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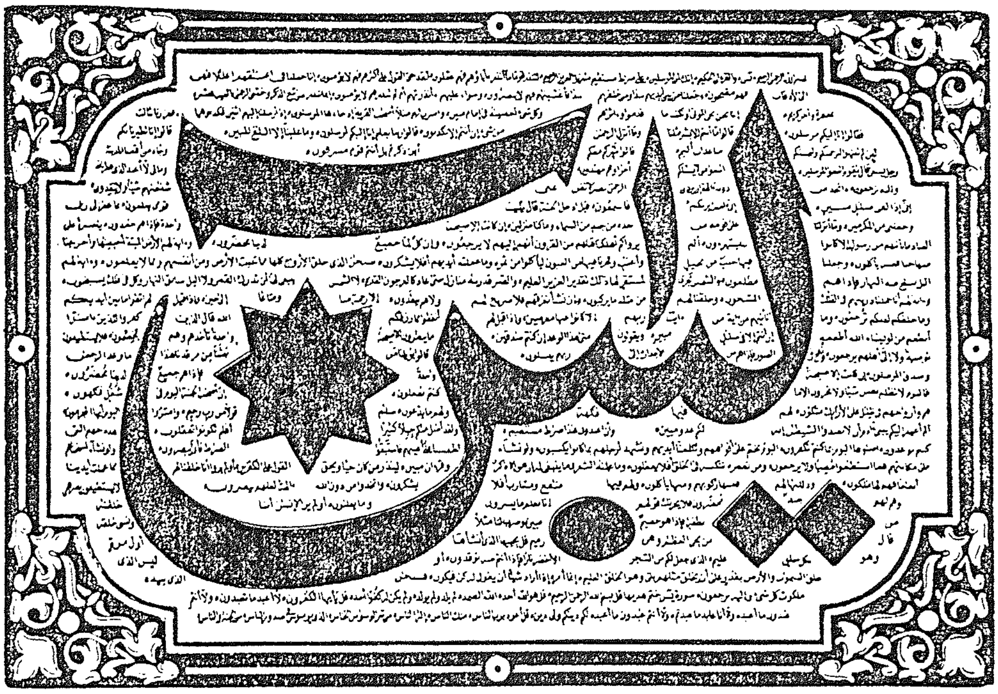

MEASUREMENT OF PRODUCTIVITY AND COST OF THE DIRECT LABOUR ORGANISATION WITHIN HIGHWAYS MAINTENANCE DEPARTMENTS

A thesis submitted for the degree
of Doctor of Philosophy

by

SONIA MOHAMED EL BAKRY

Interdisciplinary Higher Degrees Scheme
The University of Aston in Birmingham

JUNE 1981

To my parents...........my raison d'etre

To my husband...........the smile of my present

To my children..........the hope of my future

To them all.............for their faith

INTERDISCIPLINARY HIGHER DEGREES SCHEME

UNIVERSITY OF ASTON IN BIRMINGHAM

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Thesis submitted for the degree of Doctor of Philosophy

by Sonia Mohamed El Bakry, 1981.

SUMMARY

The objective of this thesis is to investigate, through an empirical study, the different functions of the highways maintenance departments and to suggest methods by means of which road maintenance work could be carried out in a more efficient way by utilising its resources of men, material and plant to the utmost advantage. This is particularly important under the present circumstances of national financial difficulties which have resulted in continuous cuts in public expenditure.

In order to achieve this objective, the researcher carried out a survey among several Highways Authorities by means of questionnaire and interview. The information so collected was analysed in order to understand the actual, practical situation within highways manintenance departments, and highlight any existing problems, and try to answer the question of how they could become more efficient.

According to the results obtained by the questionnaire and the interview, and the analysis of these results, the researcher concludes that it is the management system where least has been done, and where problems exist and are most complex. The management of highways maintenance departments argue that the reasons for their problems include both financial and organisational difficulties, apart from the political aspect and nature of the activities undertaken. The researcher believes that this ought to necessitate improving the management's analytical tools and techniques in order to achieve the most effective way of performing each activity.

To this end the researcher recommends several related procedures to be adopted by the management of the highways maintenance departments. These recommendations, arising from the study, involve the technical, practical and human aspects. These are essential factors of which management should be aware - and certainly should not neglect - in order to achieve its objectives of improved productivity in the highways maintenance departments.

KEY WORDS : HIGHWAY, MAINTENANCE, DIRECT LABOUR, COST COMPARISON, PRODUCTIVITY.

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Chapter 1

Introduction

1.1 Statement of the Problem

One of the functions of local authorities which seems to attract most of the attention of members of the public is the construction and maintenance of roads. Highways maintenance has become the problem of the national government as well as of the local authority, and there is a close interlocking of responsibilities of both.

Highways maintenance is complex, not only in its variety of activities, but also in the manner of its administration and execution. Traditionally, local authorities maintain their own roads with the aid of their direct labour organisations (DLO's). Trunk roads and motorways are the responsibility of the Department of Transportation (DTp). However, the DTp does not have a DLO and the actual maintenance work on the trunk roads is carried out by the appropriate local highways authority designated, in this case, as the agent authority (1).

During the past five years (1975-1980), the British government has imposed quite severe financial restrictions on spending in the public sector. DLO's which are responsible for maintaining much of the nation's roads are particularly vulnerable to criticism since they are paid out of public funds. Many critics argue that road maintenance could be carried out more efficiently and cheaply by private contractors who would be required to bid for the work in open competition. In fact, some road maintenance is carried out by private contractors, but diehards argue that all maintenance should be so carried out.

The original problem on which this thesis is based was suggested by the Transport and Road Research Laboratory (TRRL) about the question of competition between DLO's and private contractors for work in highways maintenance departments. The argument turns on the point advanced by private contractors that they are unfairly put at a disadvantage in such competition because the "price" bid by a DLO for a given job is less than the true cost to the highways authority.

The researcher believes that the root of the problem lies much deeper than the cost comparison between the DLO and contractor. This represents only one aspect of the controversy facing DLO's and surrounds it with misunderstanding, obscurity and prejudice. This situation turns the argument into being the problem of examining the continuing employment of DLO's as a resource within the highways maintenance departments and the possibility, if any, of eliminating or replacing them by contractors. The problem has developed into the need to answer the question : "How can the management of highways maintenance departments utilise their DLO's to the utmost efficiency?"

1.2. Objective of the Thesis

The objective of this thesis is to investigate, through an empirical study, the different functions of the highways maintenance departments, and to suggest methods by means of which road maintenance work could be carried out in a more efficient way by utilising its resources of men, materials and plant to the utmost advantage. This is particularly important under the present circumstances of national financial difficulties which have resulted in continuous cuts in public expenditure.

This aim can be achieved through :-

1. Undertaking a careful study of DLO work within the highways maintenance departments in order to indicate that benefits are derived from employing this system, and eliminating any wastage of time, money or effort in achieving their objective of offering service to the community.

2. Presenting an independent view of the principles on which the costing of DLO's ought to be based. This mainly aims at providing the management with a tool to help in decision taking regarding whether to carry out the work by DLO or contractor when cost is the criterion of such a decision.

3. Undertaking productivity measurements in order to provide the highways maintenance departments with a means of measuring, predicting and improving its method of productivity. Unless a

highways maitenance department employs productivity measurement which is meaningful for itself and for others, it is in no position to assess its present or potential level of efficiency.

1.3. Hypotheses of the Thesis

To achieve the objective of the thesis the following hypotheses are set :

1.3.1. The continued employment of DLO's is justified by the function of highways maintenance departments which can be divided into three categories as follows :

a) functions which are not feasible to let out to contractors by reason of statutory duty on the highways authority (emergency work) ;

b) functions which are feasible, but not practicable to let out to contractors because it is known beforehand that contract operation would be inordinately more expensive than DLO's operation (routine work - cyclic maintenance) ;

c) functions which are practicable to let out to contractors (specialised maintenance). Nevertheless, these functions may be undertaken more economically using a DLO in competition with a contractor.

DLO is required to be employed to carry out those functions which are impracticable or uneconomical to carry out by contractors (categories a and b). Employing DLO's for carrying out specialised work ought to be justified because of its competitiveness with contractors.

1.3.2. The price bid by a direct labour organisation for a given job is not the relevant cost to the highway authority.
The argument is advanced by private contractors, that they are unfairly put at a disadvantage when in competition with DLO's. The argument turns on the point that there are no proper management accounts designed to check the efficiency of the organisation.
On the other hand, the management argues that a DLO cannot be regarded in the same way as a contractor as it is one of local authorities resources, the cost of which has to be spread over the various jobs on which highways departments are employed. A DLO is a resource, the acquisition and continuance of which can be justified in several ways. These have to be identified because they lead to different bases for the cost comparison between the DLO's and contractors' modes of operation.

1.3.3. It is possible to establish productivity measurement within highways maintenance departments in order to seek better utilisation of DLO's.
As limited resources are available for highways maintenance departments for maintaining road networks, it is essential to ensure that they are employed in the most effective way. Only if the management of highways maintenance departments

can measure their productivity in order to test the efficiency with which their maintenance work is carried out, will they be persuaded that it can be improved. In addition, accurate measurement procedures should provide the basic information necessary for the management to exercise effective planning and control.

1.4. Research Methodology

1.4.1. The technique

To examine the thesis hypotheses, information is needed from the highways maintenance departments. There are different methods which can be used for securing the information needed. These are (2) :

a) Documentary sources ;

b) Observation ;

c) Mail questionnaires ;

d) Interviewing.

Each of the above methods will be dealt with briefly in order to point out the limitation and usefulness of its application.

a) Documentary sources

This method depends on sources giving information about the questions a survey intended to cover from available data. The main drawback of this approach is that it cannot provide evidence concerning opinion and attitude.

However, the researcher depends on this source to collect information related to organisation charts, costing data, work study measurement, etc. which was necessary to describe the system as it existed in 1976-77.

b) Observation

Observation means the accurate watching and noting of phenomena as they occur in nature. Direct observation has a number of advantages over the questionnaire since the information required is obtained directly rather than through the reports of others. Despite the usefulness of this method, many of its disadvantages result because of time and cost constraints.

However, the researcher was allowed to carry out direct observation through the help of many County Surveyors with whom contact was made when attending the Planning and Transport Research and Computational Co. Ltd. (PTRC) meetings *. As such, the researcher was able to share in the life and activities of her sample. Most of the research time has been devoted to visiting sites of work for different types of maintenance in different highways authorities.

Most of the divisional surveyors have been very helpful in allowing visits, and the opportunity was available not only to observe what is going on around us, but supplementing this by conversation, interviews and studies of records.

Nevertheless, there was still the need to obtain data on opinions and attitudes. These data were obtained by questionnaire (3).

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* Annual meeting organised by the PTRC. The company's objectives are interdisciplinary research and the development of improved computational methods in planning and transport, enabling the results of the research to be put to practical use. These objectives are pursued through the complementary activities of education research services (for example : seminars, symposia, courses, advance research).
The membership is open to local authorities, government departments, consultants, academic institutions, transport undertakings or other bodies with an interest in the development of better quantitative methods in planning and transport.

c) Mail questionnaire

The questionnaire has the advantages of complete anonymity, speed of coverage and economy. In addition, some questionnaire results can be quantified.

However, this method of collecting data suffers from many disadvantages, such as (4) :

1. The response rates reported for mail survey are much lower than interview survey. The main problem is that of getting adequate response rates. It is not the low sample numbers that is serious, but the possibility that the non-respondents differ significantly from the respondents, so that estimates based on the latter are biased.
2. The questionnaire can be considered only when the questions are straightforward and simple to understand with the help of printed instructions.
3. Questionnaire results are difficult to interpret except on a rather superficial level. This results because there is no opportunity to probe beyond the given answer, to clarify ambiguities, to overcome unwillingness to answer a particular question, or to appraise the accuracy of the information, or ensure that the right person completes the questionnaire.
4. Another technical disadvantage results from the fact that the different answers cannot be treated as independent (when the respondent fills in the questionnaire he can see all the questions before answering any one of them).

Many of the above mentioned limitations can be minimised by re-checking or collection of the questionnaire with interview (5). This provides the opportunity to supplement the respondent's answers with observational data.

For all these disadvantages, the use of a mail questionnaire alone was not preferred by the researcher as a method for collecting the data required.

d) Interview

The personal interview is considered to be one of the most useful methods of collecting data in social surveys (6). Personal interviews do not suffer from the particular weaknesses of the other alternative methods discussed above. The main advantage is that they yield a kind of information which can be accurately interpreted by suitably trained people, and which can form the basis for effective remedial action.

As a survey technique, however, interviewing has the disadvantage of slowness and expense, and it introduces sources of error and bias (7). Sources of errors must not be treated or discussed as separate entities. An interview is an interaction between two people who may affect each other in various ways.

1. The personal characteristics of interviewers (sex, age, education, social type) might influence the answers obtained. These errors might occur either because of the impression made on the respondent, the way the question was asked, or perhaps because respondents might give answers more willingly and differently to the different types of interviewer.
2. Errors arising from the respondent. The respondent may give inaccurate answers as a result of lacking the knowledge, misunderstanding the question, his memory plays him false or (consciously or unconsciously) he does not want to give the correct answer (8).

Despite these disadvantages, there are different approaches to overcome them (9). Response error can be eliminated to a great extent by employing specially trained interviewers. The respondent's error can be detected by checking the accuracy of survey responses against data from another source. This is called "record check". Another type of check is the "consistency check" (10). A common way of carrying out this check is to ask for the same information in two or more ways. Quality check or re-interviewing is considered to be another type of checking the accuracy of the answers. This kind of quality check should come soon after the first interview, for the longer the interval between, the more changes will actually occur in the respondents characteristics which may seriously affect the accuracy of the check data.

Each of the above methods has a number of strengths and weaknesses. Nevertheless, a combination of methods could be made which are thought to be appropriate to this research. The researcher found that interviewing with a guiding questionnaire was the most suitable method for collecting the necessary information and which capitalised on the advantages and minimised problems that may arise if one method only was chosen. In addition, this method will ensure that all the questions are answered.

With regard to the errors that could arise, the researcher herself carried out the interviews as she has had previous experience in survey interviewing *. In addition, in order to check the accuracy

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* The researcher has experienced personal interviewing as a member of staff in the University and work with one of the best known research Centres in Egypt (ARAC). In additon, she carried out a survey by interview during her M.Sc, covering 300 craftsmen in small industry, members of Industrial Ministry, civil servants, Insurance credit assn. & corporation socy.

of the answers, the researcher made a consistency check through repeating some of the questions in different forms, in the meantime checking the answers with documents, where appropriate.

1.4.2. Conducting the survey

The study was conducted in England during the period 1976-77. The survey, for the purpose of this thesis, was initiated by compiling a list of the counties in England, known from the Local Government Act 1972. Those counties, as shown in Appendix 1.1,include six metropolitan counties and thirty-nine none metropolitan counties.

Initial contact was made with the different counties in England by circulating a letter which briefly explained the aim of the project and asked the counties to co-operate in the completing of a questionnaire (see Appendix 1.2).

The response to the letter varied between counties. Some arranged appointments for visits to their counties, others asked for the questionnaire to be sent by mail for completion without interview, and a number regretted that they were unable to help because of lack of employees. Some failed to acknowledge receipt of the questionnaire completely (see Table 1.1).

Table 1.1 : Summary of Response to Initial Invitation to Co-operate on Research Programme

Aspect / Type of county	Completion by personal interview	Completion by mail	Unable to co-operate	No response	Total
Metropolitan	50%	-	17%	33%	100%
Non-Metropolitan	59%	8%	17%	16%	100%

To carry out the survey a sample technique was used as long as the population proportion could be inferred from the sample proportion(11). This is based on an agreed assumption that the sample proportion is likely to be close to the population proportion (12). There are many reasons for a sample rather than studying the whole population. Among them are:limited resources, limited data available and destructive testing. Regarding this thesis, the limited resource plays a part, where funds and time were not available to observe the whole population.

The sample was a stratified one and consisted of ten counties drawn up from those counties willing to co-operate with this study (13). They are distributed into two groups : metropolitan counties and non-metropolitan counties. The counties included in the sample represent 22 per cent of the whole population (metropolitan counties sample represent 33 per cent and non-metropolitan counties sample represent 20 per cent) *. Being such a percentage of the whole population, it might be said that the sample is representative from the statistical point of view. Therefore, it will be possible to generalise the results achieved.

Two questionnaires were designed in order to get the information required from the highways maintenance departments.

A. The first questionnaire was designed for the simple, straight-

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* Certain factors have been taken into consideration in choosing the different counties taking part in the survey, such as :

1. The size of Direct Labour Organisations
2. The size of the population of the counties.

forward purpose of finding out how highways authorities carry out the maintenance work, to investigate their need to have direct labour organisations, and to examine their tools and techniques for the planning and control of their work (see Appendix 1.3).

In designing the questionnaire (which was used during the interview to ensure that all of the respondents would be presented with the same set of questions) it was necessary to prepare the questions in such a way that would enable the hypotheses of this thesis to be examined.

The questions were mainly of two types : the scale type of question and the open-ended type of question (2).

The scale type of questions are considered to be effective in getting the real and accurate opinions and attitudes of the interviewees. However, this type of question suffers from the main disadvantage which results from the fact that the questions and answers do not always convey the same meaning to all persons. In this thesis an effort has been made to overcome this weakness and to explain the meaning of each question to those interviewed.

The open-ended type question has been used to ensure that every detail which the research needs will be brought out (14). This type of question gives an opportunity to everyone to express his views in detail if he so wishes.

In addition, in order to check the answer and to control the errors which could exist, a consistency check was made by repeating some of the questions in different forms.

The researcher circulated another letter (see Appendix 1.4) to the counties agreeing to take part in the survey, to determine the time suggested to carry out the survey. A copy of the questionnaire was enclosed with that letter to give them the opportunity to prepare any documentary source data, and in order to minimise the time of the interview. The researcher arranged to visit the different authorities according to the scheduled time they suggested.

The execution of the survey by interview and guided questionnaire normally started with the County Surveyor or his deputy. It was important to obtain his approval because the information required involved the co-operation of the different organisation sections of his department. In turn, he contacted the different organisation sections (sometimes by circulating a letter, in the case of the metropolitan counties and some non-metropolitan counties), agreeing to carry out the study and asking them to co-operate with the survey without disturbing the work flow. The researcher had the opportunity to visit most of the county districts or divisions and depots, and most of her time was devoted to visiting the site work and holding discussions with the divisional surveyor, his assistants, supervisors and foremen. Some of the divisional surveyors accompanied her to see some of their important work sites ; this helped to develop the observation of the work flow and conditions, and feel for the work.

As the questionnaire was divided into different sections : the highways maintenance organisation, the highways maintenance functions, the scope of DLO, the costing system, the financial data, the incentive scheme and the training programme, it was beyond the surveyor or his deputy to complete it by themselves. Therefore, they arranged for suitable people from the financial section, the training section, work study officers, engineers and managers to be interviewed. In one of the counties, the researcher was allowed to spend a week in a financial department to get a thorough understanding of its work. She spent another week with the work study section and accompanied them on one of their visits to introduce the scheme in one division of work, and attended a mass meeting with the roadmen.

During the interview it was necessary to point out to the surveyor and his deputy the importance of knowing the reasons behind the answers they gave, in addition to their personal experience regarding the difficulties and problems confronting them, because this should help in diagnosing the real problems and in reaching a practical solution. They allowed the researcher to tape the interview in order to help her to ensure that she got all their views, and to check for any piece of information needed later on. This helped the researcher to get their views regarding some sensitive questions where the answers would be "Yes, but...", or "We have to because...". It was pointed out that any information obtained would be confidential, and that it would not be assigned to a particular county. This ensured that various quantitative and qualitative measures would be made as a basis of comparison between counties, but that the information would not be disclosed to any other counties, nor would any county know with which others it was being compared.

In the meantime, the researcher explained to the surveyor or his deputy that in order to achieve the desired results from the study it was important to get the views of particular cross-sections of the work force by interviewing with another guided questionnaire. Most of them were very helpful and the researcher succeeded in winning their approval and co-operation regarding this study.

B. The second questionnaire was designed to obtain data from the roadmen in the highways maintenance department. It was a simplified type of questionnaire and was limited to broad, general items relating to key aspects of their work (see Appendix 1.5). The function of the questionnaire was not to develop detailed information but to serve as a diagnostic instrument for determining general attitudes.

The researcher carried out interviews with seventy roadmen within different highways authorities. The roadmen interviewed were all informed that the information that they gave would be confidential and that their names would not be required. The selection of persons to be interviewed was done randomly by the counties divisional surveyors. All the roadmen interviewed were members of the incentive bonus scheme and were full-time employees. The sample profile regarding age, marital status and years of service are as follows :

a) 67 per cent of the roadmen were married and 28 per cent were single.

b) The age group nearly followed the normal distribution where 50 per cent of the roadmen were between the ages 30-50 years (see Figure 1.1).

c) Only 9 per cent of the roadmen had a length of service of more than 20 years. 37 per cent had more than 10 years service and 63 per cent had less than 10 years service (see Figure 1.2).

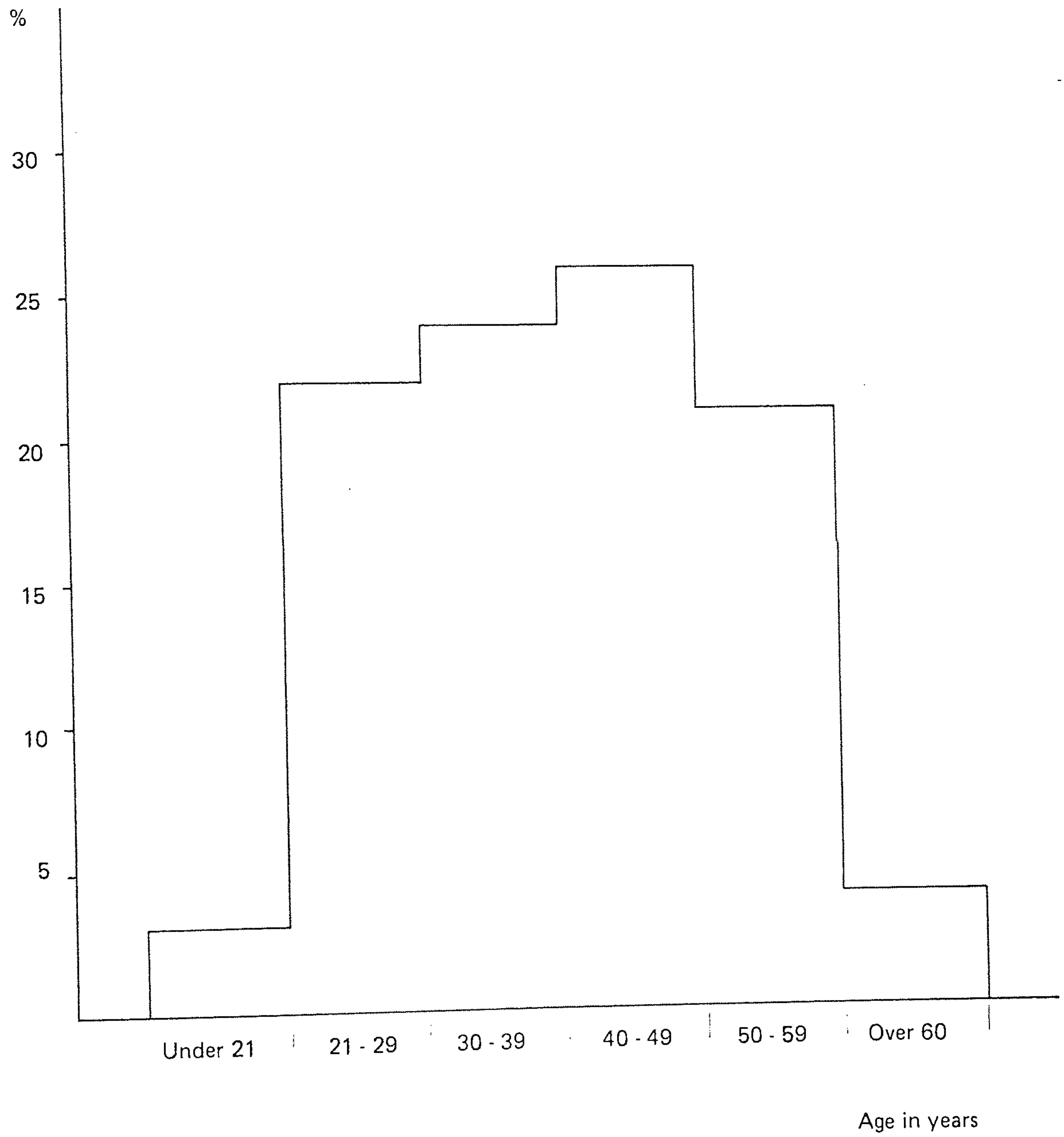


Fig. 1.1: Roadmen age grouping

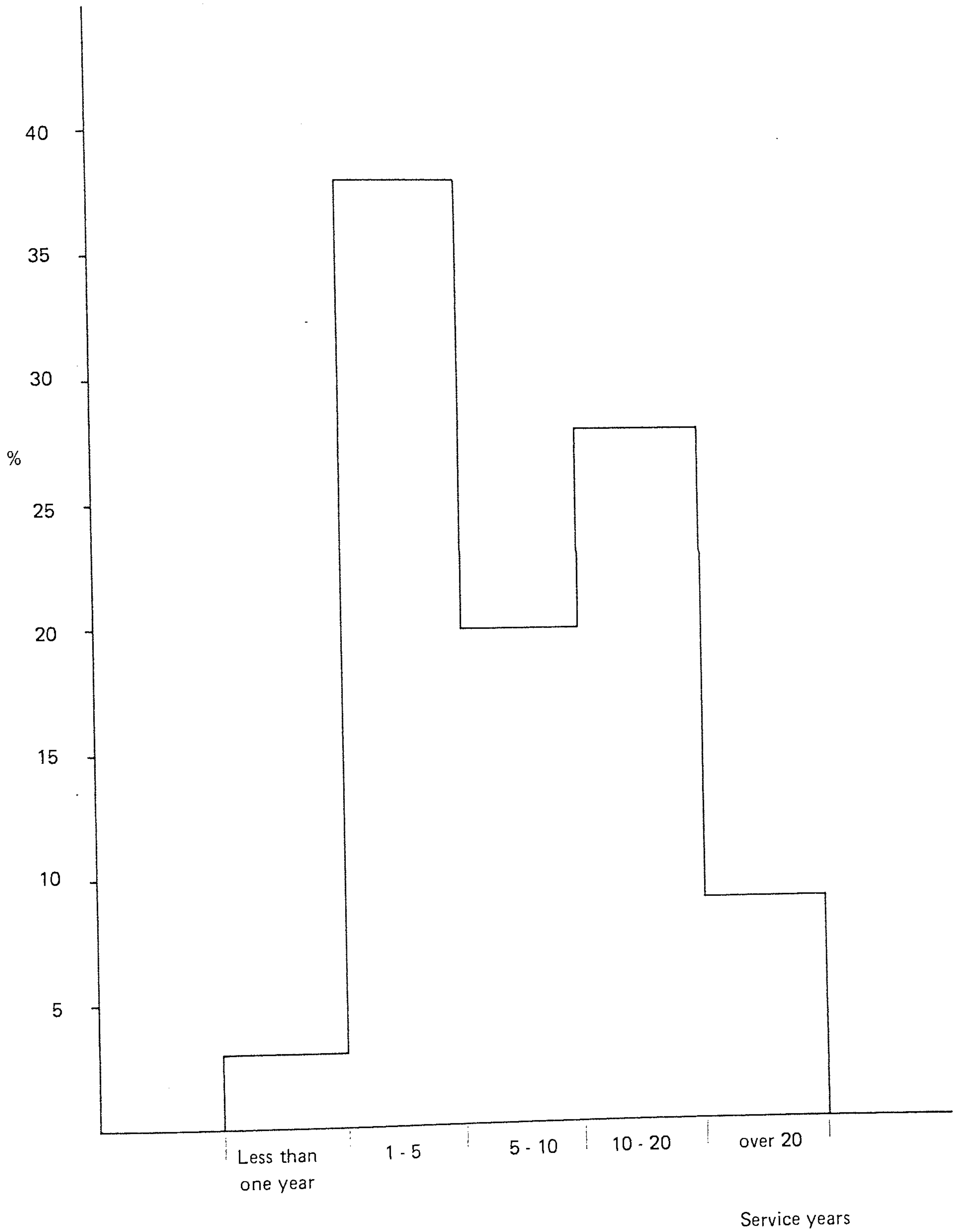


Fig. 1.2: Roadmen length of services

The interviews were carried out on the work site during the tea or dinner break, in order not to disturb the work. This required the researcher to accompany the different gangs through their normal working time from 7.30 a.m. to 4.30 p.m. This helped the researcher to observe the work flow, the gang working relations, the working conditions and the delay time. In addition, the interviews helped to obtain the roadmen's views, opinions and attitudes concerning their working conditions, incentive bonus scheme, training programmes and towards supervision and management. It was assumed that once these factors had been determined, it would be possible for the management to take the appropriate policy and exercise direct control over the quality of the management-worker relationship.

