	IMPORTANCE	LEVEL ON THIS SITE
Disrespectful		
Little Accomplishment		
Discontinuity of work		
Lack of recognition		
Underutilsation of Skill		
Incompetence of workmates		
Lack of cooperation among mates		
Poor Inspection Programmes		
Unsafe Conditions		
Productivity urged but no one cares		
Hot weather		
Cold weather		
Too Much work		
Not enough work		
....		
....		
....		

SUMMARY

1. Which problem, if solved, would yield the greated improvement on your speed and quality ?

   ----

2. Which problem, if solved, would have the second greatest effect on your productivity?

   ----

3. Which problem, if solved would have the third greatest effect?

   ----

4. On the average are you satisfied with your job on this site?

   ....YES ....NO

5. Please give suggestions on how best to improve the productivity of workers in your trade?

THANK YOU FOR HELPING THIS RESEARCH.

Mr. P.O. OLOMOLAIYE

APPENDIX C

APPENDIX C
GUIDELINE FOR INTERVIEWING

Introduction

Project managers, site agents or supervisors on all sites were interviewed to obtain details of their respective projects and their operative management practice. These interviews lasted between two to three hours. The interviews were informally conducted.

The Guides

1. Type of Building

....

....

2. Location

....

....

3. When was contract awarded

....

....

4. Project commencement date

....

5. Duration

....

6. Approximate contract sum

....

7. Is Penalty Clause in Operation

....

   The Penalty

....

8. Stage of completion

....

9. Level of contentment with bricklaying productivity on this site

....

10. How does he monitor bricklayers' productivity?

....

....

....

11. Three main factors affecting his bricklayers' productivity in order of importance

1st...

2nd..

3rd...

12. Assessment of workers' morale

....

....

....

13. Three greatest motivators in order of importance

1st...

2nd..

3rd...

14. Three greatest demotivators in order of importance

1st...

2nd..

3rd...

15. Practical Production problems on this site

....

....

16. Efforts to improve productivity

....

....

....

....

17.Comparison between subcontractors labor only and 'on the books'

....

....

....

....

18. Average bricklaying output per week

....

19. Description of the payment system

....

....

....

....

20. General Discussion

....

....

....

....

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APPENDIX D

APPENDIX D
SITE DETAILER

Introduction

This form was used to record observed site details, and author's general impressions of the various sites visited.

The detailer

SITE TERRAIN

WELFARE FACILITIES

Toilet

Canteen

Clothing

PLANT, EQUIPMENT AND TOOLS

Types on Site	Working Order	% Idleness.
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

SITE ORGANISATION

Location of Materials to point of use

Waste Levels

Materials	% Estimate
....	....
....	....
....	....
....	....

Neatness

Vertical Transportation

Scafolding

Crane and Ladder Positions

Frequency of Supervision

FORM OF CONTRACT

EMPLOYING AUTHORITY

SPECIFIED QUALITY LEVEL

SITE MEETINGS

PROGRAMME OF WORK

WORKING HOURS

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APPENDIX E

APPENDIX E

BASIC STATISTICAL TESTS FOR EVALUATING PRODUCTION OUTPUT AND MOTIVATION IN BRICKLAYING

Introduction:

Statistics has gained dominance over thoughts and intuition in the evaluation and prediction of behaviour in all fields of study. It is no longer an obscure field of study for gamblers but now constitutes the science of decision making in the face of uncertainty. Uncertainty, as it is not possible to examine a population in exhaustive detail because of its size and limited research resources. Information derived from samples drawn according to specific criteria can be used to make estimates of and inferences about the characteristics of populations. However, generalisations of this sort are not possible except consideration is first given to the question of how data are obtained and how experiments are conducted. Freund says "no amount of fancy mathematics or statistical manipulation can salvage poorly planned studies, surveys or experiments" (E.1). An understanding of the different types of data obtainable becomes essential in knowing which of the statistical tools to employ.

Types of Data.

There are three main types of data:

1- Nominal Measure

This is the lowest level of measurement. It is simply the classification of observation into categories. These categories must be mutually exclusive and collectively exhaustive. This means that no observation can appear in more than one category and all elements must be included. An example is the classification of people by sex or religion. The breakdown of bricklaying activities into 25 elements and the observations in these separate elements forming the total period of observation is also a relevant example.