1.4.3. Problems associated with the completion of the survey

The researcher faced the following difficulties when completing the study :

1. In order to carry out the study the researcher has had to seek out the highways authorities which run direct labour organisation, who are willing to impart information which could be used against them politically if it found its way into the wrong hands. Therefore, the gathering of a sufficient quantity of reliable, unbiased information has been a long process.
2. The management were, in some cases, not co-operative and tried to avoid critical questions. The reasons were that either they did not want to admit to the problems that their departments suffer from, or they wanted to avoid any more problems created once the emplyees or roadmen started to think about the existing situation. In some other cases, they said that they suffered from shortage of staff, they were busy because of the end of the

financial year, and they did not want to disturb the work flow.

3. Some of the workers were afraid to express their real feelings towards their jobs or the bonus scheme, bearing in mind that they might become management's enemies. This put pressure on the researcher to spend a lot of time trying to explain the aim of the study, and the advantage expected to be gained. In addition, it was made clear that the study is under the supervision of the University, not the local authority, and throughout the interviews no names were used.
4. It took a long time to explain the questions and their meanings to the roadmen, most of whom had only very basic reading and writing skills.
5. The researcher had to travel to different places throughout England, spending most of her time on actual visits to work sites. The fact that the roadmen were interviewed at the work sites resulted in carrying out the interview, in most cases, under severe winter conditions.

However, despite these difficulties, the researcher considers this the experience of a lifetime, and she enjoyed every minute spent observing the work or carrying out the interviews, or holding free discussions with the management team. Besides carrying out such research, it gave the researcher the opportunity to attend the PTRC meeting for three years as a steward, which provided a chance to discuss the results obtained by the questionnaire. During some seminars, the researcher raised a lot of problems confronting the authorities covered by the survey, and it was found that they represented common problems which most of them admitted could be found in their authorities.

1.5. Plan of Presentation

This thesis consists of four major parts as follows :

Part 1 : Organisational Structure of Highways Maintenance Departments

The aim of this part is to give a comprehensive review of the structure of highways maintenance departments. The second chapter is devoted to giving a brief outline of the whole system of local authority. This will act as a basis to illustrate objectives, functions, circumstances and the environments in which the highways maintenance departments' systems interact.

The third chapter deals with the organisational structure of the highways maintenance departments. The first step is to study the organisation in order to see whether , as such, it supports or hinders the manager's use of management techniques in order to increase productivity.

Part 2 : An Empirical Study of Highway Maintenance Functions

The investigation of the highways maintenance functions is based on a questionnaire collected by interview in co-operation with different authorities. The main aim of this part is to find the basis of justification for DLO establishment and its continuance. It is an attempt to find out if the Direct Labour Organisation has been fully utilised as a resource available to the highways maintenance departments.

As such, Chapter 4 is concerned with examining the continuous employment of DLO's through defining the objectives of maintenance work, its importance, and the responsibility of carrying it out.

Part 3 : The Principle of Cost Comparison Between DLO and Contractors

The main aim of this part is to design a costing system which could be employed in highways maintenance departments, according to the most suitable costing theories. Two chapters are devoted to cover this aim. Chapter 5 analyses the costing system employed within the highways maintenance departments. It also investigates the basis of estimating the cost of direct labour in order to provide a fair comparison with the contractor's price.

Chapter 6 presents the suggested cost system to be applied within highways maintenance departments. As far as the comparison between using direct labour and contractors to do the same job is concerned, the marginal costing theory is helpful. The use of marginal costing theory for highways departments is not difficult because it is easy to identify the cost unit, job or operation, and to allocate the cost elements which are used to the appropriate cost unit.

Part 4 : Productivity of Highways Maintenance Departments

The aim of this part is to provide the highways departments with a means of measuring, predicting and improving a given method of productivity. To realise this aim, the following chapters are set.

Chapter 7 is concerned with productivity measurement employed in highways maintenance departments. Work study technique has been used as a means to measure DLO's productivity. The aim of this chapter is to examine this technique in order to highlight its contribution to management information needs.

Chapter 8 aims at developing a model for measuring the productivity of direct labour. A model is suggested and is called "The Method Productivity Delay Model" (MPDM). This model provides the highways maintenance departments with a means of measuring, predicting and improving a given method of productivity. The model focuses on method productivity parameters that are measurable and controllable by the highways department. Method productivity parameters are addressed by documenting productivity delays.

This chapter also includes examples of the application of the suggested model to different maintenance operations which have been observed and calculated by original study carried out by the researcher within three different highways authorities. This application aims at highlighting the importance and practicability of the information provided by the model to help the management in measuring, predicting and improving the productivity of its work.

Chapter 9 deals with the important point of improving the productivity of direct labour organisations within the highways maintenance departments. Labour is more than just a factor of production as seen by the economists. Not only is the control function influenced by human behaviour, but the whole process of production is also permitted and influenced by it. In highways maintenance departments with many employees and little automation, productivity is likely to be determined largely by what the employee, rather than the machine does. This thesis is concerned only with improved productivity by means of improved labour training and motivation. The other points to consider relating to improved productivity by relating the method, material or plant used are beyond the scope of this study. The final chapter completes the study by providing conclusions and recommendations.

PART 1

ORGANISATIONAL STRUCTURE

OF

HIGHWAYS MAINTENANCE DEPARTMENTS

Chapter 2

The System of Local Authority

Introduction

The main aim of this chapter is to present the structure of local authorities in England.

It examines the local government as a wider background system within which the highways maintenance departments operate.

An attempt is made to examine the goals and the operation of the local authority to highlight how it interacts with other organisational systems, with the larger environmental systems of which it is a part, with the economy and society at large.

2.1. The Systems Approach

The concept of a system has slowly emerged in the present century to assume a central importance in the thinking and approach of many scientists and technologists (15). The impetus towards systems thinking and the systems approach has come from a recognition of the complex behaviour which can and does arise from both natural and man-made systems (16).

The longer term implications of systems behaviour has only gradually become apparent. It is only when these are seen to threaten human life or living styles that attention is directed to the systems activity, often in a dramatic way. Another stimulus to adopt a systems approach arose from our attempts to predict and control the behaviour of systems instead of suffering from, or just reacting to the gradually mysterious changes which occur in the surrounding physical, biological, social, economic and political climates (17).

Systems problems appear intractable since little is known about systems, about system analysis, about control over systems behaviour, or about systems design. System thinking and the systems approach is now a growth area (18). Systems ideas appear in different guises in cybernetics, systems engineering, general system theory, operational research, systems analysis, computer systems and many other fields (19, 20).

Yet it is becoming clear that a systems approach is essential if we are to have any hope of coping with the complexity of modern life with its multinational organisations, space- model, international monetary policies, high speed transport systems and so on (21).

The systems approach is necessary because many problems which arise in an organisation are associated, not with a particular function in the organisation, but with interaction between people, functions and departments (22, 23). A systems approach to many problems in British industry during the last twenty-five years would have shown that "too much emphasis was being placed on money, machines, material and not enough on blokes" (24). Greater emphasis on people would have achieved the dual result of making firms much better places in which to work, and also of increasing efficiency, profit and benefits all round (25). The systems approach also unifies the role of management and worker because they will then be able to see themselves as jointly setting up and participating in a hierarchy of systems, in so doing behavioural science approaches will be very helpful in creating an environment in which change is possible (26, 27). Changing people is not enough unless the system is put right as well. A systems approach can help a manager by giving him a clearer vision of his job, by adding greater purpose to his work, by achieving better relationships between his activities and by enabling him to make a more significant contribution to his organisation's overall objective (28, 29).

Although the word system has been defined in many ways, all definitions agreed that a system is a set of parts co-ordinated to accomplish a set of goals (27, 30, 31, 32, 33). Jenkins stated that "every system forms part of a hierarchy of systems, to design a system properly its objectives must be considered in relation to the objectives of the wider system or environment as governed by more senior systems in the hierarchy"(34, p.23).

Churchman stated that, "To make this definition more precise and also more useful, we have to say what we mean by "parts" and their co-ordination" (35, p.283). Specifically, the management scientists' aim is to spell out in detail what the whole system is, the environment in which it lives, what its objective is and how this is supported by the activities of the other parts (36).

There are five basic considerations that the scientist believes must be kept in mind when thinking about the meaning of the system (37) :

1. The total system objectives and more specifically, the performance measure of the whole system.
2. The system's environments and the fixed constraints.
3. The resources of the system.
4. The components of the system, their activities, goals and measure of performance.
5. The management of the system.

Essentially, the systems approach is that of examining the overall interactions of a group of items rather than focussing attention on the operation of each of the components in turn (38, 39). The structure of the collection is the point of interest, not the elements of the collection.

Systems analysis is merely a study of a system but it should be emphasised that one does not usually study a system as an end in itself (40, 41). Rather, the explicit motivation of any system study is to generate information so that decisions can be made (42, 43, 44). Systems analysis is a common sense analysis of what is going on and why, and how it might be done better (45). It involves trying to identify the system and its sub-systems, defining objectives and getting the facts straight (46).

The systems analysis process is iterative and it may be necessary to run through all the steps listed here several times before finally converging on an acceptable definition of the problem, the system and its objectives. The purpose of systems analysis is not merely to set problems down but also to indicate what should be done about them (47, 48, 49, 50, 51).

The main aim of considering the systems approach as far as this thesis is concerned is to provide management of highways maintenance departments with a framework for visualising internal and external environmental factors as an integrated whole. It allows recognition of the subsystems as well as the complex systems within which they must operate. By applying the systems concept to describing the local authority system as a wider system of the highways departments will help to dissolve some of the complexity. The managers will be able to recognise the nature of complex problems they face and thereby to operate within the perceived environment. Therefore, the rest of this chapter will be devoted to explaining the Local Authority system as a wider system of highways departments.

2.2. The Objectives of the Local Authority System

Like many aspects of British life, the institutions of local government have evolved slowly over hundreds of years to meet the needs of local communities (52). The demands and needs of the community, and sometimes those of competing institutions such as central government will change over time. For a Local Authority to be capable of coping with change, it would be better for it to be, to some extent, a reactive system (53). It responds to the prevailing culture or social climate, to a kind of local consensus of what should and should not be done. The goal of a local government system may be considered as a form of output. The tangible outputs are buildings, roads, schools, and service to citizens. These outputs are supposed to be the realisation of the goals. There are also less tangible goals such as civic pride and a sense of belonging to a community, and pleasure generated by the aesthetic outputs such as parks and well-designed buildings. These outputs sometimes are the goals, sometimes contribute to them or they may, in a sense, create the goals. Thus, local government is not only concerned with the provision of services but also with the overall economic, cultural and physical well-being of the community (54). This might be considered an ambiguous objective. Therefore, Local Authorities are mainly concerned with non-trading activities. Local Authorities are not making a product of measurable weight and quality, they are, for the most part, rendering intangible services. Whilst it is possible and desirable to express costs over units, the results cannot possibly have the same accuracy as in industry, for Local Authorities units are rarely output measures in the commercial sense (55).

In judging local measurement practices, present or future, the limitations inherent in the services ought to be borne in mind. The search for equivalents of industry's conclusive data takes us into fields where quantitative indicators are not easy to find. In other words, neither the objective nor the outcome can easily be quantified (56). However, there is a need for measures to enable wants to be identified and gauged, for local policies to be defined and measured and for the Local Authority to know how far its targets have been met. It is important to identify clearly the system objective because such a broad, all-encompassing objective is of little use in practice and must be reduced to more meaningful and more practical goals (57). No logical analysis can proceed far without precise, explicit statements of purposes. A task of managements' job is to challenge loosely stated goals and try to identify the fundamental purpose of a system.

2.3. The System Environment

In Britain, local government emerges as an important, multi-purpose institution, disposing of a considerable share of the natural resources, even though overshadowed in many ways by the central government (58). Increasingly in this country, central government stands or falls partly on its policies for local services, naturally claiming credit for Local Auhtorities' achievements, and casting the blame upon them for lapses.

There is difficulty in local government of securing independent criticism. The problem exists because there is no separate executive obliged to account to a governing body in the sense in which the central government accounts to the Houses of Parliament (53). Government exercises a good deal of control over local government. Ministers and the relevant minister can make decisions binding particular authorities to action or preventing action (52). Control varies from specific inspections to very broad rights given to a minister to exercise more direct control over appointments.

Theoretically it assumes that the Local Authority can take a synoptic view of local conditions, trends and prospects based upon deep analysis of environmental, economic, financial, demographic, social and other factors. It further assumes that the Local Authority has the ability to assess community needs. Finally, it assumes that the Local Authority is supposed to be able to decide in which direction and to what extent it will meet the demands.

The actual situation is very different. They have limited powers, are subjected to external restraints, have duties placed upon them by functionally conceived legislation. At the same time, a Local Authority's jurisdiction and autonomy are limited, and are diminishing. Its services are becoming fewer while government prescriptions about policy are increasing (30).

The central government, not the Local Authorities, determine the nature, scope, quality and direction of the principal local services (58, 59). It settles for each year the amount which it considers that Local Authorities should spend in the aggregate, and has ways of influencing their actions to keep them within the limit (44). Investment, which, in general, governs development, is directly controlled; efforts to allow Local Authorities more freedom in this respect are made from time to time but are invariably only marginally successful (60).

In addition, the present system of Local Authorities creates more difficult problems as the County Authorities exercise a broadly strategic role. In spite of the fact that they are responsible for an effective strategic role, they do not control the administration of all services, as some are administered by districts and others by bodies outside local government (see Figure 2.1 for the environment of a Local Authority)(61).

It can be concluded that Local Authorities are large bodies operating under the searchlight of public opinion and, as subordinate government, have additionally to cope with constraints peculiar to themselves in the light of which their management systems have to be devised. The environment surrounding the Local Authority plays a critical part in its existence. Local Authorities survive in terms of their functions in the larger environment of which they are a part. Continuing information about the demands and variables of that environment is, therefore, necessary for survival. Management must generate plans for development, control operation in order to avoid deviations and evaluate the effect of the output according to prescribed criteria.

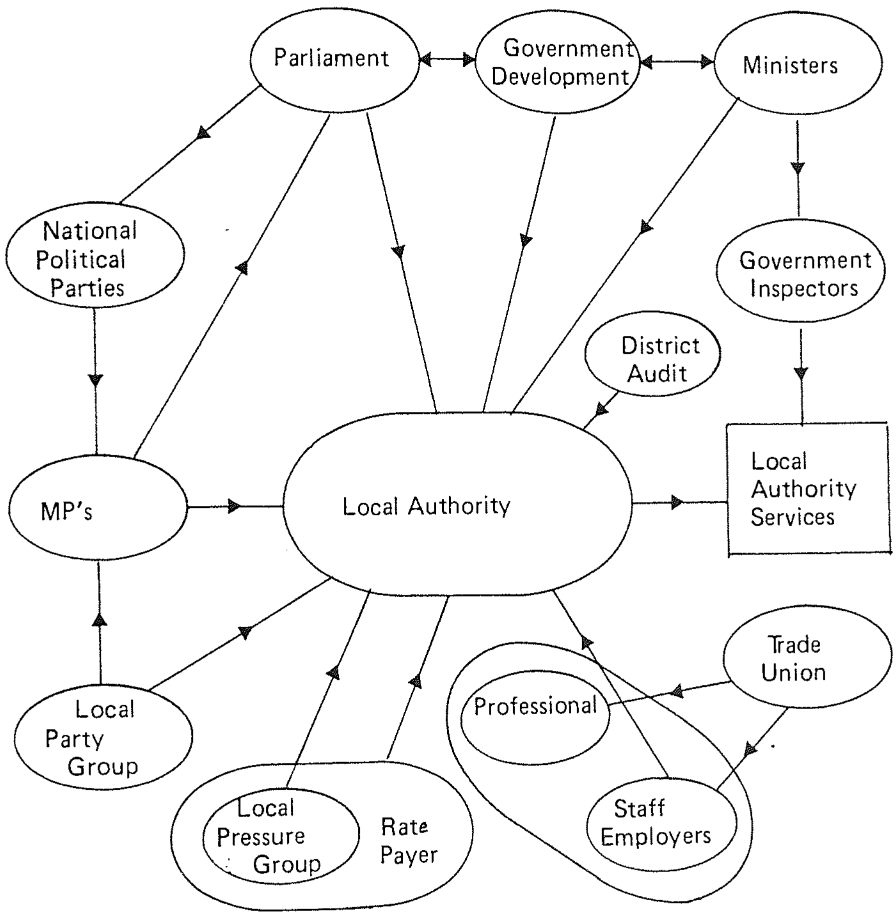


Fig. 2.1: The Environment of Local Authority

2.4. The Resources of the System

Local government's main difficulty with the inputs (i.e. the resources used) is that the conditions under which Local Authorities operate are rarely completely under control, for so much of what they do is influenced by its various environment and other factors. First, there are the legal, or statutory obligations placed upon the Authority. The central government does not always have to create legislation to get an authority to do something, it can issue guidelines or advisory papers which it suggests authorities should follow. There is always the threat of legislation to back these suggestions up, of course. These are inputs to the system, although they may appear to arise from within the system. They can be classified as stable or enduring inputs (61).

Secondly, there are inputs from the community in the form of its current needs - community needs - in the shape of schools, houses, health centres, roads, etc. Some of these can be classed as new needs which arise from innovation, others as modifications to existing needs as local demands change. These can be clasified as dynamic inputs because they are always changing. Figure 2.2 illustrates the inputs and outputs to a Local Auhtority (61).

The factors making up the final output are hard to identify and even harder to quantify (52). However, this is by no means the end of the matter, for these final outputs can be approached from various standpoints : first, the real needs of the community or a section of the community; second there is the demand which will differ from the needs (some would prefer to say the needs as recognised by the Local

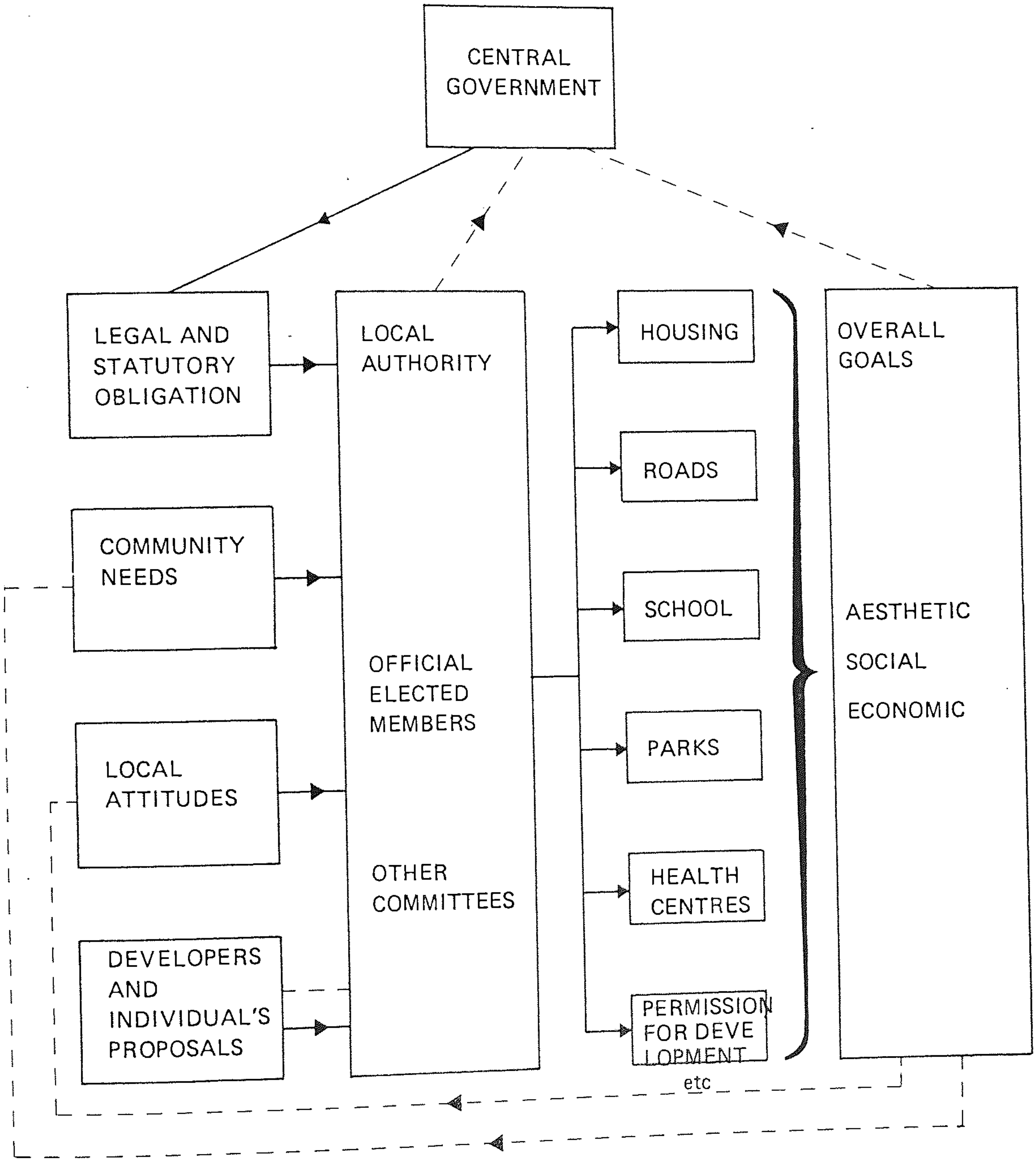


Fig. 2.2: Input-Output of a Local Authority

Authority) and finally, the target which the council sets itself. It may be that outputs from the social and allied services can be appraised only on an ad hoc basis at intervals and after deep study. This is a very different proposition from the regular assessments made by means of data continuously accumulated in the course of administration (52). Though comprehensive social indicators covering the local government services are a long way off and are, in fact, not even in sight, some small progress is being made towards them, usually by attempts to measure selected features. Indeed, to make use of the subjective judgement referred to above, it is but a step away from complete reliance on limited concrete facts, and towards a more rounded, if less categorical result. Success in finding adequate measures will be largely dependent upon individual ideas, and upon efforts towards improving local practice and the co-operative sifting of experiences.

The development of these measures, the managerial implications, means, therefore :

a) a continued improvement of the technique for handling the more familiar intermediate outputs ;

b) large scale and long range exploration into the less familiar territory of public aspirations and needs, Local Authority targets and achievements.

It has been assumed that the Local Authority, having ascertained the communities needs, can attend to them. This is not so, most obviously because the need for services outruns resources, new needs arise and expectations continually increase. One characteristic feature of systems with people in them is that they can change the goal or aim from within the system. Goals seem to emerge from a complex process of interaction between actual outputs (64), i.e. the people's idea of what they would like or should have, and the system's response to new inputs.

In order to take account of the dynamic behaviour of the system, the interaction which can occur, and particularly the many feedback links, should also be considered. The principal feedback links are (61) :

1. A former feedback link could be said to exist between the Local Authority and central government. Where the Authority does not have power to carry out certain projects it can mount a Parliamentary bill, but the process of preparing it and submitting it, and the amendments which will be made in committee amount to an interactive feedback link.
2. A fairly obvious feedback link exists between the outputs and the community needs. If, say, a new school is needed, then the provision of the school will meet that need and the current input of needs will be changed.
3. The feedback link to local attitudes is more difficult to define but undoubtedly exists. If, for example, a new school with up-to-date facilities is built in one area, parents in other localities are likely to start pressing for an improvement in the older, less well-endowed schools. This pressure is expressed as a change in both what people feel they need (community needs changing) and in their attitude to schools and the facilities offered in general. This feedback effect is one of the ones most often overlooked when new facilities or services are provided. For example, when a new motorway is built, the traffic

often exceeds the projected level because the existence of the road causes people to make journeys they would not have wanted to bother with before.

These feedback loops make possible the adaptation to a changing environment. These formal links are gradually recognised and are, in many cases, institutionalised, that is they have formal existence as procedures. But as with almost all human institutions and societies, there are many other routes for the flow of information and influence. These arise from "old boy relationships", friendships, even from accidental acquaintances through clubs. These can be classified as informal links and they play a very important part in local community life.

2.5. The Components of the System

The Council is the ultimate decision-making body of the Authority. In theory, the Council is in complete control of all its activities. The board policy decisions which themselves determine the overall plan for the community should be taken by the Council (53).