2. Ordinal Measure.

An ordinal measure is distinguished from a nominal one by its additional property of order among the categories. A category will be higher or lower than the adjacent category. However, ordinal measures do not explain the magnitude of differences between elements. Roscoe (E.2) likened them to a 'foot race without a stopwatch, the order in which the runners finish is determined but the magnitude of the intervals betwen them is indeterminate'. Ordinal scales are sometimes called rank order scales. They feature prominently in this research in quantifying the relative importances of the motivating and demotivating influences.

3. Interval Measure.

This is distinguished from an ordinal measure by having equal intervals between the units of measure, e.g. weight in grams, temperatures in degrees centigrade. It is a qualitative scale. Its main shortcoming is that it does not have "true zero". This means that one cannot interpret a score of 50 as indicating twice as much a given trait as a score of 25.

4. Ratio Measure

This has all the properties of interval scales with the additional property of a true zero. It is a higher level of measurement than interval measures. The charateristics in interval and ratio scales are perhaps most often referred to as variables, in contrast to attributes classified in nominal measures.

The activity sampling data collected during this research are based largely on interval and ratio measures. The data was recorded at regular intervals and true zero values are at the start of observations. They also possess the comparability characteristics because the number of observations taken per gang and per operative are all at 95% significance level. The bulk of the data for motivation is ordinal but were transformed to ratio measures with the relative index to enable comparative analysis. The validity of the analysis conducted on these data were tested by applying established statistical tests on each result, generating hypothesis at each juncture and accepting or refuting them based on established criteria. This appendix now describes the tests.

Statistical Tests

Descriptions of statistical data can be quite brief or elaborate depending partly on the nature of the data themselves and partly on the purpose for which they are intended. Often, results obtained in an experiment are regarded as a sample of what is obtainable if the the experiment were repeated over and over again.

Whether a set of data is to be looked upon as a sample or as a population depends to some extent on what is to be done with the data. This brings the distinction between DESCRIPTIVE and INFERENTIAL statistics into focus. When the characteristics of a sample is used in a 'broad' sense to make judgements on a population, we term this DESCRIPTIVE. But when some definite statements are made about the population from the sample, the concept of 'uncertainty' comes in. This is the domain of INFERENTIAL statistics i.e. statistics by inferences. Because of uncertainties, there is the need to determine the degree of truth represented by the data and different tests have been established to check the validity of samples.

Inferences

As stated above, descriptive statistics, identifies the common statistical characteristics of mean, median and standard deviations. Earlier studies of outputs of construction operatives adopted these (E.3). Often, reports have used these characteristics without checking them with some standard tests as expected. This is one of the main problems with some of the published works. To prevent this, tests were conducted on the statistical results in this research.

Tests on Means.

When it becomes necessary to decide whether the mean obtained from a sample is representative of the mean of the population some basic assumptions must be made. First, it must be assumed that the population is standard-normally distributed and secondly the mean of the population must be assumed. If these assumptions are made then the following equation applies for large population (n > 30):

$$z = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$$

In this formula for Z, both the standard deviation (s) and the population mean (m) are assumed to be known. When n < 30 the student t distribution rule applies with n - 1 degrees of freedom.

This equation forms the basis of tests on whether the means of two samples are from the same source, i.e. whether an observed difference between two sample means can be attributed to chance or whether it is an indication of the fact that the samples are from the same population. In such situation Z is estimated using the equation:

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Let us illustriate this with an example. Suppose 80 bricklayers in Leicestershire averaged 42.61 minutes in 'spread mortar' per 1000 bricks with a standard deviation of 6.85 and 100 bricklayers in Nottinghamshire averaged 39.12 minutes with a standard deviation of 5.92. To test whether the means are equal to one another substitute these values in the equation above:

$$z = \frac{42.61 - 39.12}{\sqrt{\frac{6.85^2}{80} + \frac{5.92^2}{100}}} = 3.61$$

Since this exceeds the value (1.96) of Z at 95% confidence level it can be held that there is significant difference between the means of the performance of bricklayers in these two areas, i.e. they are essentially different from one another. However since our comparative analysis were on site basis the number (n) is rather small per site, the student t distribution rule was applied in this research.

Chi Square Tests

Test of standard devaition

It often becomes necessary to conduct tests to check the uniformity or homogeneity of a process or operation. In this research it was necessary to test the performance of the model designed in chapter 8. Will this model be able to predict output in bricklaying using the six critical variables? The chi square test enabled this.

Chi square test has its roots in the tests of standard deviation in which tests are conducted on the equality of standard deviations of random samples. With the basic assumption that the population from which the random samples were taken is normal, tests of the equality of two samples are based on the ratios of their standard deviation in comparison to the F-distribution table:

$$F = \frac{S_2^2}{S_1^2} \text{ or } \frac{S_1^2}{S_2^2} \quad \text{which ever is larger}$$

This F is compared to the F at the appropriate level of significance for the study in order to accept or reject the hypothesis.

Test of Goodness of Fit.

This is generally used to test how an expected distribution (on the basis of theories or assumptions) fit, or describe, observed data. Often, some discrepancies are expected. To check whether these discrepancies may be attributed to chance, $\chi 2$ is determined using the formula:

$$\chi 2 = \sum \frac{(f - e)^2}{e}$$

$(f\text{-}e)^2 / e$ is calculated separately for each class of the distribution. If the c2 value is too large (by checking c2 for appropriate level of significance in the table) the hypothesis that the two sets of distribution are equal would be rejected. " In general, the number of degrees of freedom for this kind of test is given by the number of terms $(f\text{-}e)^2/e$ added in obtaining c2 minus the number of quantities, obtained from the observed data, that are used in calculating the expected frequencies" (E.1).

Analysis of Variance

As would be readily explained in statistical texts, the analysis of variance seeks to determine whether differences between more than two means is due to chance or due to actual differences between the means. There should be the basic normality assumption before conducting this analysis. The basic decision making tool is the F variance ratio which is based on the expression:

$$F = \frac{\text{Estimate of standard deviation based on variation among the means}}{\text{Estimate of standard deviation based on the variation within the samples}}$$

It has become the norm to express the various steps to calculate the F ratio in tabulated form. Table E.1 illustriates this for one way analysis of variance.

Table E.1 - Analysis of Variance Table

Source of Variation	Degrees of Freed.	Sum of Square	Mean Square	F
Treatments	K - 1	SS(Tr)	$MS(Tr) = \frac{SS(Tr)}{K-1}$	$\frac{MS(Tr)}{MSE}$
Error	K(n-1)	SSE	$MSE = \frac{SSE}{K(n-1)}$	
Total	Kn - 1	SST		

Where:

SST = The measure of the total variation named the Total Sum of Squares

SS(Tr) = Treatment Sum of Sguares which measures the variation among sample means.

SSE = The Error of Sum of Sqaures - variation of means within samples

SST = SS(Tr) + SSE

The F value calculated for each variable/sample is then compared with the F distribution table at the appropriate level of significance and degrees of freedom to determine its contribution to explainign variance in the data.

Regression Analysis

Prediction of the average value of a dependent variable in terms of the known value of independent variable is the problem of regression. This problem is normally solved by the least sqaure methods explained in most statistical texts (E.1,E.2,E.4,E.5). Different equations linking dependent variable to independent variables can be constructed depending on whether the relationship between them is linear or non linear. A linear regression model with one independent variable (i.e. one predictor) is of the form:

$$Y = c + lx$$

where
- $Y =$ Dependent variable
- $c =$ Constant
- $x =$ Independent variable
- $l =$ Coefficient

For a multiple regression model the equation is of the form

$$Y = C + l_1x_1 + l_2x_2 \ldots\ldots\ldots\ldots l_nx_n$$

The modelling in this thesis have all been of the multiple regression format because of the nature of the problem addressed. In regression analysis each l is tested for significant contribution to the coefficient of determination (R^2) which is a measure of the proportion of the variance of the dependeded variable accounted for by the predictor variables.