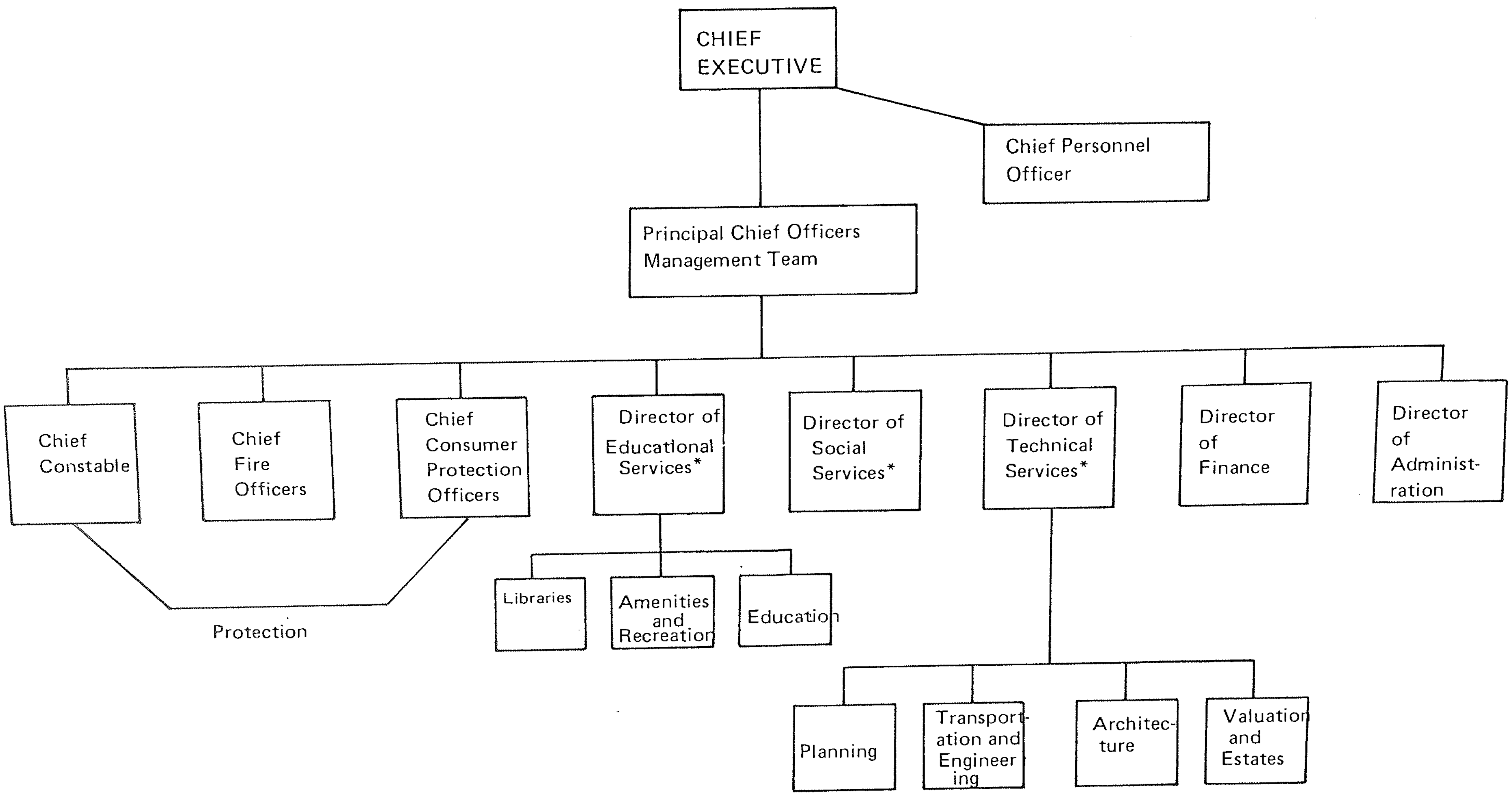
The Local Authority is organised on a functional basis. It is divided into several departments where each department is responsible for undertaking a major activity within the policy formulated by the Council. A department is headed by a chief officer who is responsible directly to the Chief Executive. The Chief Executive in a Local Authority is the head of the paid officials without a departmental responsibility. The need for a departmental system has been considered essential because of the nature of the Local Authority as a large-scale organisation (65). Figure 2.3 illustrates a typical structure of a County Council's departments (65,p.105).

In practice it is found to be difficult to control such complex organisations by monthly meetings which may include up to one hundred people. Therefore the Council sets up a committee system to deal with specific topics, bearing in mind that certain of these committees must be established by law. Figure 2.4 shows the principal committees of a typical County Council (65,p.117).

Each committee is formed by a number of elected members who are responsible for making the decisions or plans on one of the Authority's major activities. The committee reaches its decisions on the basis of information provided by the departments, and in the light of the Authority's objectives.

The operation of the Council is by fairly strict adherence to rules of procedure, and there are complex sets of standing orders governing the way Council business is done (58). In general, committees deal with their business in the month before full Council meetings, and present reports which suggest courses of action for ratification. The Council tends to be concerned with items which are contentious, there is complete delegation of Council power to a committee to speed up the execution of business and the degree of delegation may vary from committee to committee, or refer only to specific items of business (53).

Normally, these committees are composed of councillors and



* Members of Management Team

Fig. 2.3: Departmental Structure of Non-Metropolitan County

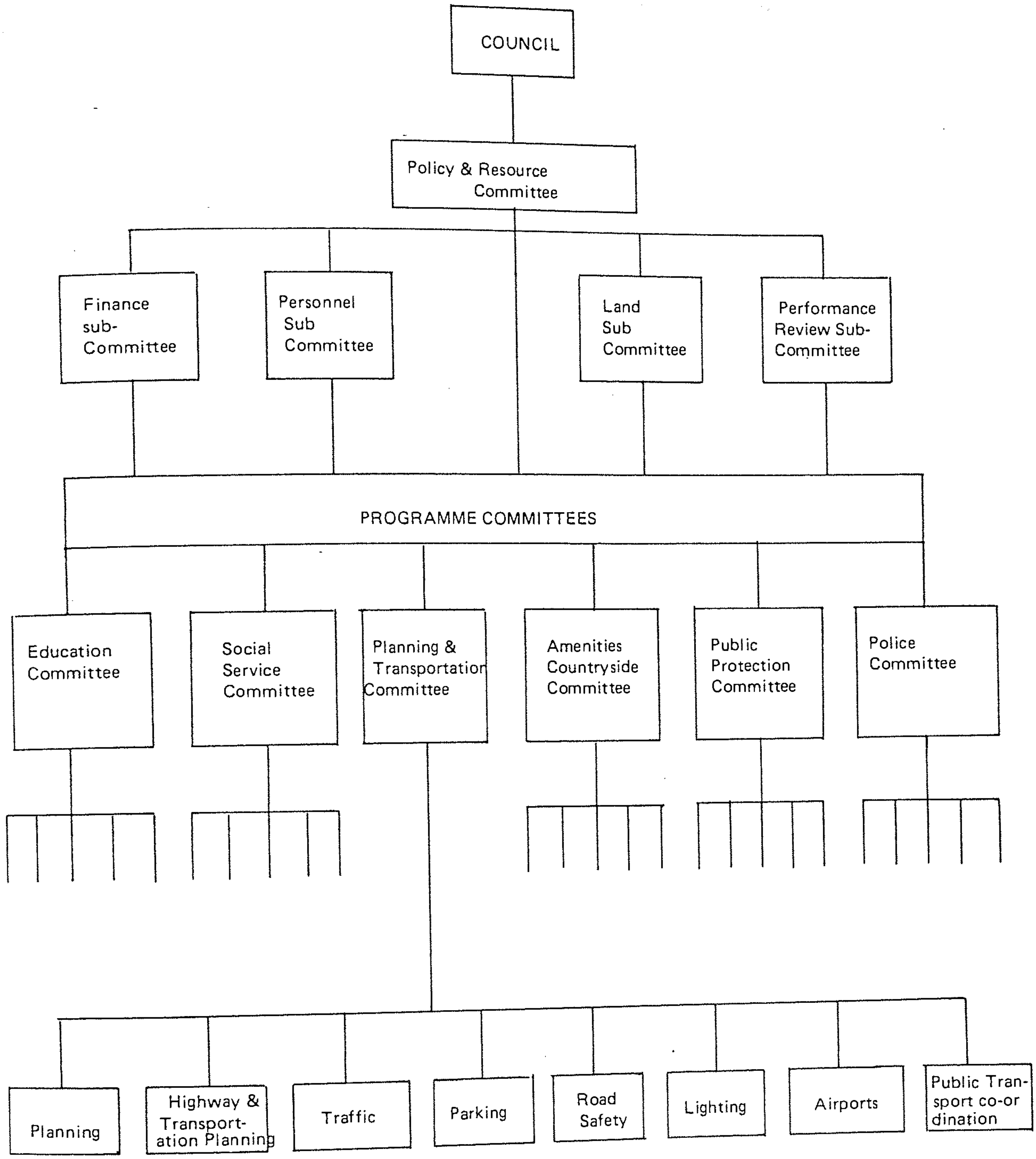


Fig. 2.4: Committee Structure of a typical non-metropolitan county

elected members and, not surprisingly, the dominant political party usually ensures that every committee is under the control of its own members. They are, as has been said, both management and a political system (58). Each committee supervises a department, a group of departments or a programme area, or has responsibility for some specialised function.

The committees have a dual function : to make recommendations to the Council and to supervise the administration. The Council, through its committees, holds each department head directly responsible. They are not, as in other large-scale concerns, subject to a general manager or control executive who would have a clear responsibility for all that is done (65). The committee system and the tradition of direct responsibility of heads of departments to the Council and its committees are thus interlocked. So during this process the members of the committees work closely with the officers in order to obtain information or seek out any technical advice. Each committee, after formulating the policies and programmes of the activity for which it is responsible, submits these programmes to the Council for approval and to be implemented by the departments concerned (66).

Whilst there are, among Local Authorities, considerable differences in the extent of formal delegation to committees, major matters of policy or of acute controversy are at least formally settled by the Council, which is also kept informed by periodical reports of the activities delegated to committees (65). The contrast between the Council and its committees, and the governing bodies of other types of large-scale organisations could hardly be greater.

So, with Local Authority committees operating as part of an organisation's structure, it can serve a purpose which would be difficult to chieve by other means. The main argument against committees is their inability to accomplish a great deal, Unless committees are well-directed and controlled they tend to be costly and politically sensitive (66). Although aware of this criticism, the system of committees in Local Authorities has been established in order to overcome the problem of the Council's having to deal with all the detailed business. Bearing in mind that decisions in local government are basically taken by elected members, it is important to provide them with up-to-date, accurate and comprehensive information together with the necessary technical advice. Thus a good and harmonious relationship between elected members and officers is very essential for effective management. There must be clear understanding by members and officers of their respective roles so that they can forge an effective partnership.

The following points ought to be considered as a main issue for improving the committee systems and to make them more effective (67):

1. The need for a committee to give unity of direction at member level.
2. A reduction in the number of committees.
3. A review of the division of functions between members and officers (i.e. increased delegation).
4. The need for the Clerk, as Chief Executive Officer, to give unity of direction at officer level.
5. A reduction in the number of departments.

2.6. The Management of the System

The local government has an important role as an essential part of British democratic government (58). The structure of local government was established by the Local Government Act of 1888-89 (52). Although life had become more complicated because environmental, economic, political and social factors were always changing, the basic structure of local government did not change until 1970.

As shown in Figure 2.5, the structure of local government was a complex array of interrelated structures (53). The separate sections of the public were served. London, being a special case, consists of a two-tier structure of the Greater London Council and London boroughs. Large towns and rural areas had two- or three-tier structures of the parish councils, municipal, urban or rural district councils. The differences in these three structures are important because different functions or powers are exercised at different levels. The county boroughs are simplest to understand in that they combine in one structure all the functions carried out in the different tiers of the other structures. The range of functions was also split in different ways in the various two- or three-tiered structures. As a result of many anomalies in the basic structure of Local Authorities, the need for reform in local government was realised.

In 1972 after a number of different studies on local government* the government introduced a new act which, in many ways drastically

* Two Royal Commissions were appointed to examine, review and report on the organisation of local government in England and Scotland. Their recommendation said that there was an urgent need for re-organisation of local government to make it more effective and efficient. For more information, see Royal Commission on Local Government in England 1966-69, Redcliff and Maude Report, Vol.1, CMND 4040, H.M.S.O. London, 1969.

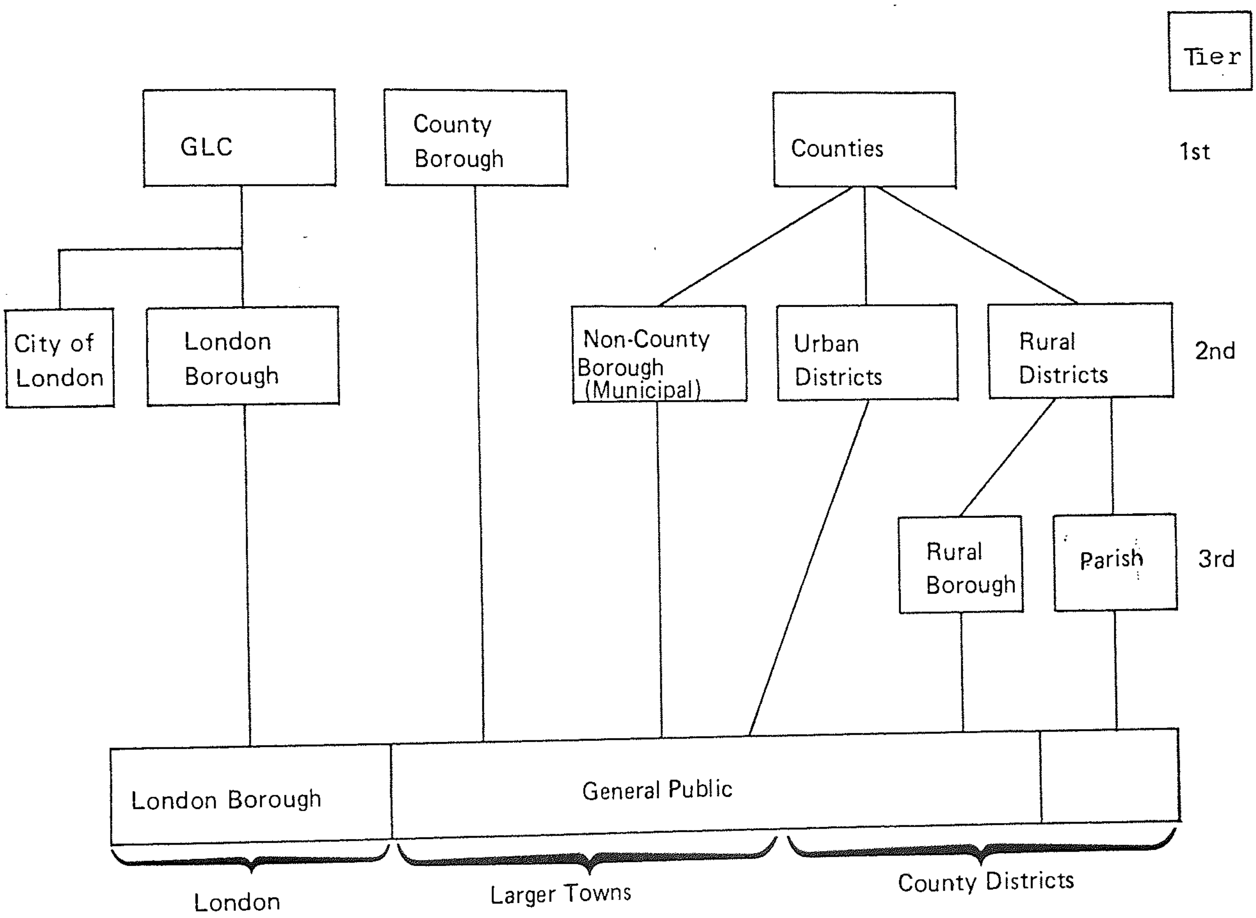


Fig. 2.5: The structure of local government before reorganisation 1974

altered the structure of Local Authorities. The Act became effective from 1 April 1974 (53).

A major feature of the new local government structure was the introduction of a two-tier system of authorities. Appendix 2.1. shows the distribution of functions of Local Authorities.

One of the basic changes was the reduction of the number of Local Authorities in England and Wales from 1,300 to only 422, together with the establishment of six new Metropolitan Councils in areas with high population densities (53). This enormous reduction in the number of authorities reflects the fact that before reorganisation, they were too small in size and this might be considered to be one of the main reasons for their inefficient operation. The Act changed many of the existing areas controlled by Local Authorities and tended to concentrate control in large, centralised units similar to County Councils. The local borough councils were transformed into district councils.

Despite this advantage of the reorganisation, however, the present two-tier system still suffers from overlapping powers.

An analysis of the distribution of function of Local Authorities (see Appendix 2.1) showed that each tier has to co-operate with the other in joint activities of various kinds. This situation has caused many of the powers to overlap between the two tiers of the authorities. For instance, functions like highways maintenance are controlled by districts and counties, which creates duplication of effort by both district and county. Despite agency agreements being made between them, allowing one authority to act on behalf of another, they created a lot of problems concerning control aspects.

Apart from these problems, another major difficulty is that the distribution of functions, especially in the Metropolitan areas, causes the financial consequences of the plans of the different tiers of authority to be difficult to reconcile.

Another disadvantage of the present two-tier system is that the county authorities may seek to increase their present range of services at the expense of the second tier in order to ensure a greater ability to implement their strategic plans. This particularly represents a potential area of conflict which lies in the Metropolitan areas where the county's role is more nebulous and confined than that of a non-metropolitan county. This could have two consequences. Either the Metropolitan county may seek to encroach on the functions of the district, or the Metropolitan county could become frustrated and lose a sense of purpose. This would be damaging to the local government system as presently conceived.

Although many changes have been made in the administration of local affairs by the reorganisation, what is controlled has altered little. Local Authority has difficulty in planning effectively. In the present local government structure, although the county councils are the planning authorities and plan makers, they have few powers of implementation, either directly or indirectly. Generally, the county authority is responsible for the development of strategic plans for the county area, and the district for the local interpretation of that plan by the preparation of local plans. In practice, this division is not easy to maintain, and might be a cause of friction between the two tiers. Although there is some kind of relationship between a district and its county, both are independent of each other in many respects (68). The county council can pass some powers down to the district council, however, the system is not pyramidal, and the districts exercise their principal powers independently of the county.

The problem is further complicated as Local Authorities were actuated by functional pressures - as a result of departmental attitude - rather than sense of unity. Many of the services provided by Local Authorities are interrelated, and one cannot be considered in isolation from the other. Therefore, in order to ensure that the most efficient use is made of resources, the effects between services must be fully recognised and this requires a proper system of corporate planning. The corporate approach seeks effective decision-making by looking at an authority's activities as a whole to avoid fragmentation and duplication. This does not mean too much centralisation, rather it aims at more co-ordination between the various committees and departments. The corporate approach will enable Local Authorities to allocate their resources through the identification of the needs and the problems of the community in order to establish overall objectives, to set long term plans and to establish control procedures to provide an adequate and effective feedback (69). It implies that the disparate services under Local Authorities should be conceived and managed as an entity in the interests of the community's need (70).

In order to implement the corporate approach, the departments are compelled to come together, learn ways of co-operating, accept control guidance and recognise their double responsibility to the whole as well as to their particular part. An impetus is given to the development and use of the administrative techniques which are required if decisions are to be made on a more rational basis. All departments are thus made aware of the council's problems, misunderstanding is avoided and criticism is forestalled. As with committee structures, the departments will eventually account to the committees, and local government officers are accustomed to serving several committees. It may well be, however, that in the absence of directorates, officers' programme area committees will be required to link with the activity of organised departments with the committees to whom they have to account (71). This might necessitate that the management system must have the capacity to respond and adapt itself to the different conditions they operate (72). This requires a drastic change in attitude by both members and officers, and existence of a firm leadership by the members, and acceptance of corporate responsibility by the officers. Both have to reconcile their functional outlooks and aspirations with wider claims (73).

Without considering these main points and adopting the corporate approach, the Local Authority has neither the organisation structure nor the planning system, nor the management methods commensurate with the job. It is essential to bear in mind that organisational structure and process has often inhibited effective management (74).

Conclusion

Local government plays an essential part in English democratic government. The Local Authority aims to solve people's problems and to fulfill their needs as effectively as possible. Its role is not only restricted to the traditional function of providing services for local people, it also has the potential role in contributing to the well-being of the local community. Because of its important role, it is vital for a Local Authority to improve its effectiveness and efficiency in carrying out its activities.

Local Authority management is in a difficult position these days. It has to fulfill the growing needs of the community on the one hand and on the other, it has to respond to the requirements of central government by economising in accordance with the general policy of reduced public spending. It has limited powers, is subject to external restraints, and has duties placed upon it by functionally conceived legislation. The environment surrounding the Local Authority plays a critical part in its existence, process and decision-making.

Local Authority organisations suffer from certain shortcomings and weaknesses as a result of overlapping powers. Their objectives are not defined clearly, they have difficulty in deciding priorities nationally and planning effectively. Local Authorities are actuated by functional pressures rather than by a sense of unity - councils are too large and committees are too numerous.

In order to seek effective decision-making, viewing an Authority's activities as a whole, the traditional departmental attitude within much of Local Authority must give way to a wider ranging, corporate outlook. Corporate planning means that each will plan as an authority and not by departments working independently. It means that the planning of their activities will be made in the light of the local community needs and problems (47). Departments will be concerned with both making their contribution to achieving the council's aims and with controlling the services to this end (50). They must be effective in the former and efficient in the latter. By making purpose more explicit, the council requires officers to be accountable according to their success or failure in meeting the community's needs, as identified and defined by the council as well as by their record of efficient administration.

Chapter 3

The Organisation of the Highways Maintenance Departments

Introduction

This chapter is devoted to a study of the highways maintenance organisation. The main aim is to examine its objectives, and the organisation structure, also looking at the functions performed and the relationships between the different parts and the organisation as a whole.

It is an attempt to view the organisation of highways maintenance departments as an open system continually affected by the environment surrounding it.

It highlights the advantage of adopting this approach to achieve a more efficient way of carrying out its function and ensure effectiveness.

3.1. Organisation Concepts

Modern organisation theory has developed from traditional organisation concepts or mechanical concepts which placed emphasis upon the organisational structure, hierarchical relationships, authority, specialisation, span of control, and line and staff relationship (75). This traditional concept, although proved to succeed in the short run by achieving impressive productivity and financial results, deteriorates the human organisation productive capability over the long term. Consequently, the favourable productivity and earnings are not sustained (76). Therefore, this traditional theory was modified substantially by the behvioural view which placed greater emphasis upon the personal and social needs of organisational participants (77).

The growth and productivity of organisations is now, more than ever, dependent upon the effectiveness of human performance (77). Every organisation is more than such a means - end system, it comes to have a unique wholeness, and a particular image and character (78). The behavioural concepts highlight the concept of the organisation as a total system encompassing individuals, informal groups, intergroup relationships and the formal structure. This means that to achieve higher productivity and efficiency, a variety of dimensions such as individual performance, interpersonal relations, policies, supervision, organisation and job structure, planning, communication, pay systems and decision-making may all require examination (79).

In recent years the study of organisation theory has drawn upon system concepts (80). The purpose of applying the systems approach to organisation is to facilitate better understanding in a complex environment, and the decision-making process would be easier to handle (81). The adopting of the systems approach will not require wholesale changes on the part of organisation structure and administrative behaviour. The organisation will be divided into major parts, each of these into sub-parts and so on, in the familiar forms of departmentalisation. The focus of attention is turning more to welding together all the organisation resources into a whole (78).

It is important to stress the idea that the internal functioning of an organisation must be consistent with the demands of the organisation tasks, technology or external environment and the needs of its members if the organisation is to be effective (82). This point of view reflects the new research finding that no one organisational system is appropriate for all circumstances (80). The evidence gathered suggests that there is a trend to exhibit flexibilities of organisation and general readiness for change (83). This refers to decision-making under different conditions. Whether the changes are beneficial or damaging should be recognised by the management who is responsible for improving the organisation's effectiveness (84). Organisational effectiveness requires the ability of interdependent individuals and groups to work together towards organisational goals- to communicate effectively with each other to co-ordinate their activities and resolve their conflicts (85). If management want to achieve higher productivity they have to develop their organisation into highly co-ordinated, highly motivated, co-operative social systems (86). Under their leadership, the different motivational forces in each member of the organisation should coalesce into a strong force aimed at accomplishing the mutually established objectives of the organisation (86). The management of that organisation has to use the different management tools and techniques in such a manner that a favourable and co-operative attitude is created and all members of the organisation endeavour to pull concertedly towards commonly accepted goals which they have helped to establish (87).

It is increasingly recognised that management needs a sound organisational structure before it can benefit fully from the decision-making tools and techniques (88). The spinal column of any enterprise is its organisational structure. The organisational structure has been defined as a formal arrangement of personnel positions designed to implement its basic objectives (89). It might be represented by organisation charts which display the formal line of authority among divisions, and how divisions are to interact (90). In other words, organisation structure refers to properties essentially internal to an organisation (91). It is considered to be the framework for carrying out the responsibilities, for the co-ordination of activities or operations, and for the motivation of its members. Organisational structure should be designed to be matched with the relevant task and environmental conditions. This proposes that organisational effectiveness is a direct function of the structure it utilises in applying its human resources to the task to improve its productivity (92).

Therefore the rest of this chapter will be devoted to studying the organisation of highways maintenance department structures to see if such an organisation supports or hinders improving productivity.

3.2. Highways Maintenance Department Organisation

The highways maintenance department is an organisation for managing the employment of given resources of labour, material, money and plant to achieve defined objectives in the maintenance of roads.

Under the Trunk Act of 1936, central government through the Minister of Transport became a highway authority of trunk roads and motorways (52). As government departments have no direct labour organisation, the actual maintenance work on trunk roads and motorways is carried out by the appropriate local Highways Authority, acting in this case as the agent authority. The highways department is one of the County Council departments which is responsible for improving the county roads. It may act as an agent authority for the Department of Transport in maintaining the trunk roads and motorways within the county borders (1). The responsibility for principal and other roads lies with the County Council, however, the District Councils may act as agent authorities for the County Council for maintenance work. Figure 3.1 illustrates the system's interacting components.

There have been a number of different studies concerned with the organisation of highways maintenance departments. All these studies have commented on the need for a simple line of authority, responsibility and accountability, and for clear channels of communication. They recommended that the highways maintenance authorities should reconsider their maintenance organisations in an attempt to provide more effective and efficient use of their resources*. In this thesis

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* For more information about the results of these studies consult :

1. Report of the Committee on Highways Maintenance, London, HMSO, 1970.
2. Parmenter, B.S.; Lancaster, J.E. and Cox, B.A., Highway Authorities Maintenance Organisation, TRRL Report 615, Crowthorne, Berks : Dept. of the Environment, 1974.
3. El Harouni, Amr Kamel, Budgeting, Budgetary Control and Management Information in the Highways Depts., PhD Thesis, University of Aston in Birmingham, September, 1975.