To be able to test each l for significance a stepwise multiple regression approach was taken on the 'GENSTAT' statistical package. In this approach, each independent variable is added to an existing model until all the variables have been exhausted. It is therefore possible to calculate F ratio at each step and also determine the R^2. To calculate F ratio at each stage we use the formular:

$$F = \frac{\text{Mean square of regression}}{\text{Mean square of residuals}}$$

This F is compared with the F distribution vaues at the appropriate degree of freedom. See chapter 8.

Correlation Analysis

Although frequently overlooked, a high coefficient of correlation does not guarantee that the relationship is not due to chance. In correlation analysis a test is conducted on the coefficients to test them for significance. The basic normality assumption is made before applying the formular below for the test:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

at n-2 degrees of freedom.
r = correlation coefficient.
n = population

The value of t obtained is compared to the t distribution value at the n - 2 degree of freedom. This value must exceed t at 95% significance levle to accept the correlation coefficients in this thesis as being significant. This formula was used extensively in chapter 7 to test the relationship between the motivation variables.

Statistical Aids

Three main statistical packages capable of analysing the data with in-built formulas were used to analyse the data in this research. These are the MINITAB, GENSTAT and STATWORKS statistical packages. Both MINITAB and GENSTAT are available on the main frame MULTICS system at the Loughboroug University. STATWORKS is available on the Macintosh PC in the department of Civil Engineering.

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APPENDIX F

APPENDIX F

BASIC PRODUCTION ANALYSIS IN BRICKLAYING

Introduction

This appendix describes details of the analysis done on different activities making up the bricklayers' working day. The traditional work study techniques for production analysis as modified for concreting operations by Price (F.1), were adapted to analysing bricklaying. The analysis procedure aims at calculating basic time, standard time, production factors and planning time which are useful estimating tools.

As earlier mentioned in chapter 5, Emsley (F.2) developed a program which should be able to do these calculations for different construction operations. It is, however, not suitable for indepth statistical analysis. Her data collection program presents both site details and summaries of observations made in a format suitable for statistical analysis on the MINITAB statistical package. See Table F.1.

Calculation of Basic Time

The 'basic time' is time spent carrying out an element of work or an operation at standard rating . From Table 1 it can be observed that some of the 25 elements of the working day are rated while others are not. The rated activities are productive (Note the difference in activities classified productive for operatives as against labourers). The basis of rating, as would readily be argued by anyone conversant with workstudy, is subjective. Although subjective, rating can be reliable if the observer is well trained. The author has been trained in workstudy rating and has rated on previous research projects . Being that all the observations were taken by the same person, i.e. the author, variations in rating can be said to have been eliminated.

Table F.1: An Example of Summary of Collected Data.

SITE DETAILS

Date 06/10/86
Site Description .... REDEVELOPMENT
Location LEICESTER
Main Contactor ....
Sub - Contractor LABOUR ONLY SUB
Time Allocated for Official Breaks 60 MINUTES

FILE 1
Job Description THREE BEDROOM HOMES
Duration of Survey 120 MINUTES
No of Observations 120
Average time between observations 1.00 MINUTES
Time Allocated to Early Start 0 MINUTES
Time Allocated to Late Start 1 MINUTES
Time Allocated to Early Finish 3 MINUTES
Time Allocated to Late Finish 0 MINUTES

FILE 2
Job Description THREE BEDROOM HOMES
Duration of Survey 143 MINUTES
No of Observations 129
Average time between observations 1.12 MINUTES
Time Allocated to Early Start 0 MINUTES
Time Allocated to Late Start 6 MINUTES
Time Allocated to Early Finish 0 MINUTES
Time Allocated to Late Finish 10 MINUTES

Table F.1 Contd.