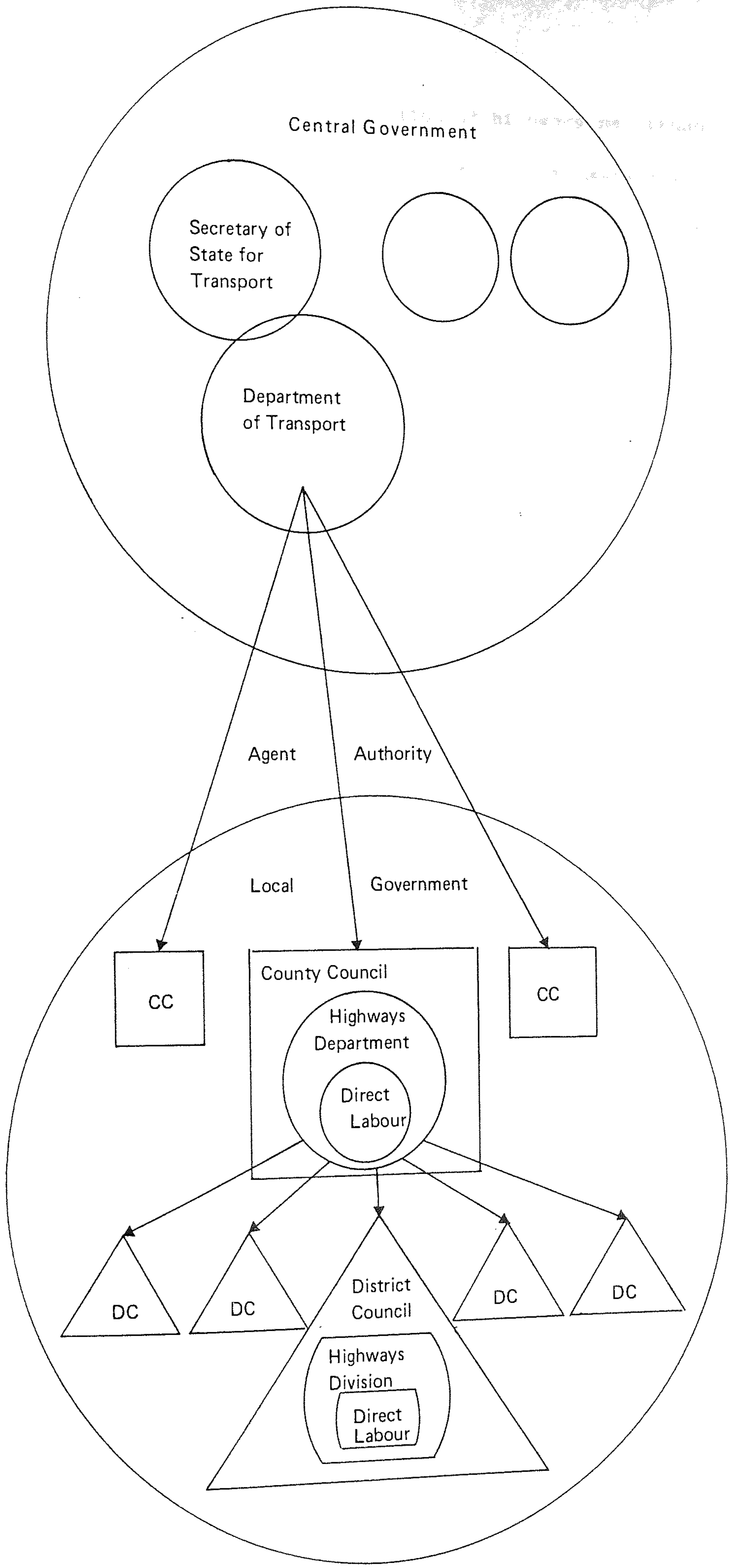

Fig. 3.1: Enteracting Existing Structure of Highways Maintenance

In this thesis the organisation of highways maintenance departments has been examined to see how far the recommendations of these previous studies have been adopted. It has approached the examination of their organisation from a different view, through considering the organisation as an open system. It attempts to reconsider the organisational structure of the highways maintenance department in order to obtain more effective use of the resources.

The investigation of the highways maintenance department's organisational structure started by asking the management to show the researcher their organisation chart. The reason behind that arose from the fact that organisational charts are an overt representation of an organisational structure, displaying the formal lines of authority among divisions, and how divisions are to interact (90). In the meantime, one ought to consider the other, informal lines of communication within the organisation, as they are considered a true pipeline of communication (93).

The questinnaire shows that the majority of the counties surveyed recognised the advantage expected to be gained by having adequate organisation charts (see Table 3.1).

Table 3.1. Effectiveness of the Organisation Chart

Reply / Aspect	Yes %
Does the organisation chart reflect the organisation objectives and does the programme meet these objectives ?	70
Are the various duties and responsibilities delegated properly and defined clearly ?	70
Is the line of authority effective from the standpoint of control ?	60
Do the people concerned have sufficient understanding of responsibilities and authority assigned ?	60

Although 70 per cent of the counties surveyed stated that they have a chart outline of the fundtional relationships of their organisations, in only 50 per cent of the counties studied were charts available. Some of these charts were very elaborate and were exhibited in the Deputy Surveyor's office. In one county, detailed departmental charts were bound together. In about half of the cases, the charts provided were not applicable to the actual situation and were not up to date. Where no organisation charts were available it was very difficult to find out exactly who was responsible to whom and to trace the pattern of prescribed relationships.

In the counties where charts did not exist, misunderstanding about the authority and responsibility of individual members of the organisation might impede the best use of the resources. Moreover, the management may not be able to work together as an integrated team. In one county the management argued that having no organisation chart did not imply a lack of organisation consciousness *. Some of the management argued that the formal charting of positions and authority is deceiving because organisations do not operate according to charts. However, some plan is necessary to co-ordinate activities, whether or not it is followed to the letter.

It is expected that the lack of organisation charts will cause differences and conflicts between departments, with the results that (94, 95) :

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* One of the highways maintenance top management surveyed was able to draw how it could be if he had an organisation chart. But the researcher asked : Are the other individuals within the organisation able to draw it ?

1. Overlapping of activities

2. Contradictory decisions

3. Failure to take decisions because they fall between the responsibility of two or more different people, and

4. No methods of resolving differences and conflict between departments.

It was found by the survey that in some of the Metropolitan counties, no accurate organisation structure of their district councils was available. This situation was blamed on local government reorganisation, although more than seven years had passed since it had happened (96). They argued that they organised the relationships with their districts through the Agency Agreement. However, the Agency Agreement does not control the organisation of their work but, in fact, controls the financial side of their work only (95). (See Appendix 3.1 for an example of the Agency Agreement).

It was found by the questionnaire that most of the counties surveyed suffered from the same organisation problems. In order to highlight these problems and to emphasise the need to reconsider the organisation structure of highways maintenance departments, a typical structure of one of the Metropolitan counties surveyed will be described in the following example.

3.2.1. Example 1

A-The organisation of highways maintenance within a Metropolitan County*

The highways authority of maintenance in the Metropolitan counties is a division of the Department of Transportation of the county.

* This county is "A" county which was surveyed within this thesis.

The highways maintenance department is organised according to the line-staff function and committee type of organisation. The county Surveyor is at the head of the highways maintenance department, as shown in Figure 3.2.

The county acts as an agent for the DTp for maintaining motorways and trunk roads. The county consists of seven district councils. The county delegates its authority to the district councils to maintain the other roads within its boundaries through an Agency Agreement (see Appendix 3.1). There is no direct control by the county on the districts' direct labour force (approximately 1,600), the only kind of control over the work to be done is through the Agency Agreement.

The principal engineer for motorways and trunk roads is responsible for the direct labour organisation of the county which is located in four depots. The county's direct labour force totals 80 and is responsible for maintaing approximately 150km of motorways and trunk roads. Although the direct labour carries out most of the work of maintaining the motorways and trunk roads, the county uses contractors for specialised work which need specialised equipment or special skills of labour. The majority of workers recruited had not enough roadwork experience. However, it is encouraging to note that many are developing appropriate skills through training programmes organised by the county training centre. As a result of providing the basic roadworkers' skills (patching, kerbing) through training programmes, the quality of work carried out by direct labour has improved significantly. The main point needing attention is the fact that insufficient communication exists between the different district councils, so far as carrying out maintenance work is concerned (97).

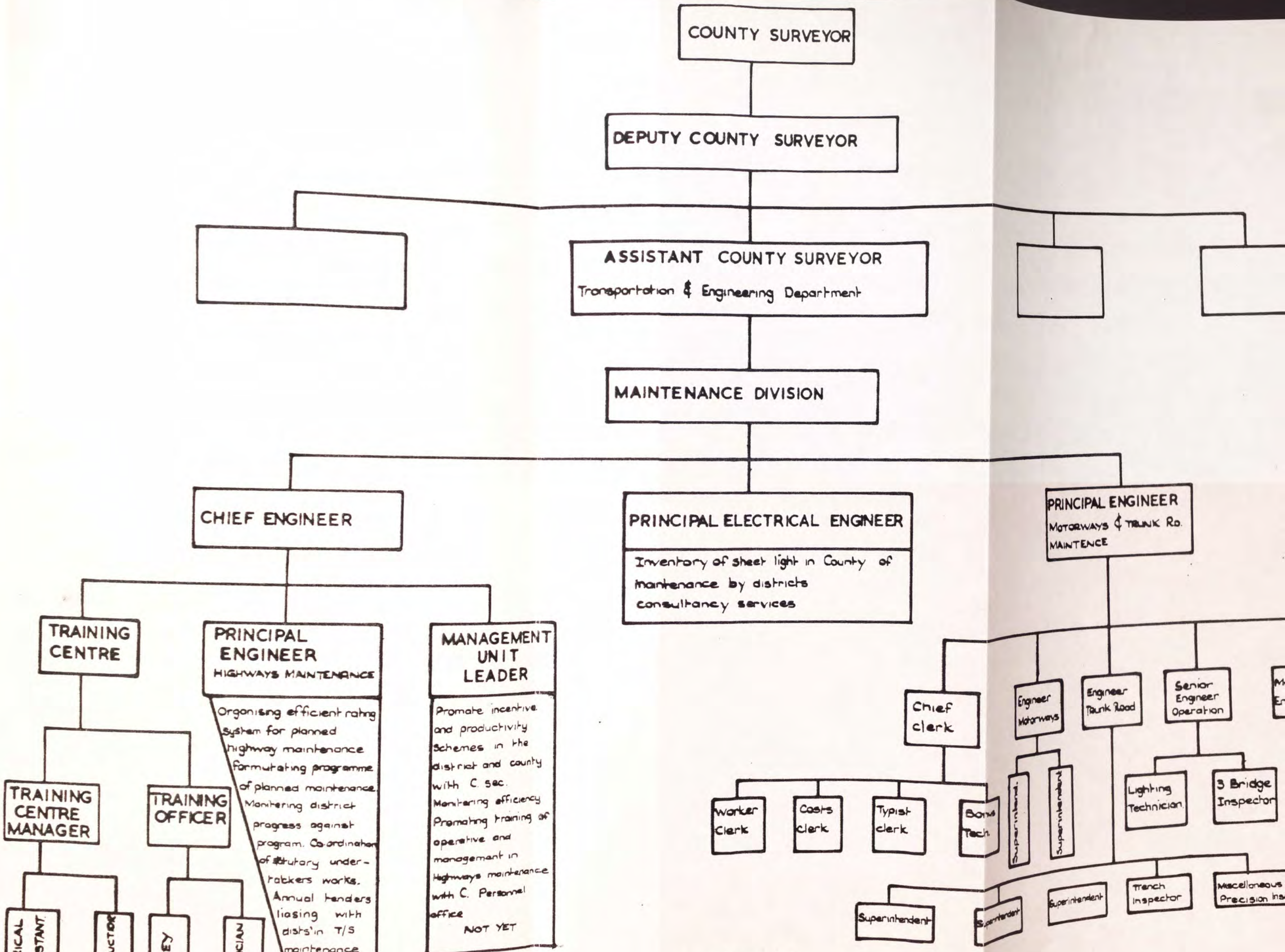

COUNTY SURVEYOR
DEPUTY COUNTY SURVEYOR
ASSISTANT COUNTY SURVEYOR
Transportation & Engineering Department
MAINTENANCE DIVISION
CHIEF ENGINEER
PRINCIPAL ELECTRICAL ENGINEER
Inventory of street light in County of maintenance by districts consultancy services
PRINCIPAL ENGINEER
MOTORWAYS & TRUNK RD. MAINTENCE
TRAINING CENTRE
PRINCIPAL ENGINEER
HIGHWAYS MAINTENANCE
Organising efficient rating system for planned highway maintenance formutating programme of planned maintenance. Monitering district progress against program. Co-ordination of statutory under-takers works. Annual tenders liasing with dists'in T/S maintenance
MANAGEMENT UNIT LEADER
Promote incentive and productivity schemes in the district and county with C. sec. Monitering efficiency Promoting training of operative and management in Highways maintenance with C. Personnel office
NOT YET
TRAINING CENTRE MANAGER
TRAINING OFFICER
Chief clerk
Engineer Motorways
Engineer Trunk Road
Senior Engineer Operation
Worker Clerk
Costs Clerk
Typist clerk
Bonus Tech.
Superintend.
Superintendent
Lighting Technician
3 Bridge Inspector
Superintendent
Superintendent
Superintendent
Trench inspector
Miscelloneous Precision

Figure 3.2.

The highways maintenance division within the county has the following functions * :

1. Assessment of the priorities.

   To fulfill this objective, the following responsibilities ought to be carried out :

   a) Organising an efficient rating system for planned maintenance of highways.

   b) Monitoring a highways register (including footways).

   c) Receiving print-outs of rating systems from districts and formulating planned maintenance programmes.

2. Allocation of funds between the districts.

   This function is carried out after assessing the priorities and requires the following responsibilities :

   a) Liaising with districts on major items of planned maintenance to effect minor improvements.

   b) Day-to-day liaison with districts, and monitoring progress of work and expenditure against programme.

   c) Liaising with the district to ensure efficient operation of the Traffic Signal Maintenance Agreements. Category of maintenance to be determined.

   d) Issuing recommendations to districts on levels of maintenance of bollards, traffic signs, street nameplates and other street furniture.

   e) Auditing work carried out by the districts and preparing schedules of unit cost with performance review.

---

* This information was provided by "A" county.

3. Monitoring performance and setting of standards. This function necessitates the following responsibilities to be carried out :

   a) Vetting and approving road layouts submitted under council development.

   b) Issuing guidance on specifications.

   c) Monitoring liaison with the statutory undertakers on :

      (i) Strategic improvements to reconcile their activities with highways maintenance

      (ii) Improvements in day-to-day procedures to minimise disruption and operative expenditure

      (iii) Liaising with Material Engineer on Marshall Testing

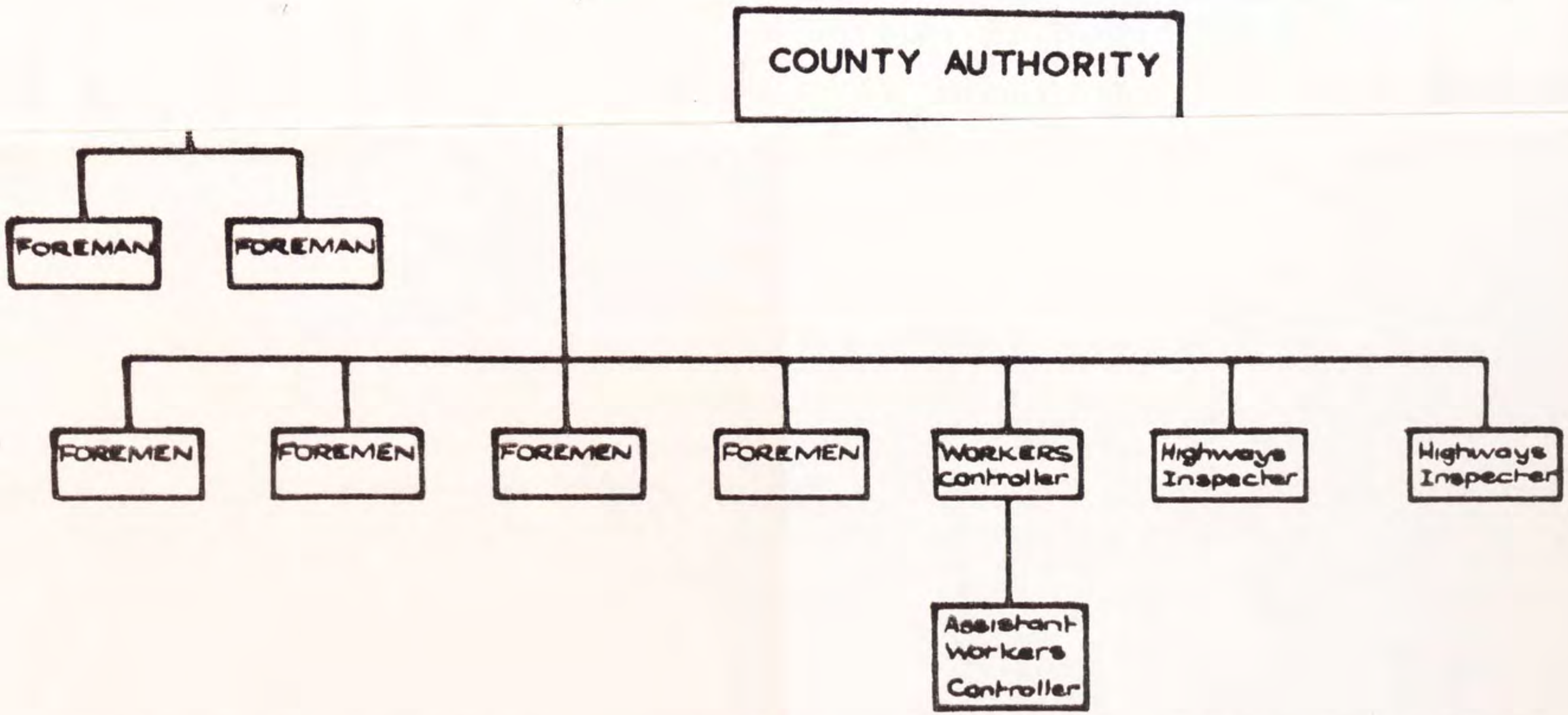
      (iv) Approving road closures proposed by districts and minor redevelopment proposals

      (v) Evaluating availability of various materials incorporated in maintenance work.

4. The design and supervision of annual maintenance contracts for trunk roads.
   This function requires preparing annual tenders to planned maintenance.

<u>B- The highway division with the district council.</u>

The organisation structures within the different districts are almost identical. The one described in Figure 3.3 represents the organisation of one of the seven district councils which are included within this Metropolitan county. This district has the highest population. The highways maintenance division within this district counc is divided into six sub-divisions:North, South, East, West, X, and Cent



DEPOT BACK UP STAFF ie. CLERICAL ASSISTANTS. DEPOT ASSISTANTS

Figure 3.3.

Organisation Chart of Highways Maintenance Division

Within a Metropolitan District Council

The maintenance division is responsible for maintaining approximately 2,300km of carriageway. Each of the Western and Northern sub-divisions are responsible for the maintenance of 500km. Southern and Eastern sub-divisions are each responsible for 400km. Central and "X" sub-divisions are each responsible for maintaining 250km. The number of direct labour employed by this district is approximately 400. This number is divided between the six divisions according to length and importance of the roads.

The funds for maintenance are allocated from the county council according to the assessment of priority. The districts set up their maintenance programmes according to the funds available, each year. Most of the work is carried out by direct labour except where specialised equipment and skills are required.

The following are the main maintenance activities of the highways division within this district.

1. Repair of footpaths : a) Bituminous paving

   b) Concrete flag paving.

2. Minor repairs to carriageways.

3. Dealing with emergency calls. This extends from damage caused by car accidents to buildings on fire.

4. Salting and gritting. A 24-hour stand-by is maintained during the winter months to ensure that if a sudden frost or snow occur, it can be dealt with within an hour.

5. Carriageway diversions. Very often, contractors carrying out works require roads to be closed and traffic diverted away from the works.

6. Complaints. Many complaints are received from the general public

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and each one has to be investigated and acted upon.

7. Accidents. Every accident reported must be investigated and special forms filled in and submitted to the accounts section in case of legal action.

8. Surface dressing. A large amount of money is spent on this item, but all the works are carried out by contract.

9. Carriageway surfacing. This work requires special machinery and expertise, and again, these works are carried out by contract.

10. Footway crossings. Whenever a person requires to drive his car off the highway onto his own land, it requires a footway crossing to be constructed. This involves dealing with all the main authorities and liaising with the owner of the property.

11. Kiosks, poles and benches. The erection of all street furniture has to be approved by the Divisional Surveyor prior to erection.

12. Electrical and Mechanical division.
    In each of the divisions there is an Electrical and Mechanical sub-division which deals with the day-to-day running of the division. Any main faults or queries have to be referred to their head office in the district.

13. Permits to excavate public highways. Before any contractor not working for the Local Authority wishes to excavate the carriageway, he must first obtain permission from the highways authority before he can start. These permits are issued by the divisional office.

14. Weed control. A contract is issued each year for the spraying of footpaths and carriageway channels to prevent weed growth.

15. Abandoned cars. Each abandoned car has to be visited and a notice put on the windscreen and after seven days, the car is recovered by a contractor who pays £2 for its scrap value.

In addition, the district is responsible for carrying out the following sewer works :

16. Gully cleansing.

17. Sewer connections. This work usually occurs when new buildings are completed and have to be connected to the public sewer.

18. Construction of new sewers. A programme is produced for this work and as money becomes available, sewers are replaced or renewed. This applies only to small schemes, the major sewer schemes are carried out by the Main Drainage Division working from district head office.

19. Maintenance of rivers. Many of the brook courses and rivers are the responsibility of the district to maintain, usually with an Agency Agreement with the main River Authority.

20. Emergency calls. Many of these calls are received following heavy rain when flooding takes place. Other calls are those received from the Public Health Department when foul sewerage is discharging into brook courses, etc.

3.3. Evaluation of the Highway Organisation and Suggested New Organisation Patterns

It seems from the description of the highways maintenance department in the above example, and from the study of the organisation of the other counties, that highway organisation is based on line-staff organisation structure. Under this system, the Authority has the responsibility for the operation of the department lodged in the top of the organisation with the Surveyor. He delegates to his Deputy or Assistant, some of his authority, and holds them accountable for the specified performance. They, in turn, delegate part of their authority to the head of the maintenance department, and so the delegation proceeds down through the organisation. All the authority's influence is seen as coming from the top downwards.

It has been assumed, in this mechanical concept of organisation, that the objectives of the organisation are accepted and understood by all its members, who subordinate their own aspirations to those overriding aims, which is not the case according to the findings of the survey and the questionnaire of the thesis (see Table 3.2).

Table 3.2. Clear Understanding of the Department's Objectives

Group \ Reply	Yes %
Surveyor	100
Deputy Surveyors	100
Departmental Management	100
Supervision	90
Operators	60

As it is expected that the management majority agree that there is clear understanding of the objectives within the organisation. However, it is clear from their answers that this concerned the top management, but to a lesser extent at the level of operators. They said that this situation is caused by the hierarchical levels of their organisation. They considered centralisation as the main weakness. They said that any information has to travel from County Surveyor down to Assitant County Surveyor, head of the department, principal engineer, team leader, technicians, supervisors, foremen and the operators. These numerous levels affect communication downward and probably the upward communication is at least as inadequate, or might be less accurate (96).

The system, therefore, lacks the sharing of involvement of the groups through different hierarchical levels. This lack of opportunity to participate will create hostility among the subordinates. Consequently, the greater extent to which the top manager (the Surveyor) makes the decisions, the greater is the probability that competition, hostility and conflict will exist throughout the organisation. This might lead to less interest in carrying out the work in the most effective way, and this might be one of the diseases from which public work suffers (98).

Another problem pointed out by the majority of the counties surveyed, when they were asked about the main weaknesses of their organisation, was the effect of the reorganisation of 1974. They said that the new counties inherited the previous authorities' problems and most of the counties have not yet settled down after the reorganisation.

60 per cent of the management stated that overlapping and duplication of functions occurred. The reasons behind their answers were :

1. Overlapping between the county and districts occurs because both are carrying out the same functions on the same road (99). In addition, overlapping necessarily follows as a result of dividing duties between the different management teams. They said that each individual manager "did not sit in his own corner and do only his own work".
2. The Metropolitan counties claim that the two systems of county coun and district council are responsible for contradictory decisions (100). There is a lack of control of the work because of the complexity of the system (101). Within the Metropolitan county,

the only way to control the work of the districts is through the Agency Agreement which, in fact, controls the financial side. There is no control over the detailed programme, the Agency Agreement serves political and not administartive ends.

3. There is lack of communication between the different districts which prevents the co-ordination between their activities (102). The researcher noticed that there was not enough communication between the different Highways Authorities which hinders the advantages o successful experiences. This situation has resulted in the development of gaps between management and working groups, and has made it difficult for the whole organisation to work as a whole entity to achieve the same objectives.

From the above discussion it could be concluded that, as far as the management of highways maintenance departments are relying heavily on a formal organisational arrangement, it fails to create a co-operative team spirit. The results obtained from human science has proved that this kind of organisation will distort and cause deterioration in human activity, in the long run. It relies on the economic needs humans, which means that when an organisation buys a person's time it obtains control over that person's behaviour (76). When an organisation relies primarily on economic needs it fails to use adequately those basic human, motivating sources which are capable of developing the kind of co-operative relationship needed to operate productively and with a minimum of conflict. The highly effective organisation required is not the traditional organisation with its vertical strucure and person-to-person relationship, but a form of organisation with group face-to-face relationships.

Therefore, the kind of organisation needed is a network system with elaborate, interlaced organisational structure. The general nature of this type of organisation consists of multiple overlapping groups, link-pinned together, as shown in Figure 3.4 (76). The vertical line would consist of such groups and so would the horizontal line. The capacity to achieve highly effective lateral, as well as vertical co-ordinates exists because of the better communication through its alternative linkages.

Many studies have demonstrated that applying the interaction influence network patterns of organisation, corresponding sizeable improvements are occurring in productivity, earnings, and other performance measurements, and in employee satisfaction, internal teamwork and union/management relationships (76, 84, 86). These achievements are esteemed as a result of more confidence and trust among the members of the organisation and across departments, and across hierarchical levels. Greater commitment to the success of the entire department is present, i,e, members strive, consequently, to reduce their differences and disputes for the greater good of the total organisation. There is greater group loyalty among the members of each group and to the entire organisation which helps create all the positive motivational forces. Consequently, all the motivational forces are additive and orientated towards achieving the organisation's goals more efficiently. This will help the management to make full use of all the resources available in order to achieve higher productivity levels.

The same basic concepts and principles of the interaction influencing network organisation structure are applicable to achieving

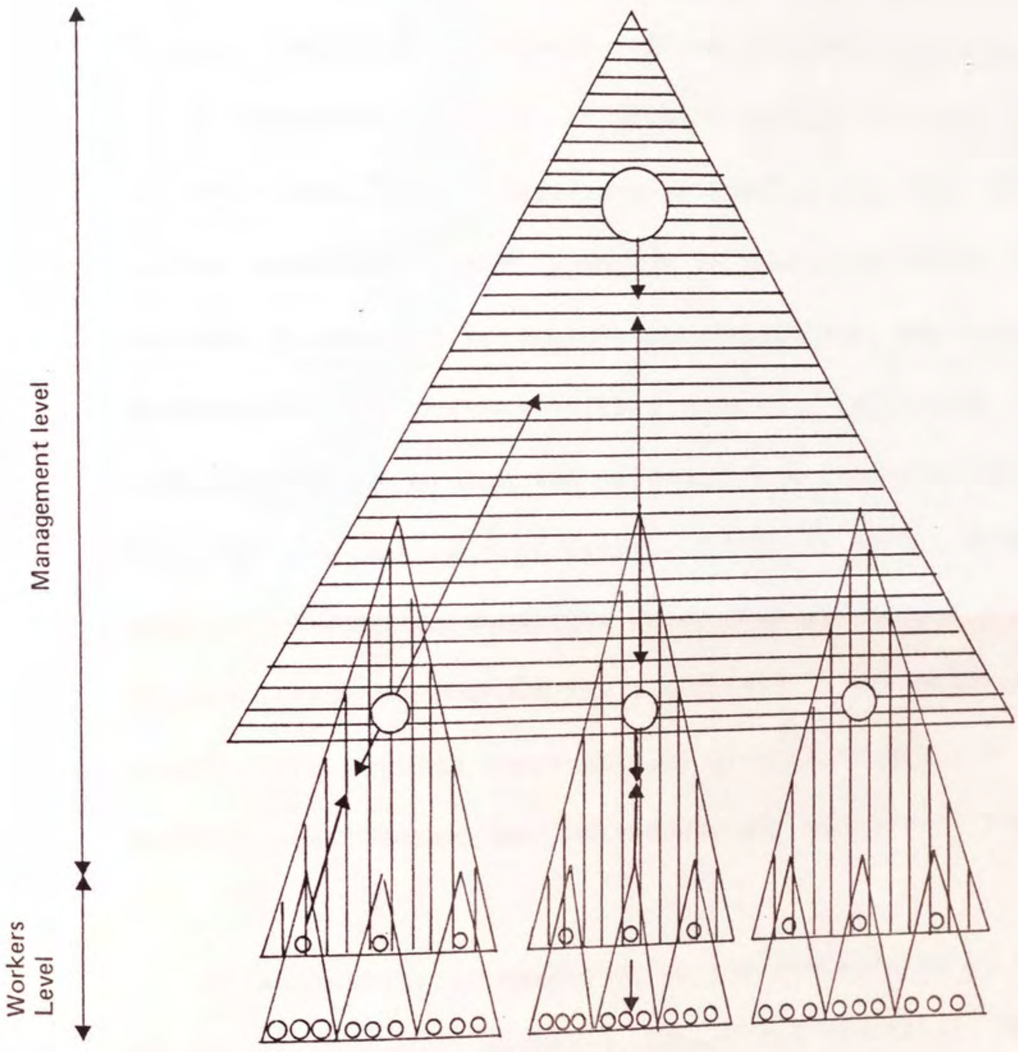

Fig. 3.4: The Overlapping Group Form of Organisation

effective co-ordination, regardless of the purpose and activity of the organsiation (76). Therefore, it is suggested that this structure should be applied to the highways maintenance department in an attempt to achieve more effective decision-making and improve the performance of the organisation. Figure 3.5 demonstrates the new structure for the maintenance organisation which is suggested by the researcher. It might be right to expect that the highways maintenance department could probably gain many advantages through adopting this type of organisation. Full information is readily available and every unit in the structure seeks to engage in activities which aid the organisation as a whole to achieve its objectives. The nature of the decision-making process in this form of organisation assures that each problem is stated and solved with a broader orientation which is best for the entire organisation (104). It builds co-operative behaviour and decreases conflict. Group decision-making provides better communication throughout the organisation, and helps through participation to provide substantially greater capacity to deal with differences between the individuals and management (104).

Communication is essential to the functioning of an organisation in all directions : downward, upward and laterally. The absence of the accurate communication will reduce not only the acceptance of the information and objectives of the organisation, but also evoke motives to distort it. If the organisation seeks to operate effectively, the management has to make sure that all the members at every hierarchical level, including the non-supervisory employee, are participating in making decisions which affect their work. This will provide the organisation with better decisions based on accurate information, and greater motivation to implement these decisions.

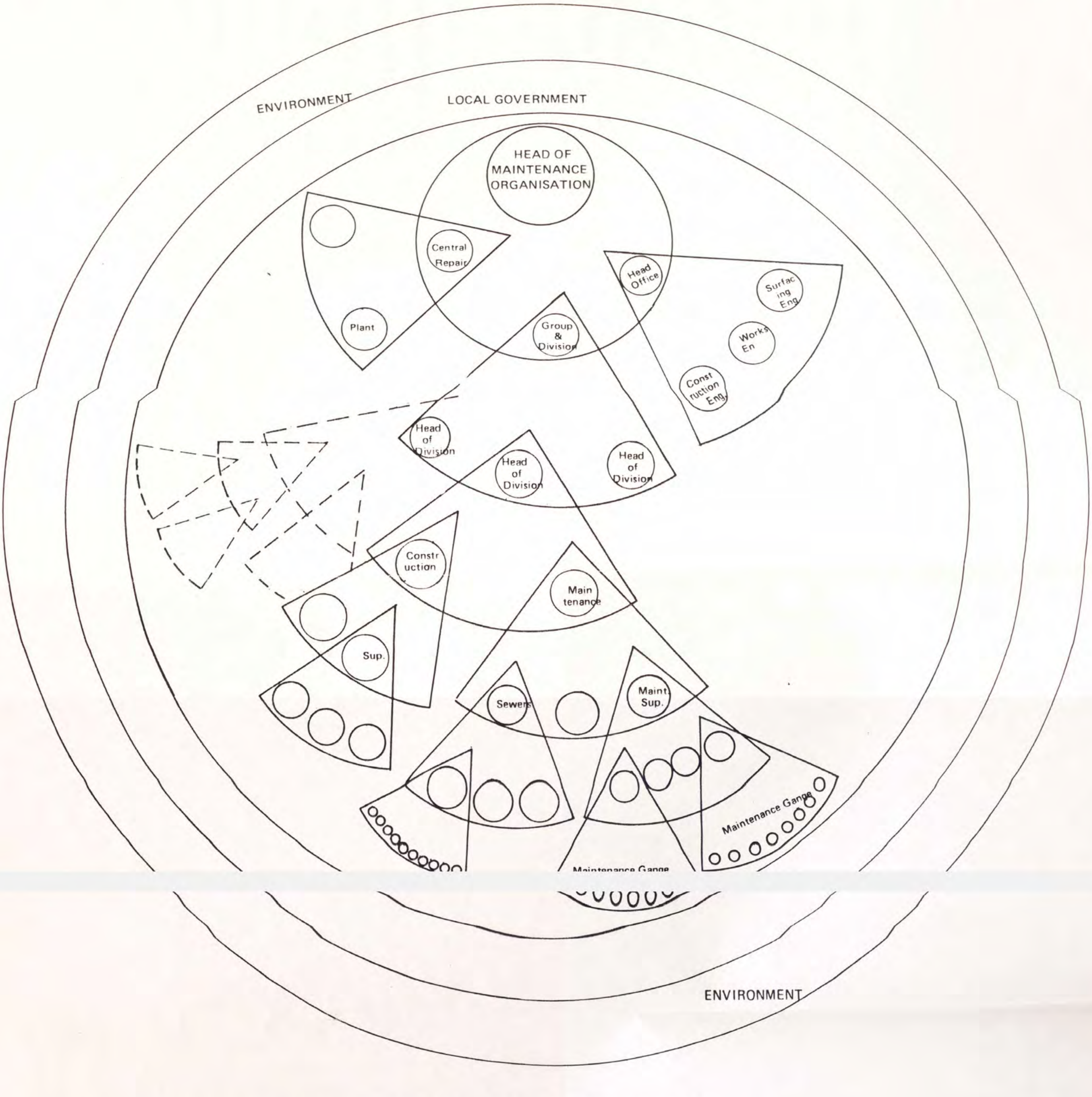

Fig. 3.5: Suggested Organisation of Highways Maintenance Departments (Interaction - Influence Net work Organisation)

Therefore, it seems to yield a more flexible organisation in which individuals at all hierarchical levels are motivated to exercise more initiative in dealing constructively with conflicts and bringing about improvement and change.

An example of the benefit which would be gained through adopting such an organisation might be given in the case of using the direct labour force within the different divisions, within the district council, in carrying out emergency work. Another benefit that could be gained is the improving of the quality of the maintenance work through using a highly trained gang to carry out the specialised work required within the different divisions, regardless of the organisational boundaries between these divisions. This means full utilisation of the resources available and better use of the money spent in training them. As far as the whole county is concerned, there could be benefits in involving each divisional Surveyor responsible for maintenance work, in planning the programme within their divisions, in co-ordination with all the other divisions. This co-ordination should facilitate the full utilisation of the special equipment by scheduling its work throughout the year within the different divisions. This scheduling will minimise the idle time, which means saving costs by improving the efficiency of the work. It would not be possible to achieve these results without the interface action of the groups within the organisation. As long as everybody - through representatives - participates in decision-making, the efforts will be directed to carry it out as efficiently as possible. In other words, this type of organisation might help in improving the productivity of the whole department.

Conclusion

It seems from the above discussion of the organisation of highways maintenance departments, that the present organisation affects the decision-making process. The highways maintenance departments have limited powers and are subject to external restraints, have extra duties placed upon them, and have to plan their work programme according to the funds available.

The organisation structure appeared to suffer from many problems, the most of which resulted from lack of communication between the different hierarchical levels and between the divisions. Thus, overlapping and duplication occur throughout the organisation. Furthermore in some cases a decision had been hindered by boundaries between the committees' terms of reference, and by departmental duties. Their organisational charts which outlined the functional relationships and responsibilities were neither precise nor maintained up to date. The different hierarchical levels within the organisation were very slow to follow and affected communication down to the lowest levels of the organisation. This situation has resulted in the development of gaps between the management and the working groups, and has made it difficult for the whole organisation to work as a whole entity to achieve the same objectives.

Therefore, it is suggested that an alternative type of organisation might help to achieve better results. This is the interaction influence network type of organisation where the organisation of the department is viewed as a whole entity having a broad objective. Through the interference action of the whole group and their participation in decision-making, better communication can be achieved.

This will facilitate better information flow through the vertical and lateral levels of the organisation which help in improving planning capacity, better resource utilisation and consequently, improved efficiency and productivity of the whole organisation.

PART 2

AN EMPIRICAL STUDY OF

HIGHWAYS MAINTENANCE FUNCTIONS

Chapter 4

An Empirical Study of Highways Maintenance Functions

Introduction

The aim of this chapter is to describe the maintenance function, its importance and its responsibilities in carrying out maintenance work.

It is an attempt to examine the management objectives and processes in order to highlight the efficiency with which maintenance work is carried out.

4.1. Maintenance Functions

For the purpose of this research, maintenance has been taken to mean "those activities which are designed to preserve rather than to improve the highway"(1,p.4).Theoretically, maintenance is carried out, directly or indirectly, to meet three broad objectives. These are :

1. Safety - good road surface conditions in regard to shape and skid resistance, adequate warning signs, etc.
2. Aid to movement - good alignment and passing opportunities, clear information signs, etc.
3. Aesthetics - e.g. well-kept grass, clean channels, good kerbing, etc.

As an attempt to find out the acceptance of these maintenance activities' objectives, the authorities covered by the questionnaire were asked to state what, in their view, is the objective of highways maintenance. Generally, most of the counties stated that the main objective of maintenance activities was to ensure that highways are maintained in a good condition, such that vehicles carrying passengers, goods, livestock, etc.,can travel safely and economically ; the physical conditions are required to ensure defined and acceptable conditions of durability, safety, amenity, etc. It is noticed from their answers that roads provide an intangible service.

The survey indicates that the term maintenance is interpreted differently in different authorities. There is also no clear dividing line between small improvements and maintenance. All of the counties covered by the survey provided all aspects of maintenance work to achieve their objectives of maintaining the highways in a good condition.

The following list suggests the range of maintenance activities as defined by the Marshall Committee :

"<u>Structure</u>

Resurfacing and correction to camber
Reconstruction and strengthening of foundations
Surface dressing
Patching
Gully emptying and repairs to drainage
Kerbs and footway maintenance
Maintenance of bridges
Maintenance of embankments
Siding and verge maintenance.

<u>Aids to movement and safety</u> :

Snow and ice clearance
Repair and maintenance of : Carriageway markings
Signs
Traffic lights
Pedestrian crossings and street furniture
Road lighting

Amenity : Grass cutting
Hedge trimming and maintenance of trees and shrubs
Sweeping and cleansing"
(1,p.4)

The county Working Party on Organisation of Highways Maintenance suggested the use of the function headings provided on p.22, para.7 of the report of the Marshall Committee.

A. Structural

B. Cyclic (including aids to movement, safety and amenity)

C. Winter maintenance (functions).

To these, the Working Party on Organisation has added :

D. Contract maintenance and

E. Miscellaneous maintenance items.

Appendix 4.1 illustrates a draft list of maintenance functions.

To examine the acceptance of this classification after it had been modified by the Working Party, the Highways Authorities were asked to ... classification of the main categories. All the counties stated that they do classify maintenance work into these different categories which are suggested by the Marshall Committee and the Working Party (see Table 4.1). They said that this classification so far provided a reasonable way of classifying maintenance work into different types for different purposes.

Table 4.1. Maintenance Classifications Adopted by the Various Counties Surveyed.

Maintenance headings	Counties replies									
	A	B	C	D	E	F	G	H	I	J
Emergency	✓	✓	–	✓	✓	✓	✓	✓	✓	✓
Structure/maintenance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Winter maintenance	✓	✓	✓	✓	✓	✓	–	✓	✓	–
Contract maintenance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Miscellaneous maintenance	✓	✓	–	✓	✓	✓	–	–	✓	–
Kind of labour	✓	✓	–	✓	✓	✓	–	✓	✓	–
Kind of plant	–	–	–	–	–	–	–	–	–	–
Others : General maintenance or Basic maintenance	–	✓	✓	–	–	–	–	✓	✓	✓

However, it was found out by the investigation that maintenance activities within each category cover a wide field that varies from one county to another. In one of the counties, cyclic maintenance includes snow clearance, grass cutting, sweeping, gully emptying, patching and maintenance of white lines and other aids to movement. This is quite different from the classification suggested by the Marshall Report where snow clearance is considered to be one of the activities included either in the emergency category or under winter maintenance. The maintenance of white lines is considered under the category of contract maintenance in one county. In another county, structural maintenance includes surface dressing, resurfacing, haunching, kerbing and general construction. The practice is different in another county where surface dressing comes under routine maintenance and resurfacing comes under major structural maintenance. Besides these differences, through the survey it was found that different terms are used to mean the same thing, such as "routine maintenance" or "cyclic maintenance" and "major maintenance" or "structural maintenance".

An attempt was made by another county to relate maintenance categories with type of expenditure in order to achieve better control. They suggested another five categories of maintenance work and tried to describe within each category the kind of labour and the trend of spending. They said that the majority, if not all, of maintenance works can be described as follows (105) :

1. Scheduled, ongoing, routine operations of a repetitive nature ; slow spending and labour intensive. Cyclic maintenance can fall within this category.
2. Unscheduled minor operations of a similar but non-repetitive nature ; slow spending and labour intensive. This category includes "Basic", "Back-up" or "Emergency" maintenance.
3. Scheduled routine operations, highly mechanised (sometimes seasonal); variable spending rates. This category includes such activities as : sweeping, gully emptying, verge and hedge trimming, carriageway marking, precautionary salting.
4. Scheduled, premeasured, mechanised, high material content, fast spending. Surfacing and surface dressing represent activities

which fall within this category.

5. Individually programmed labour/plant/materials variable-mix, variable spending rates. This category includes the following maintenance activities : structural maintenance schemes, drainage, kerbing, footways, reconstruction, major patching.

It is noticeable that there were some maintenance activities which had been divided between two categories, although meaning the same type of maintenance activity. For example, cyclic maintenance was included in the first category while sweeping and gully emptying were included in the third category. Another example is where emergency work is included in the second category and again, precautionary salting is included in the third category.

One of the authorities surveyed provided the following list as an example of the emergency maintenance activities :

a) Salting of roads at times of frost, for which purpose roadmen are on call-out or stand-by duties from October to April ;

b) The removal of fallen or dangerous trees following gale damage ;

c) Snow clearance ;

d) Storm damage resulting in flooding ; landslips ;

e) Urgent repair of road subsidence and potholes ;

f) In coastal counties, dealing with the results of coastal erosion and coastal flooding ;

g) Dealing with the results of road traffic accidents, damage to bridges, and street furniture and the spillage of dangerous chemicals on the road surface ;

h) Carrying out the repair of defective highway trench reinstatements undertaken by statutory undertakers or public works contractors ;

i) Works arising from civil emergencies.

Although the above list included the emergency maintenance activities, it also included some winter maintenance activities such as a) and c).

The point which needs to be borne in mind is that it seems there is no reason for every highway authority to try to suggest their own categories for maintenance work because this solution would lead to a widely varying interpretation of maintenance. Unless a common language is used and understood by everyone within the different highways authorities, little can be done to improve the maintenance policy which makes the task of comparing the budgets between the different authorities very complex. Therefore, as far as this thesis is concerned, it is recommended that different highways authorities work towards adopting the same classifications of maintenance activities. The classification which had been suggested by the Marshall Report and modified by the County Working Party may be considered as a key start towards achieving this end. The following factors ought to be considered :

1. The definition of basic activity should be consistent within a given authority and common to other authorities, otherwise comparison would not be possible and there would be difficulty in establishing valid estimates.
2. The defintion of a basic activity must be easily understandable and meaningful to foremen and supervisors.
3. The management system is dynamic and changeable and this means that the list of basic activities should be gradually completed, up-dated and improved.

4.2. The Importance of Highways Maintenance

Until a few years ago, highways maintenance was not regarded as a particularly interesting field of research. Only relatively recently has it been widely recognised that the task of maintaining road networks is very complex (106). This trend becomes more important with the increasing recognition of the highways network as a valuable asset which should be maintained according to an overall economic study jsutified by the community needs and benefits (107). Good roads act as a catalyst to general development and accelerate the rate of economic progress (108). The economic generative attributes of roads are becoming more widely appreciated and the demand for more and better roads everywhere is progressively increasing (109). It is a fact that one of the functions of Local Authorities that frequently attracts the attention of members of the public is the construction and maintenance of roads (110). This is not only true today, but historically, as construction of roads is one of the oldest Local Government services (111). This is important for Britain because she depends on roads for her livelihood, probably more than any other industrial country *. However, Britain has between one third to half of motorways and main roads in comparison with other industrial countries such as West Germany and Italy (112). Moreover, 92 per cent of all passenger movement is by road and the number of vehicles per kilometre in Britain is higher than for most European countries, as shown in Table 4.2. (114).

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* Some 81 per cent of Britain's freight (in Tonnes/km) goes by road, France 54 per cent, West Germany 49 per cent, Japan 36 per cent and America 27 per cent (113).

Table 4.2. Vehicles (excluding motorcycles) per km of road

Country	% by road
France	24
Denmark	27
Belgium	27
West Germany	46
Gt. Britain	47
Netherlands	50
EEC average	37

In addition, traffic densities have increased out of all recognition over the last twenty years (115). According to the figures issued by the Department of Transport, traffic in Britain has increased by 49 per cent between 1966 and 1977 ; this gives an average annual rate of about 4 per cent, compared with a 6.5 per cent increase in the road network (116). In 1978, inland goods movement amounted to 129.5 thousand million tonne-km, of which three-quarters were by road. Table 4.3. shows the dependence on roads by the different industrial sectors (112).

Table 4.3. Dependence on Roads by Different Industrial Sectors in 1977

Industrial Sectors	million tonnes	% by road
Building material, timber and aggregates	494	96.3
Food, drink and tobacco	289	99.5
Petroleum products	180	48.6
Coal and coke	167	43.6
Iron and steel	101	74.1
Chemicals and fertilizers	68	93.5
Other goods	370	97.6
All goods	1,669	85.3

Therefore, the convenience and suitability of road transport in conditions of economic activity and improving living standards, together with the greater need for personal contacts in modern business may well accelerate the rate of expansion and increase further demand for modern roads (99). It also necessitates the need to maintain the highways network at the level of the constructed condition (117).

However, the road system which has to carry all this bulk of the transport of people in this country is creaking and becoming overloaded to a varying degree by the design year (118). In the meantime, Britain has failed to provide a better system of minor roads, as the amount of money devoted by government to improve the roads has been reduced*. Table 4.4. shows the reduction in road construction and maintenance expenditure (112).

Table 4.4. Road Expenditure - Great Britain

(£million at 1975 survey price)

	1975/76	1976/77	1977/78	1978/79	1979/80
Motorways & trunk roads	392.4	378.4	378.5	357.0	359.0
Local Authority roads	364.9	351.9	302.7	266.0	269.0
Maintenance	444.0	420.2	394.6	369.0	371.0
Total	1201.3	1150.5	1075.8	992.0	999.0

* This cut has had the effect of deferring most of the Local Authority construction schemes due to commence in 1977/78. More than sixty trunk road schemes have been directly affected, of which many are of vital importance, including major links between industrial areas and ports. These links were given top priority in the English trunk road programme which was planned before the war, but completion is not now expected before the mid-1980's (112).

The government White Paper on public expenditure released in October 1979 indicated that spending on the road and transport programme for 1980/81 is to be reduced by £200 million compared with 1979/80 (118).

According to the results obtained by the questionnaire, most of the highways authorities were well aware of this problem. They said that the consequences of the cutbacks over the year would create a depressed funds condition below that required to preserve existing roads. This view was pointed out by the majority of counties. They said that the most common problem requiring appraisal when considering finance for maintenance work was the cut in public expenditure. They said that the actual effects of the financial cuts may be significantly higher since the figures presented by the government failed to reflect the effects of cost increase and inflation. They said that the effects of the cuts in road expenditure will influence not only the programme of developing the network, but also, it is expected that the existing network will suffer from insufficient funds being allocated for maintenance, This is particularly true as the present state of the road network is largely a function of its treatment in earlier years. It has been recognised that the highways network will be a wasting asset unless sufficient is spent on its annual maintenance to keep it in an acceptable condition (119).

Therefore, maintenance activities begin to require important consideration in order to guarantee that the work is accomplished in the most effective way (120). This is particularly important because the limited funds available for maintenance necessitate the need to optimise the benefits obtained from the money available (121). This situation has focussed attention on the importance of the maintenance management process, the rationale for decisions, and the efficiency with which maintenance operations are carried out (122)

Therefore, the next sections will be devoted to explaining the responsibilities of carrying out maintenance work and to examining the methods adopted by management in planning and controlling the maintenance work.

4.3. The Responsibility of Carrying Out Maintenance Works

Under the Trunk Act of 1936, central government, through the Ministry of Transport, became a highways authority of trunk roads and motorways (52). As government departments have no direct labour organisation, the actual maintenance work on trunk roads and motorways is carried out by the appropriate local highways authority acting, in this case, as the agent authority (1).

Thus, a Local Authority has the power to improve the county roads within its boundaries (123). The highways authorities have to take prompt action on road safety and other grounds for repairs to road surfaces. This is particularly important because, according to the law related to safety on roads and footways, the highways authority is liable to prosecution if, as a result of unsatisfactory maintenance, a person suffers injury (e.g. as a result of falling down into a manhole, or a car accident if it was the result of skidding on a road surface of which the measurable skidding resistance proved to be unsatisfactory). The highways authority would be unable to provide the service they are charged to provide without the involvement of either their own labour or that of a private contractor to carry out the work on their behalf (124). For the highways authorities to carry out their statutory duties of road maintenance, it seems essential to have an adequate work force spread geographically throughout a county (125). Highways authorities have nearly always carried out their statutory duties of road maintenance by directly employed workmen ; the term Direct Labour Organisation (DLO) has generally been associated with it.

4.3.1. Direct Labour Organisation Defintion (DLO) :

For the purpose of this research the DLO is taken to be "that part of the resource of the county or urban Highways Authority's organisation which is applied directly or indirectly, in the actual performance of the work in any function of the maintenance and/or construction of highways for which the authority has the responsibility" (*). That is, the resource which would be redundant if all such work were to be contracted outside the authority.

The direct labour organisation thus includes :

1. The labour force employed in carrying out the work ;
2. Their immediate supervisory staff ;
3. Any staff effort devoted solely to the planning and control of direct labour works ;
4. Plant held for maintenance and/or construction operations, together with any provision of labour and material resources for plant maintenance ;
5. Inventory holdings of materials for works ;
6. Stores and depots with their provisions of labour and facilities

* This definition was suggested by the Industrial Supervisors of TRRL.

for handling and delivery of materials to works ; and

7. Any administrative effort expended on the keeping of records, payment of wages, insurance, etc. arising from the activities of the direct labour organisation.

The results obtained by the questionnaire revealed that the sizes of DLO's differ between the counties surveyed and there was no relationship between them and the populations of the counties. (See Figure 4.1.)

The reasons for the differences in the sizes of the various DLO's has, in the past, been largely historical, geographical and economic. As explained by one of the highway engineers during one of the interviews with the researcher, "During the depression of the 1930's when grants from the road fund were made available to authorities employing a quota of workmen from the depressed areas, some county councils built up large DLO's and maintained a preference for DLO works. During the 1950's when roadmen were not so well paid as industrial workers, some counties were unable to recruit men to sustain their DLO's, particularly those counties containing prosperous industrial areas."

Some counties said that the reasons for the differences in sizes resulted from political reasons. They argued that the extent to which DLO's are used has been much influenced by the political persuasions of the county councils. They said that some county councils which have been mainly Conservative have had small DLO's whereas others with a predominant Socialist membership have large DLO's.

The DLO's exist to udertake the works contained in the approved

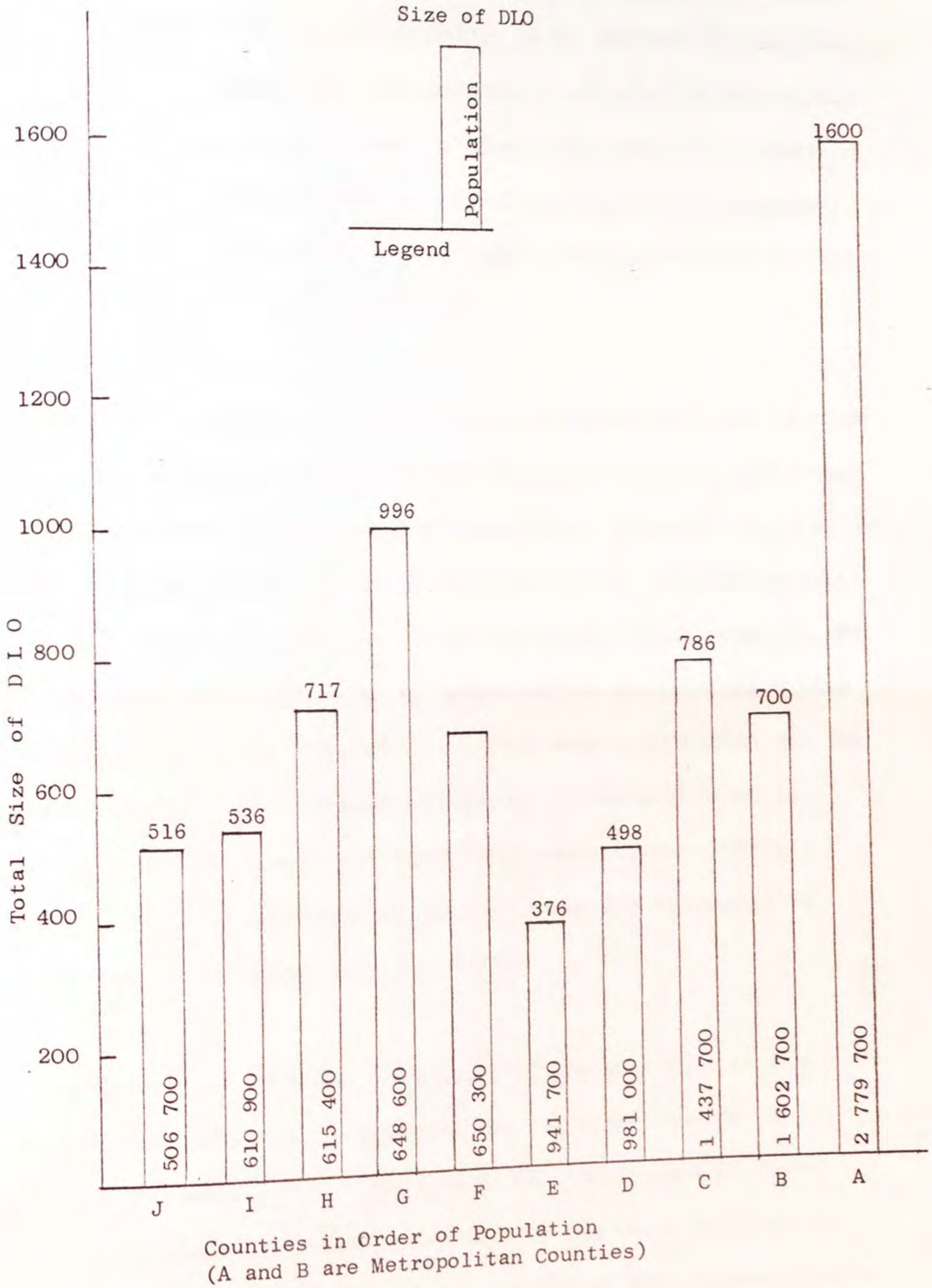

Figure 4.1.