Summary of Data With Respect To Operatives

ACTIVITY	MAN 1		MAN2		LABOUR		TOTAL		
	No.	Rate	No.	Rate	No.	Rate	No.	%	Rate
1. Spread Mortar	22	100	16	98	1	100	39	5.3	94
2. Fetch Mortar	11	97	21	94	11	91	43	5.9	92
3. Fetch Brick	15	96	28	96	46	92	89	12.1	92
4. Cut Brick	11	100	24	95	0	-	35	4.8	94
5. Lay Brick	46	97	41	96	0	-	87	11.8	96
6. Fill Joints	16	98	18	93	0	-	34	4.6	93
7. Measuring	3	92	3	92	0	-	6	0.8	92
8. Setting & Checking	24	98	11	90	0	-	35	4.8	92
9. Raking % Pointing	4	100	0	-	0	-	4	0.5	100
10 Supervision	2	-	2	-	0	-	4	0.5	100
11 Idle & Away	22	-	37	-	47	-	106	14.4	-
12 Fatigued	7	-	9	-	16	-	32	4.3	-
13 Waiting	7	-	8	-	3	-	18	2.4	-
14 Searching	7	-	2	-	3	-	12	1.6	-
15 Rework	3	-	1	-	0	-	4	0.5	-
16 Confused	1	-	3	-	3	-	7	1.0	-
17 Ancillary Work	10	-	1	-	0	-	11	1.5	-
18 Other Works	12	-	6	-	14	-	32	4.4	-
19 Drive dumper	0	-	0	-	0	-	0	-	-
20 Operate Mixer	0	-	0	-	2	100	2	0.3	100
21 Climb	3	-	3	-	32	-	38	5.2	-
22 Distribute	0	-	0	-	60	98	60	8.2	98
23 Fetching	11	-	8	-	4	100	23	3.2	100
24 Cleaning	0	-	0	-	14	100	14	1.9	100
25 Read drawing	0	-	0	-	0	-	0	-	-

The ratings were done with a 100 standard rating scale base. The procedure for calculating basic times in each activity involved the following steps.

1. The data were read into the MINITAB statistical package. Because we were dealing with over 100 bricklayers, the data for each element including rates were entered as 'columns' in the minitab data file.
2. For rated activities, the basic time of a bricklayer in a certain element was calculated using the expression:

   $$\text{Basic Time} = \frac{\text{Number of Observation in an element x Rate x Obervation Interval}}{100}$$

   Since the observation interval was 1 minute, the expression becomes:

   $$\frac{\text{Number of Observation in an element x Rate x Obervation Interval}}{100}$$

3. For unrated activities the observation time was imply taken to be the basic time.
4. The unit basic time was with respect to a unit of output i.e. the basic time divided by the production output over the obsevation period.
5. The Total Basic Time for a gang was calculated by adding the basic time in each activity for the particular gang.
6. The Overall Basic Time was the summation of total basic time in all activities.
7. The Unit Overall Basic Time was calculated by dividing the overall basic time by the production output.

Calculation of Standard Times

Standard time is the total time in which a task should be completed at standard performance i.e. basic time plus relaxation allowance. The relaxation allowance takes care of the worker's time spent:

(i) recovering from the effort of carrying out specified work under specified conditions (fatigue allowance);

(ii) allow attention to personal needs and

(iii) (rarely) recover from adverse environmental conditions (F.3).

What relaxation allowances should be allowed on each element can be a great problem. The allowances given in the report of the Organisation, Methods and Work study panel of LAMSAC were adopted (F.4). The allowances given for 'energy output', 'posture and movement', 'working conditions' and 'basic allowances' were added to the data in different coulmns of the MINITAB package.

The relaxation allowances were coded according the LAMSAC report. For example, 321 for 'fetch mortar' mean it falls into category 3 for energy output, 2 for posture and movement and 1 for working conditions. All these allowances were added together into another column in the MINITAB file. See Table F.2 for an illustration. The standard time can then obtained by increasing the basic time according to the percentage of the total relaxation allowance.

Calculation of Production Factors.