Total Sizes of Direct Labour Organisations
in each of the 10 Counties Surveyed (1976-77)

annual estimates. The county councils, therefore, maintain DLO's of such a size as to be sufficient to carry out, effectively, the highways maintenance work and, incidentally, to be adequate to meet the many emergencies that occur, and sufficient to cope with the average work load of improvement schemes. At times when there is a reduction in the average works programme as a result of financial stringency, county councils' DLO's carry out appropriate works for other departments and other public authorities.

Although the continuous cuts in the road maintenance and improvement programme during the period 1975-80 have resulted in a shortage of work, decisions relating either to use a DLO or contractor might not be made in relation to the immediate situation but to the expectations of future volumes of work, i.e. according to the actual needs of the present network assessment, or at least similar to those which have been available in previous years. It would seem to be unwise for the highways authorities to maintain large DLO forces sufficient to carry out all maintenance and large improvement schemes within a county because the work load of the latter usually fluctuates in response to the economic situation (126).

The extent to which DLO's are employed for this type of work depends on the Ministry of Transport and the Department of the Environment. In 1972, the Department of the Environment Circular 90/72 set a limit of £40,000 on the size of job above which DLO's can be successful only by competitive tendering, and undertake works of construction and improvement on trunk roads and other roads on which direct grants were payable. The Department of the Environment

Circular 49/75 raised this limit to £100,000. During the survey it has been explained that some authorities had submitted tenders on the same basis as contractors, following the procedure for tendering prescribed by county council standing orders relating to contracts. The standing orders require that the appropriate committee of the council approve a list of selected tenderers (127). A county surveyor's department could make an application for their DLO to be included in that list. Tenders in the form of priced bills of quantities are submitted and all tenders received are opened at the same time after the closing date (124). Normally, the lowest suitable tender is accepted. Consequently, there appears to be no advantage for the county surveyors' departments over contractors in the process. It was found by the questionnaire that it is, to some extent, up to the highways authorities as a matter of choice, whether to carry out maintenance work by DLO or contract (see Table 4.5).

Table 4.5. Categories of Maintenance Carried Out by Direct Labour and Contractors

Maintenance Categories	Kind of labour	Counties' replies									
		A	B	C	D	E	F	G	H	I	J
Emergency work	Direct	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Contr.									✓	✓
All maintenance routine work except special	Direct	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Contr.		✓		✓					✓	
Cyclic Maintenance	Direct	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Contr.		✓							✓	
Specialised work, white lines, fencing	Direct					✓					
	Contr.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Contr. work, bridge work, traffic signals, cats eyes	Direct										
	Contr.	✓	✓	✓							
Surfacing and surface dressing	Direct		✓					✓	✓		
	Contr.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Other : street lighting, grass cutting	Direct										
	Contr.								✓	✓	✓

Table 4.5 shows a summary of the maintenance works categories and the kinds of labour employed to carry it out in the counties which were surveyed. In the absence of a DLO the maintenance work would be carried out under contract by firms in the private sector. However, the type and amount of maintenance work carried out by DLO's differs, and varies between the different highways authorities. However, there were some criteria that affected those decisions.

4.3.2. The Criteria affecting the decision of choosing between DLO's and contractors

It was found out by the questionnaire that the decision on the amount of maintenance work to be carried out by DLO has various bases. These are :

a) Type of maintenance work ;

b) The availability of DLO in number and necessary skills, and

c) The cost of carrying out the work.

Apart from these, the council's attitude affects the decision but to a lesser extent.

A. Type of maintenance work :

It was argued that the functions of highways maintenance can be divided into three categories, namely

1. Functions which it is not feasible to let out to contract by reason of statutory duty on the highways authority, or due to unpredictable urgency (emergency work)
2. Functions which it is feasible but not practicable to let out to contract because it is known beforehand that contract operators

would be inordinately more expensive than direct labour organisations

3. Functions which it is practicable to let out to contract.

To examine this argument, the counties were asked about the categories of maintenance work which, in their opinion, can only be undertaken effectively or otherwise by direct labour. Their answers are shown in Table 4.6.

Table 4.6. Kinds of Labour undertaking Different Categories of Maintenance Work

Maintenance categories	Reply %		
	DLO	Contract	Total
Category 1 : Emergency work and winter maintenance	80	20*	100
Category 2 : Routine and cyclic maintenance	70	30	100
Category 3 : Specialised maintenance work requiring specialised equipment	30	70	100

* Some counties used contractors jointly with their DLO to deal with emergencies as a result of labour shortage.

1. The results in Table 4.6 show that the majority of the counties surveyed preferred that the emergency work and winter maintenance should be done by their DLO's. They believed that DLO's are the most sensible and practical way to deal with emergency work. They said that in times of emergencies the public expects assistance from county roadmen even though the tasks performed are sometimes outside the statutory duties of highways authorities. They said that the importance of a directly employed labour force readily

available locally can not be over-emphasised, particularly for the emrgency maintenance work duties.

However, the highways authorities are not regarded as emergency organisations, although there were many situations that called for a quick response from them. Besides the emergency work, county councils also undertake, on a rechargeable basis, the reinstatement of trenches which have been excavated in highways for underground services, by statutory undertakers.

2. Routine and cyclic maintenance represent the function suggested in the second category where 70 per cent of the counties surveyed preferred to carry it out by DLO's. There is a belief among them that they can achieve higher and more reliable standards of work with less supervision than is the case where the work is done by outside contractors (121). The majority of the counties said that it would not be practicable to carry out day-to-day maintenance by contract.

Their reasons for that are the difficulties of supervising a private contractor on small, scattered jobs and the close control that is necessary over the quality of materials and workmanship. Moreover, they argue that the additonal cost of such supervision and the cost of using a private contractor who will commonly require high day work rates for the wide range of jobs, need to be taken into account. One of the highways engineers, during the interview, supported this idea ; according to his experience with DLO works, he said that :

"...the degree of control of direct labour works is not so high as that for contract works. In my authority, advantage is often taken to vary schemes when required and change specifications, if necessary, without the issue of a variation order. This gives us the flexibility which is so useful, without further additional costs being made to the scheme."

One of the Metropolitan counties surveyed provided the following information regarding their DLO. They employed approximately 1,550 roadmen ; about 70 of these were employed directly by the county, and the remainder were employed on maintenance works by the district councils acting as agents to the Metropolitan county. The approximate total annual expenditure on road maintenance undertaken by the DLO in this county in 1976 was £10,990,000, and the expenditure on contract work was £3,637,000. (See Table 4.7).

Table 4.7. Approximate Annual Expenditure on Maintenance Work

(at "A" County, February 1976)

Approximate expenditure Direct Labour only		(£)	
Agency	Road maintenance	8,800,000	
	Lighting maintenance	1,700,000	
DoE	Trunk road maintenance	490,000	
	Total	10,990,000	(75 per cent)
Value of contract work		(£)	
Agency	Road maintenance	3,078,000	
	Lighting maintenance	200,000	
DoE	Trunk road maintenance	294,000	
	Lighting maintenance	65,000	
	Total	3,637,000	(25 per cent)
		14,627,000	(100 per cent)

It is noticeable from Table 4.7 that about 75 per cent of the maintenance work is carried out by DLO. As far as improvement schemes are concerned, they said that practices varied across the country in each district council, but in general, DLO's works included minor schemes up to approximately £10,000 although some £50,000 schemes have been carried out by them.

3. Only 30 per cent of the counties agreed to carry out specialised work by direct labour. This kind of work (such as surfacing and surface dressing) represents the third category of work suggested above. There are two extreme cases covered within the counties surveyed.

At one extreme some counties argued that they could compete with contractors, given the specialised equipment and facilities. They argued that they are concerned with seeing that they get value for money. They are trying to get more efficient work and to prove themselves. It was noticeable that the management was a keen supporter of the DLO's of these counties. They try to keep them fully occupied during the year on different maintenance work categories. They argued that it is vital to carry out work by DLO's other than just the routine and cyclic general maintenance, otherwise, such a task, by itself would not be sufficiently attractive in pay or in types of work to recruit the best class of manual worker or supervisor. In addition, it would not provide a proper career for a trainee worker or provide supervisory management with the opportunity of an efficient organisation.

One of the counties which carried out most of the maintenance work by DLO provided this example of direct labour capital improvements including rechargeable work to other departments, as follows (128) :

	Direct	Agent
By direct labour	(78.5%) £3,176,281	(99%) £718,300
By contract	(21.5%) £ 871,383	(1%) £ 8,000
Total	(100%) £4,047,664	(100%)£726,300

Total for the whole county £4,773,964

The practice within this highways authority is that maintenance is carried out by a multi-purpose gang responsible for all general maintenance works within a given area. In other highways authorities there were functional gangs (patching gangs, kerbing gangs, public rights-of-way maintenance gangs, bridge work gangs, etc.). However, decisions have to be made as to the degree of specialisation of groups within the authorities. There was a belief that a fair degree of specialisation is desirable, but not extending beyond the limits where the disadvantages of organisational incentives, skills and training necessary for high productivity and travel difficulties exceed the amount which would have to be paid in travelling and subsistence costs (128).

Some of the highways authorities are in favour of carrying out some major capital works at least once a year. They believe that one or two of these major works taken on each year will provide a good opportunity to train and develop the skills of both road workers and supervisory management. Moreover, it will help to test the efficiency of the organisation in economic terms, and is necessary for high productivity and efficient organisation.

At the other extreme, some other counties argued that even if they had the specialised facilities they could not compete with contractors due to the following reasons :

a) The specialised work ought to be carried out during a certain time only and that will affect the full utilisation of the skilled labour.

b) It is not economic to carry out such activities by DLO's provided with specialised equipment because the rate of utilisation will be much lower than for the contractors ; consequently the counties' plant costs are higher.

c) There are problems associated with obtaining road materials at suitable prices and at suitable times.

Most of the reasons mentioned above resulted because every highways authority used its DLO within its boundaries. However, the researcher believes that to tie a DLO down in the way indicated would lose any advantage gained from the flexibility of the DLO within the authority. There is hope that in the foreseeable future a development could take place to allow any county council to move its DLO freely according to its needs, regardless of the man-made boundaries between the different districts.

It is important for the highways authorities to take into consideration the fact that to be able to carry out the basic work-load and to attract staff and road workers of good skill, it is necessary to provide opportunities for greater job satisfaction, earning power, development and training offered by acrrying out some of the annual programmes of structural maintenance and minor works.

B Availability of direct labour in number and skills

It was found out by the questionnaire that the availability of labour with the necessary skills required to carry out the different aspects of maintenance work represents the decisive basis for the decision on the amount of maintenance work to be done by direct labour. The highways authorities are not free to recruit labour (129). In many counties, the highways labour strength is a fixed figure, there being no reserve of labour to draw upon when required (130). The highways authorities try to manage with the available resources and their attitude is to let direct labour do as much as they can of the maintenance work (131). There are a lot of occasions within the different counties covered by the questionnaire when they invite tenders from contractors to carry out some maintenance work simply because they do not have sufficient manpower to carry out the work. 60 per cent of the counties surveyed said that their DLO size is not sufficient to carry out the required maintenance work. They said that there was no reliable estimate of the scale of DLO required according to the workload of the appropriate functions which it is required to undertake. They stated that there was no estimate of maintenance capacity and the calculation of it, if any, was usually done in the work study sections for bonus scheme purposes. Moreover, they said that there was inadequate measurement of gang performance, and the activities of maintenance had not been adequately identified and measured. They said that this insufficient and poor or inaccurate measurement of work led to an unrealistic or non-existent annual plan or statement of priorities. They said that political and other pressures of different bodies were leading to unforeseen changes in the priorities and nature of works. Consequently, they said that inadequate, inappropriate and changing resources resulted in a lack of commitment to programmes.

In addition, the management expected, with the current economic situation and with the continuous reduction in maintenance budgets, that there would be redundancies in their labour force. Moreover, they argued that there are difficulties in the recruitment of suitable skilled labour - for carrying out specialised work - because of differences in wage rates between local authorities and contractors.

This might be true because 70 per cent of the counties surveyed said that the reason for not carrying out maintenance work by DLO was the shortage of skilled labour.

Despite the importance of training in solving this problem, the questionnaire proved that only 60 per cent of the counties organised training for their workers, either as individual schemes or joint schemes with neighbouring authorities. The rest of the counties where no training programmes had been organised argued that their reasons were :

a) Lack of facilities to provide training for their workers because of cuts in public expenditure.

b) Difficulties associated with the management of training programmes. They said that the administration problems prevented the possibility of gaining any benefits from training.

c) A few counties argued that they did not need training because they employed the roadmen with the skills and abilities needed according to the job specification of the National Joint Council for Local Authorities Services (manual work).

However, the researcher believes that as far as the latter reason is concerned, there is a need for the newly-employed roadmen to be introduced to their new work environment. A knowledge of what the organisation has to offer the roadman, and what the roadman is counted on to give can be achieved by a simple induction course (132). A general induction programme can be aimed at everyone and it has its effect on the morale of the new employee. Furthermore, the highways department's need for training does not end with the initial induction of a new employee, but there will be a need to retrain the existing roadmen.

It is important for the highways authorities to have special programmes directed to individuals or segments of a working group to develop certain abilities which help them to increase the versatility and mobility of their skilled roadmen. The extent of the training programme depends on whether the problem is localised or widespread. Training can be used as a framework and a means to provide the highways authorities with (133) :

1) Roadmen with a wider range of skills (i.e. roadmen with skills in more than one task : patching, kerbing and surface dressing)
2) Roadmen with greater skills
3) Roadmen with new skills to operate new items of equipment and drive vehicles (i.e. roadworkers and plant operators).

Adopting such policies will help the authorities in the employment of its DLO carrying out specialised work by occupying them throughout the year with other work, either in the same division or in another division, taking into consideration transportation costs and difficulties.

C The cost of carrying out maintenance work.

The replies to the questionnaire proved that the cost of carrying out maintenance work is the decisive factor in only 20 per cent of the decisions as to the amount of maintenance work to be done by DLO's.

There is a belief among the highways authorities surveyed that provided they got the skilled labour and equipment, the work could be carried out at cost with no element of profit and with more flexibility. It is expected that they can save money because DLO's do not have to make a profit (134).

This fact obtained by the survey is supported by another study contained in a sample taken from counties in all parts of England and Wales, which indicates a large measure of consistency in the financial savings resulting from the use of DLO's (128). The results obtained revealed that for direct works, tenders have been between 3 and 35 per cent lower than the next lowest tenders. The average savings on these 138 schemes - together costing approximately £20 million - was 16.9 per cent compared with the next lowest tender price.

The above economics achieved by DLO's over contractors have led some Local Authorities to undertake a number of small and medium-sized improvements by DLO. In the previous study concerning the use of direct labour by county highways authorities, the following facts show the use of DLO's (128) :

1. Typically, between 65 and 75 per cent of the works of new constructions are undertaken by contract and only between 25 and 35 per cent by direct labour, subject to the county council's tenders being the lowest.
2. About 50 per cent of the total maintenance and improvement works in a typical county is undertaken by DLO and 50 per cent by contract.
3. For all maintenance purposes, the 47 non-Metropolitan counties in England and Wales employ directly a total of about 27,000 roadmen. Another 5,000 roadmen are engaged on highways work by district councils acting as agents to the non-Metropolitan counties.
4. In the six Metropolitan counties most of the road maintenance and construction work is undertaken by the Metropolitan district

councils as agents of the county councils, and these, taken together, employ about 10,000 roadmen (excluding the Greater London Council).

5. Although the duties of the roadmen are interchangeable between maintenance works and improvement works, it is estimated that about 7,000 of the 27,000 roadmen in non-Metropolitan counties are normally engaged on improvement works.

6. The approximate total annual expenditure on road maintenance undertaken by DLO's in non-Metropolitan counties is £150 million and the expenditure on maintenance work undertaken by contract in those counties is £11 million. In the non-Metropolitan counties, DLO's are responsible for carrying out annually, improvement schemes of a total cost of about £45 million. In addition, work to the value of about £7 million is carried out on behalf of other departments of the county councils and other public authorities.

However, there is an argument advanced by contractors that they are unfairly put at a disadvantage when in competition with DLO's because the price bid by a DLO for a given job is less than the relevant cost to the highways authority (124, 135). Part 3 of this thesis is devoted to examining the costing system within the highways maintenance departments. The next section will be devoted to examining the management systems of highways authorities in order to determine their efficiency in carrying out maintenance work.

4.4. The Management System of Highways Authorities

This section is devoted to an examination of the highways management system, and a questioning of the practice of the highways' management methods of work in order to seek improvements. The main aim is to attain the objectives of providing work planning and control information that could be understood and used by all involved from senior management to the foremen on site. It should be clear that accomplishing planning for maintenance work is not regarded as a formal procedure, but rather requires a basic approach that can be tailored to suit individual highways authorities. This might be true because the more accurate the planning information is, the stronger will be the justification of the overall maintenance budget. In the meantime, if the information is incorrect it will lead to dissatisfaction or abuse of the results.

However, most of the counties covered by the survey said that they had to plan their work according to the amount of money available and not according to the needs arising from the actual conditions of their roads. They argued that they could not, in the existing economic situation, forecast their future needs or plan ahead beyond five years. This situation had arisen because there was no certainty about the level of funds, with everything likely to change suddenly, as in November 1976 when the government decided to cut its share of Local Government spending.

Most of the counties covered by the survey claimed that restraints on expenditure seemed, in many cases, to prevent maintenance policy from being sufficiently forward-looking. Table 4.8 shows their replies.

Table 4.8. Forecasting and Planning the Future Needs

Aspect \ Reply	Yes %	No (%)
Has adequate time been alotted by those concerned in respect of forward planning and ways of meeting objectives ?	40	60
Are forecasts established to reflect future needs ?	20	80

The situation stems from the financial system under which those responsible for maintenance have had to operate, such that insufficient regard has been paid to the importance of planned maintenance over a period, in order to provide consistent standards of road conditions (136).

Although the management of the highways authorities consider the lack of funds as an excuse for not planning maintenance work, the researcher believes that it should be the reason for urgent planning. It is believed that if the financial resources of maintenance work, translated into terms of material, equipment and labour, are limited, it must accordingly be allocated effectively.

The management might allocate the resource and use it in the most effective way through :

1) Planning and programming the maintenance work as objectively as possible, thus enabling long-term budgeting to be adopted.
2) Rational choice of priorities between different roads or maintenance activities (optimisation of product) in order to establish the most economic way of carrying out a given activity.
3) Control of the actual work by measuring, and comparison with

planned work, and correcting where necessary in order to activate a maximum rate of productivity.

4.4.1. Planning and programming maintenance work

This important step involves estimating the amount which should be spent on maintaining the roads (137). The sources of money for the roads come from the rate support grant and the rates (138). The counties have to submit a "Transportation Policy Programme" (TPP) and from this plan the government will allocate the amount of grants. The questionnaire proved that many counties' managements are fully aware of the financial procedures. They claim that they are under constraint from central government which decides on the amount and level of expenditure and determines the nature, scope, quality and direction of the principal local services (139). It settles for each year the amount which it considers each Local Authority should spend in aggregate, and has ways of influencing their actions to keep them within the imposed limits (140).

After determining the annual funds available for each authority to spend on maintaining its network, it determining the way these funds should be spent by allocating them according to a priority list of sites for treatment.

It was found by the questionnaire that engineers have difficulty in justifying the amount of funds they needed to spend each year to maintain the highways in a suitable condition. In other words, the output is mainly services to the public which are difficult to measure in money terms (125). They said that the factors making up the final output are hard to identify and even harder to quantify. This weakness was apparent in the presentation of the information within the budgets. They said that in the actual situation, the funds were provided on the basis of cost per unit distance, per class of road, updated annually on the historical cost of the previous year. The management of highways authorities said that it is the budget which determines the programme of maintenance work and not meeting the community needs. They have to adopt short term treatments for the highways where a long-term treatment is needed. In some counties the engineers candidly explained the actual situation which is that they have to do some patching treatment to roads where, in fact, resurfacing treatment is needed*. They explained that for a road defect to be patched frequently indicates a basic deterioration in the highway structure. This situation will eventually require more extensive and expensive treatment, and is likely to be uneconomic in the long term.

In another county, the highway engineer explained that he coped with the cuts in the maintenance fund available by reducing the standard of the cyclic maintenance (i.e. by reducing the frequency of grass cutting, gully emptying, etc.) It was realised that the information required to provide work schedules for cyclic maintenance

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* During one of the applications of the Method Productivity Delay Model to a reinstatement operation carried out by the researcher concerned with this thesis, the pavement was seen to be in a very bad condition. By explaining what had been noticed to the highway engineer, he said he was aware of the poor condition of the road but that he had no money to resurface it at the moment. He said that they were carrying out the reinstatement on behalf of the gas authority, although it might be cheaper for them to resurface it now instead of returning in three months time to repair it again. On the same afternoon, while the maintenance gang were carrying out their work, one of the adjoining households quarrelled with the roadmen. It was claimed that they were wasting the ratepayers' money by doing an unsatisfactory job. He said he knew that they would come again in a short time to do the other patching although the pavement obviously needed resurfacing. Another example, in another district, given to the researcher concerned a surface operation to part of a road which took half a day to be ... after the completion of the work some holes ... and 6 men to fill them in.

was, to some extent, inadequate.

The analysis of the results obtained by the questionnaire revealed that it is difficult to say with complete confidence whether or not the work allocated was within the capacity of the men and plant allotted to the task.

Theoretically, there are three common techniques which can be used for the work-load assessment (126) :

(i) The labour factor method

(ii) The work output method

(iii) The work value content method.

Most of the counties covered by the survey said that they adopt the labour factor method in assessing the work-load. This method uses the average gross cost of employing a man for a unit of time and allows for plant, materials and other costs. They agreed that the work output method is considered to be more accurate, but it requires detailed bills of quantities to be prepared.

The practice is different in some other counties where they adopted the work value content method. This method is a development of the work value method and is based upon the use of work study values. They said that they adopted the work value method because it can allow for variations in performance of groups of workmen. One of the counties which applied this method gave the following example of how the computer calculated the total cyclic maintenance requirements of a work unit, area and county in the following way :

$$\frac{\text{... standard minute value}}{60} = \text{standard hours}$$

b) Standard hours x effective performance factor of the gang x th annual frequency = clock hours of work per annum.

Effective performance factor = $\frac{\text{Productive work completed(inPHSs)x}}{\text{Time taken (in clock hours)}}$

c) $\frac{\text{Clock hours per annum}}{\text{Availability(basic 40hr week)}} \times 3 \times 47 =$ number of gangs per cou required per annum

d) Annual cost per gang x number of gangs = costed works programme

It seems that this method, being more directly linked to bonus systems, is useful where a fully integrated work programme, pay, bonu and fiancial control system is used. As for determining work loading, the particular skills or other requirements of labour together with notes on any particular item of plant or equipment should be listed so that the specific needs of the individual job are fully described. Appendix 4.2 illustrates an example provided by one of the highways authorities covered by the survey, of programmed maintenance work.

The point which needs to be emphasised is that the annual programme must always be the key to good, overall allocation of resources It is important that the annual work programme covers all work in each division and allows the following factors to be taken into account in order not to restrict the work flow. These are :

- weather conditions
- availability of suitable gangs with regard to both work-load and location
- political or structural priorities
- design needs
- public utility involvement

The analysis of the results obtained by the questionnaire revealed that at the majority of the authorities covered by the survey there were no programmes for individual jobs. They argued that it might lead to undue complexity in their work. But the res cher believes that preparing such programmes should help to smoot their work. For many simple jobs, all that is required is the pre aration of simple forms showing the resources required and the du ations. For major work or more complex jobs, a simple bar chart sh ing work stage, resources and durations may be adequate. In additi any immediate works programme can be prepared when the work starts This "future work programme" can be prepared by supervisors. Figur 4.2. illustrates an example of using a bar chart within one of the highways authorities surveyed. The information within this program needs to be in sufficient detail to give clear instructions on wha work that gang is required to do and what plant and materials are required, plus an indication of the expected daily output. This sh help management to recognise the available skills and reveal where additional training for specific tasks would be beneficial. Progre ing may be by endorsement or by drawing in date lines which follow the work achievement.

The researcher indicates that the highways authorities might be able to obtain more accurate information about planning the work-lo by adopting network analysis techniques for planning their work*. The information expected to be obtained by adopting such techniques

* It was planned originally to cover the technique of network analysis within this thesis in order to complete the recommendatior but it has been covered through another PhD thesis by A. El Harc with the same supervisory team. Therefore the researcher prefers use it as a source for more information to those who believe the can get benefits from its applications. (See El Harouni, Budgeti Budgeting Control and Management Information in the Highways Departments, PhD thesis, University of Aston in Birmingham, Septemb 1975.)

COUNTY SURVEYOR'S DEPARTMENT
PROGRAMME AND PROGRESS CHART

LEGEND

PROGRAMME & % COMPLETION — 40% — TARGET

TIME LINE — WEEK INDICATOR

DIVISION 'C'
PERIOD 1st APRIL TO 22nd JUNE
SHEET No. 1

Annual Estimate No.	Road No.	Location	Job Description	Est. £	Foreman	Week Ending 6/4 Week No. 1	13/4 2	20/4 3	27/4 4	4/5 5	11/5 6	18/5 7	25/5 8	1/6 9	8/6 10	15/6 11	22/6 12	
						M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F	M T W T F
		Various	Maintenance Patching	300	Kimber													
30355	III	Narrow A	Shaping of Carriageway by Resurfacing Machine	536	"													
30157	A284	Townville B	Renewal of Kerbline and Resurfacing of Footway	1226	"													
30154	A29	Whitetown C	Resurfacing of Footway	270	"													
30161	A2024	Whitetown D	Renewal of Kerbline and Resurfacing of Footway	2828	"													
34290	B2178	Narrow E	Renewal of Bus Lay-By	400	Doncaster													
30654	A27	By-Pass F	Renewal of Joints in Concrete Carriageway	500	Leaning													
		Various G	Maintenance of Rural Footways	3500	Palmer													⁂

NOTES

⁂ WORKS TO BE CONTINUED

Figure 4.2.

Programme and Progress Chart

should help management to ensure that they can carry out maintenance work to the following requirements (141) :

- sufficient capacity to do the work
- sufficient capability to do the work
- sufficient flexibility to keep DLO's fully utilised and ensure a continuous flow of work throughout the year
- keeping the total operational costs of completed work to a practical minimum
- control of the work by highlighting the bottleneck situation where decisions have to be taken to keep any organisational problems within bounds.

4.4.2. Rational choice of priorities

It might be expected that the more systematic and objective the method employed is for planning a maintenance programme, the greater the probability that preventive action will be taken in time to arrest progressive deterioration in any section length of the highways network (142).

The Marshall Report recommends the use of a maintenance rating system. The main aims and uses of a maintenance rating system are (142) :

a) To provide a simple and factual means of evaluating the maintenance needs of the road system to simplify the programming of maintenance work.
b) To provide an objective assessment to ensure a clear priority of works.
c) To relieve political pressures or considerations.

d) To ensure that the money available is properly allocated to those areas of greatest need.

e) To indicate when deterioration has reached such a level that remedial action is needed.

There were two rating assessment systems for allocating the funds of highways maintenance works (142, 143) :

1. MARCH - Maintenance Assessment Rating and Costing of Highways - which was developed by the City Engineer Group, and
2. CHART - Computerised Highways Assessment of Rating and Treatment - which was developed by the Transport and Road Research Laboratory in conjunction with various highways authorities.

Both of these techniques enabled roads to be graded according to the degree by which they fall short of safety standards, etc.,"marks" or "points" being given for the various features. These gradings were weighted according to the roads classification and the volume of traffic. The inspection system should identify those stretches of the highways network at which deterioration has reached, or passed the critical level, and where alternative forms of treatment may be justified. Consequently, the computer print-out of these rating systems determines the priority of project to be carried out according to the actual needs*. So it helps, when rationalising spending on maintenance , to point out the best use of limited finance. To achieve the best results with either of these systems, the highways authority needs to computerise its system and adopt pre-determined

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* A complete manual for MARCH and CHART is available for those authorities who wish to apply either of these systems.

quality standards in order to compare the results obtained by these rating systems. Although adopting any of these systems will help in determining the priority of maintenance in an objective way, only 40 per cent of the authorities covered by the survey adopted either MARCH or CHART (see Table 4.9).

Table 4.9. Adopted rating systems

Rating systems \ Reply	Yes (%)
MARCH	20
CHART	20
Others	30
Not adopting	30
Total	100

About 30 per cent of the authorities covered by the questionnaire said that they had developed their own system to assess road conditions and determine the needs of the different maintenance activities. Their main reason for not adopting MARCH or CHART was the lack of money and staff to operate these systems. However, they said that they hoped to adopt one of them after they had the required facilities.

On the other hand, 30 per cent of the highways authorities said that they assessed the needs of maintenance by personal observation and depended on their experience to determine the priority of the maintenance work to be carried out. They seemed quite satisfied with their own systems and the results they obtained and said that there was no need to adopt any other system.

However, the researcher believes that there should be a quantitative method adopted for deciding on the need for maintenance and the allocation of resources. The availability of such information provided by the rating system would help in controlling the maintenance programme and ensure that only necessary work is done. Furthermore it should guarantee that the work is accomplished in the most effective way. Unless the management of the highways maintenance department can measure the objective of its activities, its course of action will be unsatisfactory. The management needs to introduce the establishment and measurement of maintenance quantitatively (144). However, the accomplishment of a given quantity of maintenance work may not be indicative of the level of quality achieved.

4.4.3. Control of the work by comparison and measurement of the planning work

If the management of the highways maintenance authorities are to have full control of maintenance programmes, they must be able to define and measure quality as well as quantity. Therefore the management should set the standards which indicate the means necessary for carrying out a given task, and provide rules of action depending on the conditions (measurement and visual assessment) which should provide a uniform level of maintenance service throughout the highways network. To ensure this, a good management system should incorporate the flexibility to respond in an effective way to the different types of standards listed below (103) :

a) Quality standards for defining a level of quality below which the various characteristics of roads should not fall, thus ensuring that the user is provided with a level of service that is satisfactory both from the technical and economic points of view.

b) Quantity standards that define quantitatively the resources necessary, on average, to achieve the required level of service.

c) Performance (productivity) standards which define, for each basic activity, the working method and personnel needed as well as the usual productivity rate expected under normal conditions.

Although the management of highways departments seems fully aware of the benefits derived from having standards, only 70 per cent of the highways authorities had set up standards. The highways authorities who adopted no standard times argued that the main reason for this was the unavailability of money. They argued that it could take a lot of money and time to set standards which are tailored to local circumstances. They said that there was no point in adopting any standard with the continuous cuts in expenditure, as budgets determine what proportion of the standards should be adopted. From those who said they have standards, only 40 per cent had adopted the Marshall standards. These standards were suggested by the Marshall Committee as national standard times for individual maintenance operations which could be compared with local actual times to serve in the interim. The remaining 30 per cent of the counties had set up their own standards. Their main reason for doing this was that the Marshall standards gave them only a broad indication of the overall picture. They said that the work content of what is apparently the same operation varies greatly between authorities. Therefore, they argue that adopting such standards might be expected to give inadequate and unrealistic results. There was a belief among them that in most of the cases the Marshall standards are unachievable and need to be reset according to the nature of the job and the factors which affect it. They doubted the possibility of having a national standard because of the different circumstances which vary between the different authorities according to :

1. Metropolitan or non-Metropolitan county
2. Rural or urban areas
3. Small or large county
4. Method of carrying out the maintenance work
5. Materials used and means of supply and storage
6. Skill and experience of the labour force
7. Scope and availability of adequate tools and equipment, also adequacy of the maintenance of this equipment
8. Its management system
9. The organisation structure
10. The working environment.

However, the researcher believes that it is important to have national standards for most of the maintenance activities for the purpose of making comparisons between the different authorities. It may, perhaps, be possible to extrapolate efficiencies of authorities based on these key activities and thus enable inefficient authorities to be located. There are some facts which require to be considered in establishing the national standards. These are :

1. The main factor to consider is the accuracy and realism of a standard. Nationalisation of a standard time must be made only after serious study of the relevant operations over a period of time.
2. It is not just a matter of breaking down the work into elements and estimating the time. It must be appreciated that the time required to do an operation might differ if the same operation

is performed in different circumstances.

3. Another main factor to be considered depends on the environment surrounding the performance . For example, relaxation requirement, work rates, repeatability of the actual work, materials to be used, tools, the ground conditions and the weather conditions.
4. It is important to consider the capability of the average, motivated man to do the operation and relate this to the quality of the supervision.

In order to relate the standard times to the condition on which they are based, an adequate work specification must be prepared for each job (109). In addition, a detailed description of the method by, and the conditions under which the work is to be performed is needed. These details should include a layout of the work place and particulars of the machines, tools, appliances, materials and services used. Reference should be made to the duties and responsibilities of the worker while doing the work involved (105).

However, in the highways maintenance authorities surveyed, there were no adequate schemes for job specification. Although the majority of the highways authorities' management said that they have a scheme of job specification as shown in Table 4.10, it was only a scheme for staff and not for roadmen.

Table 4.10. Job Specification Scheme Within Highways Authorities

Aspect \ Reply	Yes (%)
Is there operating within the highways maintenance dept. a scheme for job soecification?	90

Moreover, 70 per cent of the authorities argued that there is no need to adopt such a scheme of job specification for the roadmen for the following reasons :

1. The roadmen are tied to work specifications on the national scale and are paid according to national grade conditions.
2. Adopting such a scheme will tie every worker within certain defined duties and that might increase problems with the unions.

Even in authorities which kept some records, it was either not available or very broad and without useful details. This information was needed to be filed for record purposes so that the effects of any changes in the way of doing the job can be determined and the work content and standard time amended accordingly. One purpose of having this information, therefore, is to provide the highways authorities' management with a means of checking to what extent the values it records may be used elsewhere. The conditions under which standard times are set may bear a close resemblance to those under which a similar operation is being performed in a different location.

It should be recognised that standards are to be considered as references for guidance and not only as objectives to be attained. Consequently, the management, acting on the information obtained, by comparing the road conditions with the standards, will be able to establish work programmes and to estimate the funds needed to carry out its activities and to accomplish its objectives. The management of the highways authorities should be aware of the ways of interpreting the meaning of the information obtained, and should use it in the framework of an overall strategy. In other words, the management should be able to use it not only for control purposes, but also to set objectives, appraise progress and evaluate performance (141). In the meantime, by measuring performance it will ensure that the work is accomplished in the most effective way (111). Therefore, there is a need for the management of the highways departments to adopt a refined technique of efficientcy evaluation in which facts replace "guesstimates" and the evaluation reveals the facts and explains the reasons behind them (63).

However, the management within the highways maintenance departments argued that measuring productivity is considered to be a very difficult task. They said that measuring productivity for maintenance work suffered not only from the problems of measurement generally recognised (examples of these problems will be discussed in Chapter 7), but also with problems relating to the type and nature of their work. They claimed that they have the following problems :

1. The main problem in measuring productivity is that of measuring the final output because of variations in the amount of work required to produce a unit of output. Besides, the output of maintenance work is related to several factors which are difficult to quantify.
2. They argue that the input factors are difficult to determine completely because of the uncontrolled environment. They said that they were carrying out their maintenance work under changeable and undesirable environments which affected the optimal working conditions and consequently influenced productivity.
3. They said that "the process of calculating productivity is extremely complex". This attitude might have resulted from the fact that they were unfamiliar with concept of productivity. They appear to lack the knowledge of the ways to measure productivity

and do not appreciate its usefulness. This difficulty led to the next problem.

4. The management of highways departments in some authorities believed that using productivity measurement was inappropriate in their application to maintenance work. They believed that the cost of implementing productivity measurement might exceed its benefits.
5. In some authorities, while the management are fully aware that their DLOs' productivity is lower than the contractor, thus resulting in higher costs, they had reservations as to whether the problem could be solved. Their answer was, "We have to live with it".

But the researcher believes that if something exists or is done in a traditional way, there is no reason to suppose that it must continue in that form, or even continue at all. The researcher believes that the attitude of the management has to be changed and they have to find ways to measure their productivity in a purposeful way, because the inadequacy of the measurement used will have a gap in the amount and kind of information available to them. By measuring the efficiency of using different resources available for maintenance work, the management could discover any possibilities for improving its productivity. The information provided by measurement highlights the main area of wastage or undesirable results which need corrective action from the management.

CONCLUSIONS

This chapter highlights the importance of highways maintenance activities which aim to keep the road network in such a suitable condition as to fulfill the purpose of roads to their users.

The majority of authorities covered by the questionnaire considered the shortage of funds for maintenance work to be a very serious problem which affected their work. Moreover, they considered this problem to be the main reason for not adopting the appropriate management systems. However, the analysis of the results obtained by the survey reveals that the highways maintenance authorities suffer from some disadvantages which have resulted from the lack of adopting the management techniques necessary for planning, measuring and controlling maintenance activities.

It was found by the questionnaire that there were :

- no clearly defined measurable objectives for their activities ;
- no adequate long-term plans for maintenance work, different classification of maintenance work, and
- no national standards employed for judging the maintenance activities,

The absence of these procedures makes the task of planning and controlling the work complex. In addition, the highways authorities' managements argue that the task of measuring productivity of maintenance work is considered to be very difficult and complex because of the nature of maintenance activities.

The Local Authorities have the responsibility to maintain the roads within their individual boundaries. To carry out this responsibility, each authority has to choose between its own work force and private contractors. There was a belief that it would be convenient and practicable for each highway authority to establish a DLO to carry out the day-to-day routine work and consider its existence very essential in dealing with emergencies. They believed that besides the facility to deal with emergencies, DLO's also offer the desirable combination of lower cost, good level of service and a reasonable standard of workmanship. In addition there is the possibility for DLO's to compete for specialised maintenance work (like surfacing and surface dreassing) provided they are more economic, skilled and efficient.

Therefore, the researcher beives that if the management of highways authorities hopes to improve the utilisation of its DLO as a resource, they should try to answer the question of how they could become more efficient. The management can support the use of DLO versus contractors if there is information available proving that they are providing a better service at a lower cost. Among the tools available to management to help in the decision of comparison between DLO and contractors are the costing systems and productivity measurement techniques. Part III will be devoted to an examination of the costing system of the highways authorities in order to evaluate its suitability and felxibility in helping the management in rationalising its decision regarding the utilisation of DLO's.

PART 3

THE PRINCIPLE OF COST COMPARISON BETWEEN DIRECT LABOUR ORGANISATIONS AND CONTRACTORS

Chapter 5

The Costing System within the Highways Maintenance Departments

Introduction

This chapter describes the costing systems operating within the highways maintenance departments. It explains the basis for estimating the cost of Direct Labour Organisation.

It also highlights how decisions about the cost of maintenance work have been taken.

5.1. The Costing System Operating within the Highways Maintenance Departments

The objective of Local Authority accounting is to provide the information needed to ensure (56) :

- showing how the Local Authority has used the funds provided from rates and grants
- a means of achieving the efficient use of Local Authority resources
- an unbiased and informal basis for decision-making and control purposes
- compliance with statutory requirements, so that they can provide data for central government about their activities.

It is vital to devise and implement a sound accounting system for highways maintenance (96). In addition, the preparation of costing data for several purposes has great value as an aid to management of highways maintenance departments.

The costing of highways maintenance is under the direct control of the County Surveyor, subject to the control exercised by the County Treasurer through the financial controller and his internal audit office (145). The costing systems for a highways department have to be sufficiently flexible to meet all the demands upon them from varied sources and for different purposes (105). Apart from the normal internal statements, reports, costs and statistics are required for committees, government, council members and professional bodies.

The costing system has to conform to any relevant Standing Orders or regulations of the Finance Committee, Statutory Provisions and Ministry of Transport circulars. The results of the section fall under three headings (146) :

1. The preparation of the Ministry of Transport grant claims
2. The preparation of data to complete the council's Abstract of Accounts
3. The preparation of cost statements, reports and statistics for internal use in the department.

So the form of cost accounts is very important if they are to provide the information required for the county council accounts, the Ministry of Transport accounts, and the basic management control accounts without any duplication of effort.

The majority of highways authorities believe that it is necessary to adopt the total costing technique because different groups have to bear the total cost of the work done by highways maintenance. They maintain that the cost which ought to be charged cannot be achieved without incurring both direct and indirect costs, and that total costing technique will ensure a fair price being quoted when pricing any job for comparison with a contractor's price. According to this technique the costs charged to DLO's are those directly incurred, plus apportioned overheads. It was found from the questionnaire that most of the counties divided their cost elements according to direct and indirect costs as shown in the following table.

Table 5.1. Cost Elements

Basis of cost element	Reply %
Direct and indirect	70
Variable and fixed	-
Other*	30
Total	100

* Some of the counties divided the cost elements as follows :

(i) Divided the cost of the total bulk of the job between labour, materials and plant.

(ii) Divided the cost of the total bulk 50 per cent for labour and 50 per cent for materials and plant.

The units of cost include the element of direct materials, direct labour, plant, site haulage, use of tools and a fair proportion of normal overhead expenses.

The total cost of a unit consists of the cost of the material that actually becomes part of the cost unit, the wages paid to labour for the time they are working on the direct materials, expenses incurred specifically on behalf of the cost unit, a share of overheads incurred in production, and of the administration overheads which are incurred in managing the department.

The main method of classifying highways expenditure adopted by Local Authorities are according to a) routes, b) types of road construction and c) class of service combined with job number. Figure 5.1. represents the method of classifying the highways expenditure according to the type of maintenance work, combined with job number. The expenditure is broken down into more detailed figures analysed into the elements of cost (labour, materials, plant and contracts).

Table 5.2. represents the classification of expenditure according to the type of road and class of services (again from one of the Metropolitan counties covered by the questionnaire).

The control of expenditure by means of budgets has always been a feature of highways authority accounting. The budget must interpret the policy of the Highways Committee and serve as the main instrument for planning and controlling the work. All of the counties surveyed stated that they have a budget control system.

In each highways committee, the County Surveyor, County Treasurer, Assistant County Surveyor and Divisional Surveyor produce the budget estimate of the next years expenditure. The preparation of the annual estimate represents the most important administrative job falling on a County Surveyor during the year.

The estimated budget should be as accurate as possible to avoid over-expenditure which would be unfavourable to the Finance Committee (146). It is of equal importance that it should avoid under-expenditure which would not please the Highways Committee when the need for maintenance arose. In spite of this, the information available in the department for estimating is obsolete in enabling estimates

Periodic Expenditure Summary Report (Principal roads) (Maintenance)

"H" County, County Surveyor's Dept.
Work management system

Date : 14 April
Periodic Weeks: 49 & 50
Report for Work Unit 3
Year : 1974/75

EXPENDITURE TO DATE

Code	Description	Total in period	From Week 01 through to Week 50				
			Labour	Plant	Material	Contract	Total
	Elements	0-9	0	3&4	6&7	5&8	0-9
005	Surface treatment (flexible surfaces)	0	2	0	80	0	81
009	Patching (flexible surfaces)	77	398	771	318	0	1488
011	Patching(concrete roads)	0	0	0	0	323	323
015	Sea defences	0	0	15	0	0	15
016	Embankments and cuttings	0	9	0	0	0	9
017	Grass cutting and siding	88	755	2008	5	156	2923
019	Grass cutting and siding by tractor	0	0	571	0	0	571
019	Grass cutting and siding	0	0	56	0	0	56
021	Hedge cutting	0	34	0	0	0	34
024	Verge repairs	123	170	165	0	0	335
025	Trees and shrubs	18	179	166	0	426	770
027	Fences	0	8	21	0	0	31
029	Kerbing	56	48	102	18	0	169
031	Footways	177	962	645	205	0	1827
035	Pedestrian crossings	0	0	29	0	0	29
036	Pedestrian crossings	73	0	0	0	0	359
037	Road markings	0	19	3	2	0	24
038	Road markings as above by contract	55	0	55	0	833	988
040	Road studs installed by contractor	0	0	0	109	0	109
041	Guard rails	14	78	61	35	0	195
043	Traffic signals	0	11	0	0	0	75
044	Traffic signals	27	0	0	0	60	719
045	Traffic signs - excl. illumination	13	861	461	799	0	2066
046	New signs - safety	3	32	12	272	0	316
049	Illumination of traffic signs	164	0	0	0	0	264
050	Traffic signs	25	52	24	0	0	76
051	Surface water drainage	132	1529	702	496	72	2807
053	Winter precautions	0	14	2	0	0	16
055	Winter precautions	174	636	1216	256	0	2117
057	Snow clearing	0	3	12	0	0	15
059	Gully emptying	0	157	56	0	0	213
060	Gully emptying by gully emptier	77	0	413	0	0	413
061	Sweeping, cleansing and watering	111	3639	505	6	0	4159
062	Sweeping and cleansing by suction sweeper	50	10	3007	0	0	3018
063	Scavenging	189	2341	375	0	0	2716
064	Scavenging	0	0	10	0	0	10
066	Litter	0	94	0	0	0	94
068	Vandalism	14-	46	24	18	12	85
071	Miscellaneous works - explain use to H.O.	0	0	9	0	0	9
074	Footway-to be used only by special mainten.	0	52	30	0	0	82
	TOTAL ORDINARY MAINTENANCE	1631	12138	11527	2539	1901	29425
	ESTIMATE OF EXPENDITURE 28,250						
081	Street lighting maintenance (current)	0	0	0	0	0	1490
082	Renewals by boards	920	0	0	1838	482	2524
083	Renewals	648	0	0	0	0	692

Figure 5.1.

Periodic Expenditure Summary Report

Table 5.2. Summary of Expenditure of Highways Maintenance ("A" County)

(excluding MARCH program) Week 44 February 1977

	Central (£)	North (£)	East (£)	West (£)	South (£)	X (£)
Carriageways						
Patching flexible roads	19,236.71	13,495.32	17,241.48	19,957.08	17,442.87	23,565.30
Patching concrete roads	1,383.54	350.49	1,911.05	1,784.21	954.84	CR 27.36
Resurfacing	8,929.32	8,654.82	4,421.51 CR	2,658.71	12,242.02	18,921.30
Special Treatments	3,046.18	2,917.40	3,233.55	4,399.68	12,223.91	300.00
Retaining walls	352.97	-	249.54	-	4.37	-
Footways						
Resurfacing -asphalt	21.92	4,285.44	20.16	-	-	852.47
Resurfacing -bricks	59.62	-	0.47	-	-	-
Resurfacing -tarmac	591.79	CR321.43	-	6,825.82	2,539.29	6,607.65
Resurfacing -flags	504.00	-	CR1,544.25	25.78	-	320.76
Repairs -bricks	112.65	285.88	46.82	41.95	772.72	-
Repairs -asphalt	1,037.94	486.99	646.79	33.64	CR1,484.49	4,709.14
Repairs -flags	36,232.58	49,854.39	17,533.01	38,476.11	33,610.48	12,619.58
Repairs -tarmac	20,372.15	21,300.34	28,203.59	29,272.90	21,528.49	30,359.56
Kerbing repairs	2,122.69	1,507.43	2,636.17	2,607.48	1,044.03	5,861.59
Realignment	1,509.45	2,079.83	316.65	485.71	655.77	-
ACTUAL EXPENDITURE	95,513.51	104,896.90	66,073.52	106,569.07	101,534.30	104,089.99
Annual Expenditure	104,000.00	104,000.00	104,000.00	104,000.00	104,000.00	104,000.00
Budget at Week 44	90,000.00	90,000.00	90,000.00	90,000.00	90,000.00	90,000.00

for proposed work to be accurately determined from the existing records. This information is based on historical data and does not rely on physical standards in building the budget. As the questionnaire showed, 70 per cent of the counties surveyed used historical estimated figures in preparing the budget (see Table 5.3.).

Table 5.3. Basis of Preparing the Budget

Basis of preparing the budget	Reply %
Standard Unit Rate	30
Historical Unit Rate	70
Total	100

In addition, the information available in the department for estimating is insufficient as the department did not estimate the detailed expenditure of every job except for large improvement operations. 80 per cent of the counties covered by the survey stated that they do not prepare an estimate for every operation within the job. Only if it is a big job is an estimate made of the total heading of expenditure. In other cases of specific work, the estimates are built up by using unit cost rates and relevant data compiled from past experience. However, it was found that item coverage and unit rates varied greatly from one division to another across the county, as the preparation of estimates was left to the individual engineer or technician.

The practice in one county is to depend on a form devised as a standard estimate comprising about 250 different items grouped in the same way as a bill of quantities. (Table 5.4. shows the estimated unit rates used in this county).

Although one of the first questions to be asked when works are being considered is "How much will it cost ?", and the answer to that question will determine whether or not the work will be carried out, it was found by the questionnaire that in only 30 per cent of the counties has the estimated cost of work to be carried out by DLO's been prepared.

The next section is therefore set up to consider and examine examples of the cost system within highways authorities, to determine its suitability to calculate the cost of work carried out by direct labour organisations so as to ensure, as far as possible that costs are related to similar work being carried out by private contractors.

Table 5.4. "E30" Unit Rate

"H" County Council
County Surveyor's Department

7. January 1975
(p.7)

Item code	Description of job	Units	Unit Rate	Unit Material cost	Unit Plant cost	Unit Labour cost
608B	Adjust levels of surface box stop cocks	Number	3.61	1.04(29)	0.62(17)	1.95(54)
608C	Adjust levels of surface box valve cover	Number	5.49	1.63(30)	0.93(17)	2.93(53)
608D	Adjust levels of surface box gully	Number	9.99	3.25(33)	0.93(9)	5.82(58)
608E	Adjust levels of surface box light duty manhole	Number	6.83	0.85(13)	0.82(12)	5.15(75)
608F	Adjust levels of surface box med. duty manhole	Number	12.54	3.41(27)	2.67(21)	6.46(52)
609A	Bituminous spray tack coat	MSQ	0.19	0.06(29)	0.09(46)	0.05(26)
640A	Haunch c/way (will cover 2.5m road widening)	MSQ	4.43	2.92(66)	0.92(21)	0.60(13)
701A	EO excavation for kerbing	Metres	1.11 } 3.81	0.0 (0)	1.11(100)	0.0 (0)
701B	Kerbing lay on sub base ready mix	Metres	2.70 }	1.31(19)	0.37(14)	1.02(38)
701C	Kerbing lay on sub base site mix	Metres	3.17	1.30(41)	0.49(15)	1.38(43)
701D	Lay granite setts at 45° as kerbing (splay)	Metres	3.35 } 4.54	1.83(50)	0.13(4)	1.69(46)
701E	EO for excavation in hard surface (setts)	Metres	0.89 }	0.0 (0)	0.62(70)	0.27(30)
702A	Channel ready mix	Metres	2.58	1.50(58)	0.29(11)	0.80(31)
703A	Footway edging concrete	Lin M	0.91	0.35(39)	0.09(10)	0.47(52)
703B	Footway edging wood	Lin M	0.47	0.30(64)	0.0 (0)	0.17(36)
750A	PC paving slabs	MSQ	4.37	1.82(42)	1.24(28)	1.30(30)
751A	Flexible footway base	MSQ	0.92	0.64(69)	0.02(3)	0.26(28)
752A	Flexible footway base course wearing course (asphalt)	MSQ	0.85	0.53(62)	0.11(13)	0.21(25)
754A	Vehicle crossing heavy duty } covers complete	MSQ	15.95	8.09(51)	3.27(21)	4.60(29)
754B	Vehicle crossing normal } construction	MSQ	7.00	3.79(54)	1.72(25)	1.49(21)

5.2. The Basis of Estimating the Cost of Direct Labour Organisation Work

Recently, it became a requirement of the Department of Transportation that works costing more than £100,000 can be undertaken by DLO only after success in open competition with contractors (124). The highways authorities frame their tender list for the new job from firms who have already satisfactorily completed contracts for them without exorbitant claims. Some counties drew up an ad hoc list after advertisement or direct approach, but subsequently restricted the list to a certain limited number (100). This method has the advantage of both simplifying the routine work and providing a better balance of selection than if it were made from a purely local list. Both DLO's and private contractors tender for the jobs and the one with the lowest price (providing it has satisfied the other conditions) will win that tender.

Contractors and those who are hostile to direct labour argue that the price bid by direct labour organisations for a given job is less than the true cost to the highways authority. They are suspicious that the accounts for direct labour works are not kept on a sufficiently accurate basis and that the management and financial control of the works are less strict than for contract works. The Local Authorities have been attacked that their accounts systems are not designed to check the efficiency of the direct labour organisations. They claimed that the existing accounts are simply there to show where the money has gone and were quite incapable of demonstrating whether or not the maintenance department was operating efficiently (147).

Other contractors argue that Local Authorities are not fairly comparable with contractors' tenders because proper charges for supervision and administration are not added to the work figures (124, 148, 149). One of the counties surveyed turned down this point by supporting an example showing two schemes which have been carried out by cometitive tenders (see Table 5.5.).

Table 5.5. Cost Comparison between Direct Labour and Contractor

	Direct Labour	Lowest Contractor
1. Project 1,dual carriage-way and circulating scheme (14.5.73)	£186,194	£219,221 (15% excess)
2. Project 2, improvement (18.6.74)	£103,734	£147,146 (42% excess)

As far as the example of the two projects mentioned are concerned, each direct labour tender includes an item to cover staff support costs and overheads to make it comparable with other tenders, and the sums included were as follows :

Project 1, Dual carriageway scheme	£9,100 or 5.4%
Project 2, Improvement scheme	£5,300 or 5.4%

This 5.4% is based on a formula which takes account of the following factors :

1. Works Managers/Divisional Surveyors staff salaries as a proportion of Works Unit/Divisional Budget.
2. Public service given by all staff.
3. Head Office (Direct Works Staff) as a proportion of total direct labour budget.
4. All Head Office senior management salaries and overheads as a proportion of departmental works budget.
5. Accommodation, furniture, central charges, etc.

In the case of competition with contractors the highways maintenance departments prepare Bills of Quantities which go to the competitive tender. The value of the work done is assessed by either:

a) valuation of jobs based on a schedule of rates derived from competitive quotations from private contractor (Example 1) or

b) Charging jobs by a system of target hours calulated using work study data, where the cost per hour to be used is worked out from contractors' competitive quotations for typical jobs (Example 2).

5.2.1. Examples of Cost Comparison between Direct Labour Organisations and Contractors

Example 1. This example presents an estimate made for one job which has been prepared using direct labour rates and using contractor rates.

A. Estimate for Direct Labour Work

The preparation of estimates is made as a Bill of Quantities. Estimates must be prepared with each item of work carefully set out and described. All itmes were broken into one or more of the following parts :

Materials, labour, transport, plant.

The direct labour rates quoted include the council's overheads. The rates which have been used were those applicable during 1978-79 (see Table 5.6. - DLO detailed estimate).