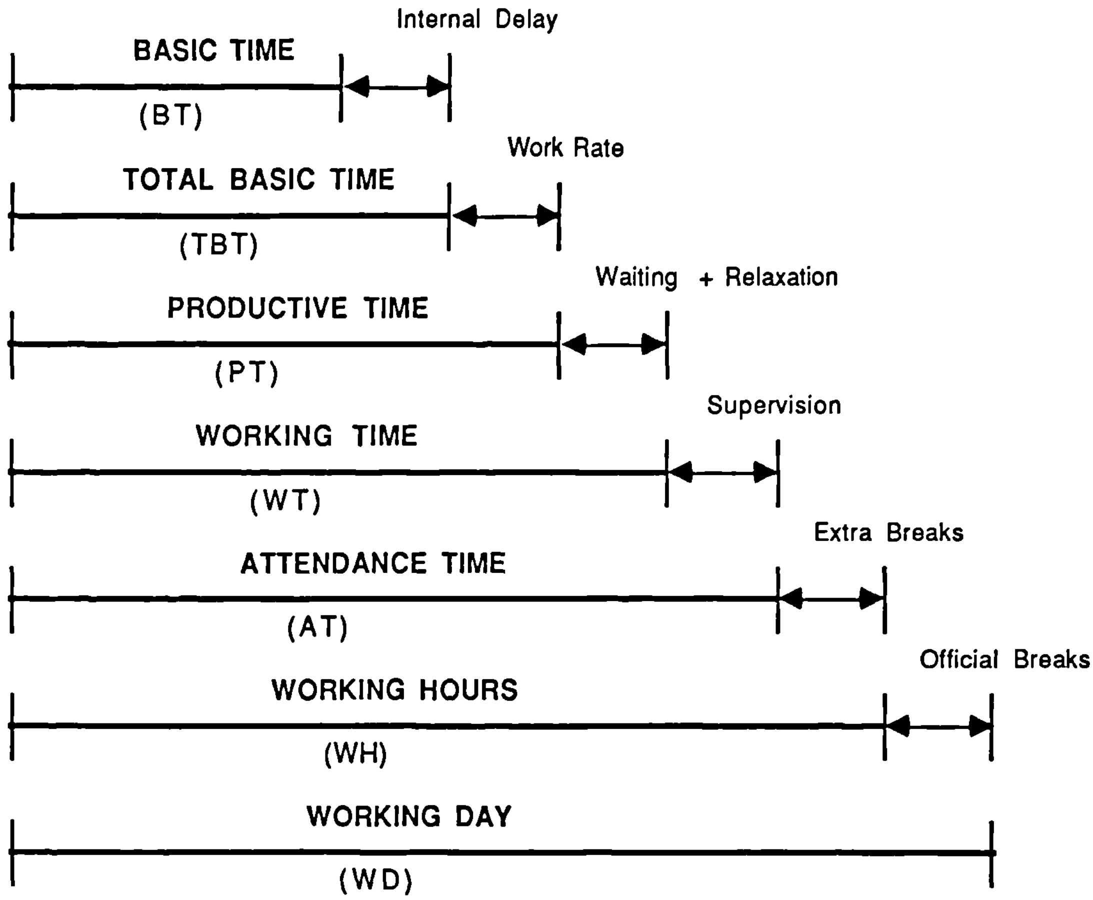
Production factors are measures of performance directly relating to how bricklayers spend their working day. Calculating this is based on the 'site factor' principle developed at the Loughborough University of Technology (F.4). In the previous study, four main factors namely Work rate (F1), Waiting time for work or materials (F2), Extended Breaks (F3, and Relaxation (F4) were identified as the main causes of variation in output between gangs, sites and individual operatives. This research has identified another main cause - supervision (time spent taking instruction and inspection) which is difficult to classify into any of the four classes previously identified. See Figure F.1

Table F.2 An Example of the Calculation of Standard Time For a Gang

				RELAXATION ALLOWANCES					
A.C		OBT	BT	E	P&M.	B. Al	Code	T all	STD. T
1.	Spread Mortar	44	44	4	2	10	321	16	51.00
2.	Fetch Mortar	27	26.7	4	2	10	321	16	31.00
3.	Fetch Brick	26	25.8	4	2	10	321	16	29.90
4.	Cut Brick	6	5.9	4	2	10	321	16	6.80
5.	Lay Brick	66	65.8	4	2	10	321	16	76.30
6.	Fill Joints	0	0	2	2	10	221	14	-
7.	Measuring	1	1.0	0	0	10	111	10	1.10
8.	Setting & Checking	7	6.2	0	0	10	111	10	6.80
9.	Raking % Pointing	57	55.8	2	2	10	211	14	63.60
20	Operate Mixer	15	14.1	4	2	10	321	16	16.40
22	Distribute	87	80.9	4	2	10	321	16	93.80
23	Fetching	32	31.3	4	2	10	321	14	36.30
24	Cleaning	14	12.1	4	2	10	321	16	14.00

Note: **A.C** - Activity Code, **OBT** - Observation time, **BT**- Basic Time, **E** - Energy Output, **P&M.** - Posture and Movement, **B.Al** - Basic Allowances, **T. all.** - Total Relaxation allowances, **STD.T**- Standard Time.

Figure F.1 - Caliberation of Production Factors



$F1 = \frac{PT}{TBT}$ i.e. $\frac{\text{Productive Time}}{\text{Total Basic Time}}$ $F2 = \frac{WT}{PT}$ i.e $\frac{\text{Working Time}}{\text{Productive Time}}$

$F3 = \frac{AT}{WT}$ i.e. $\frac{\text{Attendance Time}}{\text{Working Hours}}$ $F4 = \frac{WH}{AT}$ i.e. $\frac{\text{Working Hours}}{\text{Attendance Time}}$

$F5 = \frac{WD}{WH}$ i.e. $\frac{\text{Working Day}}{\text{Working Hour}}$

The relationship between the working day and the Total Basic Time can be expressed as :
Working Day = TBT x F1 x F2 x F3 x F4 x F5

Lets say FT (Total Production Factor) = F1 x F2 x F3 x F4 x F5

The working Day equation then becomes TBT x FT. This relationship is used to calculate planning times for estimating purposes.

If this principle is applied to individual bricklaying operatives, gangs and sites, we would have 'Man', 'Gang' and Site factors respectively with F1, F2, F3, F4, and F5 for each category. The 'Man Factor' will provide important information about individual's performance to the management. The 'gang' factor gives the performance of the individual gangs while site factors show the overall performance of the sites.

From the breakdown of elements into categories corresponding to the different classification of the working day in Figure F.1; and puting them into the relevant equations, F1 to F5 and FT values were calculated for the operatives, gangs and sites. 'Man' factors for all operatives are described in Table F.3 below:

Table F.3: Statistical Description of 'Man Factors' in this Research

CATEGORIES	NOS	MEAN	MEDIAN	STD. DEV	MINIMUM	MAXIMUM
F1	106	1.0556	1.0330	0.9717	0.5005	10.7704
F2	106	1.5700	1.4690	1.0580	0.1520	8.9000
F3	106	1.0202	1.0118	0.0360	0.9490	1.2022
F4	106	1.1703	1.1441	0.1607	1.0030	1.6550
F5	106	1.1256	1.1254	0.0835	1.1200	1.7362
FT	106	2.3950	2.0300	2.1260	0.9960	18.0000

Going by the mean value of FT above it can be concluded that a realistic estimate of planning time in bricklaying will be 2.395 x Total Basic Time.

References

F.1 Price A.D.F., An Evaluation of Production Output for In Situ Concrete Work, A Ph.D thesis, Dept. of Civil Engineering, Loughborough University, 1987.

F.2 Emsley M.W. and Harris F.C., Computerised Collection of Workstudy Data, Building Technology and Management, Vol. 11, 1984 / 1985.

F.3 BS3138:1979, Glossary of Terms Used in Work Study and Organisation and Methods.

F.4 Harris F., Price A.D.F. and Emsley M., An Evaluation of Production Output For Construction Labour and Plant, *SERC GR/B/55138*.

APPENDIX G

APPENDIX G
Some Analysis Programs

Underlisted are some principal component and 'best' regression analysis programmes which may be easily adapted for analysis of the type in this thesis. Interested readers should contact reference 69 for further information.

A - Principal Components

```
'refe' bricks
'unit' $ 97
'integer' gangsize = 2,3,4,5,6
'integer' codes = 22,21,71,72,41,23,24,51,31,11,61,32
'factor' size $ gangsize
'factor' site $ codes
'vari' vars(1...25), sc(1...25)
'set' x = vars(1...25)
'matr' pcs $ 97,25
:      pcst $ 25,97
'read/mvi = 0' size,op,site,vars(1...25)
'pcp/print = ltc' variates = x; scores = pcs
'calc' pcst = trans(pcs)
'equa' sc(1...25) = pcst
'head' h1 = "first pc"
'head' h2 = "second pc"
'head' h3 = "third pc"
'head' h4 = "fourth pc"
'head' h5 = "fifth pc"
'head' h6 = "sixth pc"
'head' h7 = "seveth pc"
'head' h8 = "eigth pc"
'head' h9 = "ninth pc"
'head' h10 = "tenth pc"
'head' h11 = "eleventh pc"
'head' h12 = "twelth pc"
'head' h13 = "thirteenth pc"
'head' h14 = "fourteenth pc"
'head' h15 = "fifteenth pc"
'head' h16 = "sixteenth pc"
'grap/atx =h2, aty=h1' sc(1); sc(2);
'grap/atx =h3, aty=h1' sc(1); sc(3)$;
'grap/atx =h4, aty =h1' sc(1); sc(4)$;
'grap/atx =h5, aty =h1' sc(1); sc(5)$;
'run'
```

B - Fitting the General Model

```
'refe'  bricks
'unit' $ 97
'integer'  gangsize = 2,3,4,5,6
'integer'  codes = 22, 21,71,72,41,23,24,51,31,11,61,32
'factor'  size $ gangsize
'factor'  site $ codes
'vari' op,vars(1...25)
'read/mvi = 0' size,op,site,vars(1...25)
'terms' size,op,site,vars(1...25)
'y' op
'fit' vars(1...25); res =r
'calc' s = op-r
'graph' r;s
'run'
```

C - Fitting the General Model with Site

```
'refe'  bricks
'unit' $ 97
'integer'  gangsize = 2,3,4,5,6
'integer'  codes = 22, 21,71,72,41,23,24,51,31,11,61,32
'factor'  size $ gangsize
'factor'  site $ codes
'vari' op,vars(1...25)
'read/mvi = 0' size,op,site,vars(1...25)
'terms' size,op,site,vars(1...25)
'y' op
'fit' site,vars(1...25); res =r
'calc' s = op-r
'graph' r;s
'run'
```

D - 'Best' Stepwise Regression Modelling

```
'refe'  bricks
'unit' $ 97
'integer'  gangsize = 2,3,4,5,6
'integer'  codes = 22, 21,71,72,41,23,24,51,31,11,61,32
'factor'  size $ gangsize
'factor'  site $ codes
'vari' op,vars(1...25)
'read/mvi = 0' size,op,site,vars(1...25)
'terms' size,op,site,vars(1...25)
'y' op
'best' vars (1...25)
'best' vars (1...25)
'best' vars (1...25)
'best' vars (1...25)
'best' vars (1...25)
'best' vars (1...25)
'best' vars (1...25)
'best' vars (1...25)
'run'
```

E - 'Best' Analysis of Site and Gang Size

```
'refe'  bricks
'unit' $ 97
'integer'  gangsize = 2,3,4,5,6
'integer'  codes = 22, 21,71,72,41,23,24,51,31,11,61,32
'factor'  size $ gangsize
'factor'  site $ codes
'vari' op,vars(1...25)
'read/mvi = 0' size,op,site,vars(1...25)
'terms' size,op,site,vars(1...25)
'y' op
'best' size, site; res =r
'best' size, site
'calc' s=op-r
'graph' r;s
'run'
```

F - 'Best' Analysis of Site, Gang Size and Motivation

```
'refe'  bricks
'unit' $ 97
'integer'  gangsize = 2,3,4,5,6
'integer'  codes = 22, 21,71,72,41,23,24,51,31,11,61,32
'factor'  size $ gangsize
'factor'  site $ codes
'vari' op,vars(1...25)
'read/mvi = 0' size,op,site,vars(1...25)
'terms' size,op,site,vars(1...25)
'y' op
'best' size, site,moti; res =r
'best' size, site,moti
'best' size, site,moti
'calc' s=op-r
'graph' r;s
'run'
```