B. Estimate for Contract Work

The contractor has prepared a Bill of Quantities based on rates which have been used on tenders prepared in early 1978. It is by keeping records of all class of work on all possible occasions that the rate for an item can be built up.(see Table 5.7).

Example 1.A. Direct Labour Estimate (including on-costs)
at "A" County

Bill no. 4 Kerb and footpath reconstruction Sheet no.1

Item No.	Description	Quant.	Unit	Rate	£	p
	Section 4 : Fences, Gates and Stiles					
4/1	Removal and re-erection of existing timber front garden gate 1.0 metre high, 1.0 metre wide.	10	No.	1.03	10	30
	Section 5 : Drainage					
	Raising or lowering covers and gratings on existing chambers and gullies					
5/1	Raising the level of Public Utility or newer manhole cover and frame exceeding 0.250sq.m. but not exceeding 0.50sq.m. on brick or precast concrete chamber by 150mm or less.	5	No.	22.37	111	85
5/2	Ditto item 5/1 Public Utility boxes not exceeding 0.100sq.m.	3	No.	6.86	20	58
5/3	Ditto item 5/1 Public Utility boxes not exceeding 0.250sq.m.	6	No	13.68	82	08
5/4	Raising the outlet level of cast iron down pipe	2	No.	2.58	5	16
	Total Sections 4 and 5					
	Carried to Summary				229	97

Bill no. 3 Kerb and footpath reconstruction: Section 6. Sheet no.2

Item No	Description	Quant.	Unit	Rate	£	p
	Section 6 : Earthworks ;. Excavation					
6/1	Excavate concrete in cuttings and excavation in bulk in the open.	-	cu.m.	-	-	-
6/2	Excavate existing pavement brickwork masonry and the like in cuttings and excavation in bulk in the open.	3	cu.m.	8.16	24	48
6/3	Excavate unsuitable material in cuttings and excavation in bulk in the open	2	cu.m.	5.24	10	48
	Disposal of Material					
6/4	Disposal of unsuitable material including concrete existing pavement, brickwork masonry and the like in tips off site.	5	cu.m.	1.50	7	50
	Completion of Formation					
6/5	Formation of suitable material	250	sq.m.	0.28	-	70
	Total for Earthworks Carried to Summary				43	16

Item No.	Description	Quant.	Unit	Rate	£	p
	Section 11 : Kerbs and Footways					
	Kerb channelling and edging					
11/1	Take up including race set aside and relay B.S.340 Fig.7 (125mm x 250mm) kerb complete with bed back and haunch.	-	lin.m.	-		
11/2	Take up kerb of any type including race and dispose	500	lin.m	1.19	595	00
11/3	Take up and remove to Council Depot one row of setts	500	lin.m.	0.62	310	00
11/4	Ditto item 11/3 two rows of setts	-	lin.m.	-		
11/5	22.5/20 concrete 100mm x 100mm in channel	500	lin.m.	0.22	110	00
11/6	Ditto item 11/5 200mm x 100mm	-	lin.m.	-		
11/7	Precast concrete kerbing B.S. 340 Fig.7 (125mm x 250mm) laid straight or curved over 12 metre radius	400	lin.m.	3.44	1376	00
11/8	Ditto item 11/7 laid to curves of 12 metres radius or less	-	lin.m.	-		
11/9	Precast concrete kerbing B.S. 340 Fig.2(125mm x 150mm) bull-nose laid straight or curved over 12 metres	80	lin.m.	2.15	172	00
11/10	Precast concrete kerbing B.S. 340 dropper kerbs laid straight or curved over 12 metres radius	20	lin.m.	4.07	81	40
11/11	Precast concrete edging B.S.340 Fig.11 (51mm x 152mm) laid straight or curved over 12 metres radius	90	lin.m.	1.57	141	30
11/12	Precast concrete dished chann-elling B.S.340 (250mm x 75mm) laid straight or curved over 12 metres	-	lin.m.	-		
11/13	Oak barge board edging (150mm x 25mm) including stakes laid straight or curved over 12 metres	-	lin.m.	-		
	Carried to collection				2785	70

Bill no.3 Kerb and footpath reconstruction : Section 11 Sheet no.4

Item No.	Description	Quant.	Unit	Rate	£	p
					2785	70
	Footways					
11/14	Take up set aside and re-lay on 25mm mortar bed precast concrete paving flag footway on existing sub-base	-	sq.m.	-		
11/15	Take up including sub-base set aside and re-lay on 150mm 22.5/20 concrete bed precast concrete paving flag footway	100	sq.m.	6.49	649	00
11/16	Ditto item 11/15 re-lay on 150mm dense bitumen macadam road base with 25mm sand and cement bed	70	sq.m.	6.99	489	30
11/16/A	Provide and lay 50mm flags on 150mm 22.5/20 concrete bed	20	sq.m.	7.95	159	00
11/16/B	Ditto item 11/16A but 63mm flags	-	sq.m.	-		
11/17	Take up broken precast concrete paving flags and dispose	20	sq.m.	0.76	15	20
11/18	Non-selective residual weed-killer to manufacturers rate of spread	1000	sq.m.	0.04	40	00
11/19	Flexible constructed footway Granular type 2 (clinker ash) sub-base 100mm thick	1000	sq.m.	0.90	900	00
11/19A	Ditto item 11/19 75mm thick	-	sq.m.	-		
11/20	Ditto item 11/19 50mm thick	-	sq.m.	-		
11/20A	Ditto item 11/19 25mm thick	-	sq.m.	-		
11/21	Flexible constructed footway bitumen macadam base course 50mm thick	1000	sq.m.	1.57	1570	00
11/21/A	Ditto item 11/21 75mm thick	-	sq.m.	-		
11/22	Flexible constructed footway bitumen macadam wearing course 12.5mm thick	1020	sq.m.	0.84	856	80
11/23	Ditto item 11/22 fine cold asphalt	-	sq.m.	-		
11/24	Bituminous spray B.S. 594 Clause 4.1.5. Class K1:40 in footway	1020	sq.m.	0.07	71	40
	Carried to collection				7536	40

Bill no.3 Kerb and footpath reconstruction: Section 11 Sheet no 5

Item No.	Description	Quant.	Unit	Rate	£	p
					7536	40
11/25	100mm thick 22.5/20 quality concrete footway	-	sq.m.	-		
11/26	Ditto item 11/25 150mm thick	50	sq.m.	3.71	185	50
	<u>Provisional Item</u>					
11/27	Double slate membrane vertical damp-proof course exceeding 300mm but not exceeding 600mm high to properties at rear of footpath		lin.m.			
	<u>Collection</u>					
	Total p.1				229	97
	Total p.2				43	16
	Total p.5				7721	90
	TOTAL FOR KERBS AND FOOTWAYS			£	7995	03

Bill no.3 Kerb and footpath reconstruction : Sections 4 &5 Sheet no.1

Item No.	Description	Quant.	Unit	Rate	£	p
	<u>Section 4</u>					
	<u>Fences, gates and stiles</u>					
4/1	Removal and re-erection of existing timber front garden gate 1.0 metre high 1.0 metre wide	10	No.	5.00	50	00
	<u>Section 5</u>					
	<u>Raising or lowering covers and grating on existing chambers and gullies.</u>					
5/1	Raising the level of Public Utility or sewer manhole cover and frame exceeding 0.250sq.m. but not exceeding 0.50sq.m. on brick or precast concrete chamber by 150mm or less.	5	No.	13.00	65	00
5/2	Ditto item 5/1 Public Utility boxes not exceeding 0.100sq.m.	3	No.	6.00	18	00
5/3	Ditto item 5/1 Public Utility boxes exceeding 0.100sq.m. but not exceeding 0.250sq.m.	6	No.	5.50	33	00
5/4	Raising the outlet level of cast iron down pipe	2	No.	2.00	4	00
	Total Sections 4 & 5 Carried to summary				170	00

Bill No.3 Kerb and footpath reconstruction: Section 6 Sheet no.2

Item No.	Description	Quant.	Unit	Rate	£	p
	<u>Section 6 Earthworks : Excavation</u>.					
6/1	Excavate concrete in cuttings and excavation in bulk in the open	-	cu.m.	-		
6/2	Excavate existing pavement brickwork masonry and the like in cuttings and excavation in bulk in the open	3	cu.m.	7.50	22	50
6/3	Excavate unsuitable material in cuttings and excavation in bulk in the open	2	cu.m.	1.00	2	00
	<u>Disposal of Material</u>					
6/4	Disposal of unsuitable material including concrete existing pavement, brickwork masonry and the like in tips off site	5	cu.m.	1.50	7	50
	<u>Completion of Formation</u>					
6/5	Formation of suitable material	250	cu.m.	0.04	10	00
	Total for Earthworks Carried to summary				42	00

Bill No. 3. Kerb and footpath reconstruction : Section 11 Sheet no.3

Item No.	Description	Quant.	Unit	Rate	£	p
	Section 11 :Kerbs and Footways					
	Kerb Channelling and Edging					
11/1	Take up including race set aside and re-lay B.S.340 Fig.7 (125mm x 250mm) kerb complete with bed back and haunch	-	lin.m.	-		
11/2	Take up kerb of any type including race and dispose	500	lin.m.	0.38	190	00
11/3	Take up and remove to Council Depot one row of setts	500	lin.m.	0.18	90	00
11/4	Ditto item 11/3 two rows of setts	-	lin.m.	-		
11/5	22.5/20 concrete 100mm x 100mm in channel	500	lin.m.	0.32	160	00
11/6	Ditto item 11/5 200mm x 100mm	-	lin.m.	-		
11/7	Precast concrete kerbing B.S.340 Fig.7 (125mm x 250mm) laid straight or curved over 12 metre radius	400	lin.m.	2.85	1140	00
11/8	Ditto item 11/7 laid to curves of 12 metres radius or less	-	lin.m.	-		
11/9	Precast concrete kerbing B.S.340 Fig.2 (125mm x 150mm) bullnose laid straight or curved over 12 metres	80	lin.m.	2.71	216	80
11/10	Precast concrete kerbing B.S.340 dropper curves laid straight or curved over 12 metres radius	20	lin.m.	3.33	66	60
11/11	Precast concrete edging B.S.340 Fig.11 (51mm x 152mm) laid straight or curved over 12 metres radius	90	lin.m.	1.50	135	00
11/12	Precast concrete dished channelling B.S.340 (250mm x 75mm) laid straight or curved over 12 metres radius	-	lin.m.	-		
11/13	Oak barge board edging (150mm x 25mm) including stakes laid straight or curved over 12 metres radius	-	lin.m.	-		
	Carried to collection				1998	40

Bill No. 3 Kerb and footpath reconstruction: Section 11 Sheet no.4

Item No.	Description	Quant.	Unit	Rate	£	p
	Footways				1998	40
11/14	Take up set aside and re-lay on 25mm mortar bed precast concrete paving flag footway on existing sub-base	-	sq.m.	-		
11/15	Take up including sub-base set aside and re-lay on 150mm 22.5/20 concrete bed precast concrete paving flags footway	100	sq.m.	4.00	400	00
11/16	Ditto item 11/15 re-lay on 150mm dense bitumen macadam roadbase with 25mm sand and cement bed	70	sq.m.	4.30	301	00
11/16A	Provide and lay 50mm flags on 150mm 22.5/20 concrete bed	20	sq.m.	6.20	124	00
11/16B	Ditto item 11/16A but 63mm flags	-	sq.m.	-		
11/17	Take up broken precast concrete paving flags and dispose	20	sq.m.	0.30	6.	00
11/18	Non-selective residual weed-killer to manufacturers rate of spread	1000	sq.m.	0.01	10	00
11/19	Flexible constructed footway Granular Type 2(clinker ash) sub-base 100mm thick	1000	sq.m.	0.42	420	00
11/19A	Ditto item 11/19 75mm thick	-	sq.m.	-		
11/20	Ditto item 11/19 50mm thick	–	sq.m.	-		
11/19B	Ditto item 11/19 25mm thick	-	sq.m.	-		
11/21	Flexible constructed footway bitumen macadam base course 50mm thick	1000	sq.m.	1.43	1430	00
11/21A	Ditto item 11/21 75mm thick	-	sq.m.	-		
11/22	Flexible constructed footway bitumen macadam wearing course 12.5mm thick	1020	sq.m.	0.70	714	00
11/23	Ditto item 11/22 fine cold asphalt	-	sq.m.	-		
11/24	Bituminous spray B.S.594 Clause 4.1.5. Class K1 : 40 in footway	1020	sq.m.	0.01	10	20
	Carried to collection				5413	60

Bill No. 3 Kerb and footpath reconstruction: Section 11 Sheet no.5

Item No.	Description	Quant.	Unit	Rate	£	p
					5413	60
11/25	100mm thick 22.5/20 quality concrete footway	-	sq.m.	-		
11/26	Ditto item 11/25 150mm thick	50	sq.m.	3.20	160	00
	Provisional item					
11/27	Double slate membrane vertical damp-proof course exceeding 300mm but not exceeding 600mm high to properties at rear of footpath	-	sq.m.	-		
	Collection					
	Total p.1				170	00
	Total p.2				42	00
	Total p.5				5573	60
	Plus 7% Supervisory on-cost				404	99
	Total for Kerbs and Footways			£	6190	59

The highways maintenance department added a plusage of 7 per cent at the end of the bill quoting the contractor's rates to cover supervision on cost, and in order to enable comparison to be made between DLO and contractor (see Table 5.7 for the contractor's estimated Bill of Quantities).

The comparison between the cost of carrying out the work by DLO and contractor is shown in Table 5.8.

Table 5.8. Example 1 : Cost Comparison betwen DLO and Contractor

Project	DLO	Contractor
Kerb and footpath construction	£7995.03 29%excess	£6190.59

According to the total cost of both DLO and contractor, the contractor's cost is less than the DLO by £1804.44. Therefore the management decided to carry out the work with the contractor.

However, there were no detailed costing figures available within this county to show how the total cost built up so as to ensure as far as possible that costs are related to similar work being carried out by private contractors. Therefore, the following examples are prepared for this research to show how the comparison between DLO and contractor is carried out.

Example 2 This example represents the comparative costs of a MARCH type repair involving the replacement of a street 7.3m. wide and 50m. long, of kerbs, carriageway haunches, resurfacing carriageway, reinstating verge and re-levelling and resurfacing footpaths.

In this Example, a different approach has been taken in the preparation of the final estimate for work carried out by DLO and the contractor. One important thing they have in common is that the quantities are accurate and all the foreseeable items of work have been included. The researcher would like to point out that these figures are not readily available in the counties' cost sheets and have been prepared especially for the purpose of this research.

A. Estimates for Direct Labour Works

In this county the cost of labour can only be obtained from experience and records should be made on all possible occasions of the time taken to carry out the various classes of work. Information should be provided about which gangs will be available for the work under consideration, the number of workers employed and the condition of the site. From this information a labour constant in man hours for each operation under the various wage rates can be determined. To the basic cost of labour must be added "on-cost", that is the cost of provision for holidays, insurance, sickness, etc. (Table 5.9 shows a typical example of the types of overheads charged to wages). This is taken as a percentage of the wage rate and it is the job of the costing officerto determine what it should be.

The cost of materials does not, as a rule, present any difficulty. For a large number of materials the market price is known or obtainable and most highways authorities have annual tenders for the materials required for road works. It has not been beneficial to have all the materials delivered to site because the increase in cost for delivery of small quantities far outweighed the handling costs charged for drawing materials from the depot, e.g. tarmac and cement.

The cost of materials is subject to a percentage addition when drawn from the depot (see Table 5.10).

Plant and transport costs can be calculated by determing the number of plant hours and tranpsort hours required for each unit of work and the hourly cost of the machine. The hourly rate is determined upon the basis of the output which can be expected when the work is being carried out, not the maximum output. It is the engineer's responsibility to decide what plant and transport will be required for the work and its availability. When hired plant is used, the quotation should be obtained from the firms concerned. This quotation should cover the cost of fuel and drivers' travelling time and expenses (see Table 5.11). Sometimes, this has already been done by annual tenders. In this example they add 15 per cent for direct supervision and administration (see Table 5.12). The final estimated total cost for DLO is shown in Table 5.13.

Table 5.10. Stores Handling Overheads 1973/74, "A" County (£)

Issues :	Stock	832,719		
	less airport	8,700		
			824,019	
	Direct		240,892	
	Total		1,064,911	
Petrol & Oil :	L.M.Can	688		
	Haulage	58,709		
	Plant	2,734		
	Equipment	8,459		
	Tools	19,851		
Total Handling charged			155,408	
Less petrol & oil (2.15%)			2,261	
			153,147	
Recovery factor				14.38%
Recent factor				20%

Table 5.11. Schedule of Vehicles, Head of Account 66

Rates chargeable from 26.2.79

City Engineer's Department "A" County

Vehicle Group	Details	Hourly rate(£)	Cost (£)	Depreciation cost + 40%		Garage Month (£)
				Month (£)	Year (£)	
03	Lorries- 3ton nominal load Diesel	4.14	6,632	155	1,857	2
	1977 Ford-Whiteliner OOG909R	Plus	6,632	155	1,857	D
	" POH44R	£0.35	4,450	104	1,246	2
	" POH45R	per	4,450	104	1,246	2
	" POH61R	hour	4,450	104	1,246	2
	" POH62R	when	4,450	104	1,246	2
	1978 " SOE142S	snow	7,500	175	2,100	2
	" SOE207S	ploughs	7,500	175	2,100	2
		are used				
04	Lorries- 2ton nominal load Diesel	4.02				
	1971 BMC Redline Tipper WVP872J		1,300	30	364	2
	1972 BMC Tipper 420FG COA471K		1,403	33	393	2
	" COA472K		1,403	33	393	2
	" COA475K		1,403	33	393	2
	" COA480K		1,403	33	393	2
	" COA481K		1,403	33	393	2
	" COA483K		1,403	33	393	2
	" COA485K		1,403	33	393	2
	" COA486K		1,403	33	393	2
	" COA487K		1,403	33	393	2
	" COA488K		1,403	33	393	2
	" EOM409L		1,403	33	393	2
	" EOM410L		1,403	33	393	2
	1974 BLMC Redline Tip. GOJ428N		2,429	57	680	2
	" GOJ429N		2,429	57	680	2
	" GOJ430N		2,429	57	680	2
	" GOJ431N		2,429	57	680	2
	" GOJ436N		2,429	57	680	2
	" GOJ437N		2,429	57	680	2
	" GOC333N		2,429	57	680	2
	" GOC334N		2,429	57	680	2
	" GOC335N		2,429	57	680	2

Table 5.12. Example 2A : Highways Supervision and Administrative Cost

1. Depot costs	
Highways. 44.13% of total depot operation 44.13% of 980.010	£438,360
2. Direct supervision	
Engineers' salaries and administration costs	£460,000
Total	£898,360
Total expenditure on highways on which this can be carried	£5,990,000
Direct expenses and administration (898,360/5,990,000)	15%

Table 5.13. Example 2A : Total Direct Labour Estimated Cost

Estimated time	
Labour cost	
3-man gang for 80hrs each @ £1.98 per hour	£475.20
Add 15% overheads on wages	£355.00
Transport	
1 3-tonne lorry, 120hrs @ £4,55 per hr.	£546.00
1 footpath roller, 120hrs @ £3.20 per hr.	£384.00
1 compressor, 120hrs @ £2.40 per hr.	£288.00
Materials	
6m^3 concrete @ 7.50 per tonne	£100.20
100m P.C. kerb @ £0.70 metre	£ 70.00
8 tonnes dense bit. road base @ £9.50 per tonne	£ 76.00
Tack coat 2.2gals.	£ 1.20
Catter 3m^3 at £3.00 per tonne	£ 18.00
Medium temperature asphalt, 2.5tonnes @ £14 per tonne	£ 35.00
Footpath base, 2.5m^3 @ £42.12 m^3 (10 tonnes)	£ 50.00
Footpath surface dressing 1.5m^3	£ 36.00
Total	£2,434.60
Add 15% supervision and depot costs	£365.00
Total	£2,799.60

B. Estimates for Contract Work

It is assumed that the normal procedure adopted by the contractor is similar to that of preparing a direct labour estimate plus an addition for profit. The Bill of Quantities is prepared to cover every foreseeable item of work, and the Bill priced item by item (140). It is the responsibility of the engineer to judge, as nearly as possible the amount of the lowest acceptable tender. The contractor uses the Bill of Quantities for valuation purposes. In addition to the preparation of the Bill of Quantities, various documents are needed to define a contract. These documents are (127) :

Conditions of Contract

Specification and

Drawings

After the contractor receives these documents, he prices the Bill of Quantities and submits his tender.

If he succeeds in winning the contract, he has to carry out the contract based on the original documents. (See Table 5.14, the total cost for the contractor).

As a result of the comparison between DLO and contractor costs, a decision has to be taken to assign the work to a contractor because his total cost is less than the DLO by £712.05.

Table 5.14. Example 2B : Contractor's Estimated Costs

Theoretical Contractors' Rates 1979-80 Rates

Hypothetical MARCH Exercise

				(£)	(£)
1.	Break out existing kerb and kerb-race and cart to contractor's tip	100m	@	0.95	95.00
2.	Break out macadam surfacing 75mm thickness, 1m width	$100m^2$	@	0.45	45.00
3.	Break out pitching foundation up to 150mm thickness, 1m width	$100m^2$	@	0.70	70.00
4.	Excavate for, provide and lay 8 : 1 P.C. Concrete to kerb base	$100m^2$	@	1.35	135.00
5.	Provide and lay 125mm x 250mm concrete kerb. Include bedding and backing	100m	@	2.90	290.00
6.	Provide and lay dense bituminous macadam 20mm size BS 4987 1973 Group 2 Section 2.26 to haunches	8tonnes		17.50	140.00
7.	Clean and prepare surface prior to laying tack coat	$365m^2$		0.03	10.95
8.	Raise gully iron work	4 no.		10.00	40.00
9.	Raise manhole covers	1 no.		12.00	12.00
10.	Provide and apply tack coat	$365m^2$		0.06	21.90
11.	Cut key to haunches	100m		0.35	35.00
12.	Provide and lay 20mm Medium temp. asphalt	$365m^2$		1.38	508.70
13.	Provide and spread topsoil to verges	$100m^2$		0.75	75.00
14.	Provide and lay turf to verges	$100m^2$		0.60	60.00
15.	Take up existing flag paving and cart to contractor's tip	$100m^2$		1.12	112.00
16.	Provide and lay 100m shale to footpath	$100m^2$		0.85	85.00
17.	Provide and lay 50mm thickness bit. macadam 20mm footpath base	$100m^2$		2.12	212.00
18.	Provide and lay 25mm thickness limestone agg. footpath surfacing	$100m^2$		1.00	100.00
					£2,087.55

(* 15% depot costs should be added)

CONCLUSIONS

The highways maintenance departments adopt a total costing technique where all costs are eventually charged to the maintenance work. They believe that they have to adopt such a costing system because they charge the work to different parties who ultimately must bear all the cost, and the method of apportionment needs to be fair.

The highways maintenance departments do not estimate the total cost of every job except in the big improvement operations, and they usually prepare a Bill of Quantities in these cases.

In the cases of cometition with contractors, the highways maintenance departments prepare Bills of Quantities which go to the competitive tender. In such cases, they calculate the labour direct cost and labour on-cost, the material cost and the plant cost, plus an overhead percentage for administration costs determined according to experience from previous years. There are no standards for calculating the cost units in most of the counties.

To evaluate this system and to determine its suitability to the highways maintenance work it is essential to consider in more detail the objectives of the costing system and how it aids management in decision-making. In the meantime, the different costing techniques should be highlighted to explain the attributes at the stage of comparison between alternative courses of action, therefore, allowing possible suggestions as to the most suitable costing system for highways maintenance departments, taking into consideration the circumstances and conditions of work.

Chapter 6

The Suggested Costing System for Highways Maintenance Departments

Introduction

This chapter is devoted to explaining the costing objectives and the different costing techniques. In the light of the information provided by each technique, it will be possible to evaluate the suitability of the costing systems applied within the Highways Department which have already been described in the previous chapter. According to the results gained from the evaluation, a suggested system will be recommended.

6.1. Costing System Objectives

Cost accounting may be thought of as a modern development but it is as old as management (151). Cost accounting techniques have been traced back to prior to the Industrial Revolution. Modern cost accounting concepts began with the movement in Scientific Management (152). Although it focussed mainly on work improvement and measurement, this led to great interest in cost reduction and thus cost accounting. The science of costing developed rapidly during World War I and World War II. It sprang from the need for more accurate and better accounting information to enable decisions to be made (153). The advanced technology and the need for more precision in predictions necessitated the need to calculate more closely.

It might be useful to consider the nature of costing before examining its objectives.

6.1.1. Costing definition

The simple words "cost" and "costing" have a variety of meanings which results from using words loosely.

The word "cost has been defined according to the Oxford Dictionary as "the price paid for something". But in management terminology, cost refers to expenditure, not revenue. The word "cost" has been defined according to the terminology issued by the Institute of Cost and Management Accountants as the "amount of expenditure (actual or notional) incurred on, or attributable to, a specified thing or activity" (154,p.17). Cost is not an absolute value but depends on the viewpoint, objectives and intentions of the person using it and the different circumstances in which it is used (155).

A cost is the 'value' of economic resources used as a result of producing or doing the thing costed. Cost is not limited to money, it includes all benefits or desired effects which may have to be sacrificed in order to obtain greatest benefits (156). This value is made up of two components : the quantity used of the resource and the price per unit. Therefore, mathematically, cost can be stated as (157):

Cost = Usage x Price or Rate

The term cost may refer to actual cost or estimated cost ; it can rarely stand on its own and should be qualified as to its nature or limitations and related to particular things or "object of thought". According to the terminology of Management and Financial Accountancy, the term "costing" is defined as "the ascertainment of cost" (154,p.9). Consequently, costing is essentially the use of data to construct cost statements.

Cost Accounting is defined by the Institute of Cost and Management Accountants as "the application of accounting and costing principles, methods and techniques in ascertainment of costs, and the analysis of savings and/or excesses as compared with previous experience, or with standards" (154,p.9). It includes the presentation of information derived therefrom for the purpose of managerial decision-making. The information to be produced may be divided into two groups: basic data required regularly at stated times and data required in respect of particular works or to assist with the solution of special problems (158). Therefore, cost data may be considered as "building bricks' which can be used to construct different building designs (157). In other words,"the same cost data can be arranged and re-arranged to give a number of quite different statements, and no one way is the only correct way" (157,p.12). The form of the cost account is therefore important in that it should, as a matter of routine, produce simultaneously the information required for each purpose.

The value of costs lies in the benefit derived from their use. Therefore it is important to ensure that the proper selection of information is made and that proper use is made of it (158).

It is important when dealing with costing data to take into consideration the following general costing principles (157) :

(i) Costs should be related as closely as possible to their causes.

(ii) A cost is not charged until it is incurred.

(iii) Abnormal costs are excluded from costs. Their presence in the costs would tend to distort cost figures and mislead management.

(iv) Past costs are never charged to future periods.

6.1.2. Costing objectives

The accounting system is the major quantitative information in almost every organisation. The costing function is to provide information, usually of a financial character (159). It is an empirical study so that the rules which govern it are largely conditioned by the operations, personnel and policy of the undertaking with respect to which its techniques are to be applied (160). The underlying principles and objectives of all costing systems are the same, but the application of these principles and the method by which the objectives are to be achieved vary with every business's circumstances. Consequently accounting is aimed at "improving the total information system of the entity ; that composite of men, machines and procedures which exists to provide information of relevance to internal and external decision-makers" (158,p.149). Taylor suggests the following objectives of costing (155) :

1. To assist in the determination of price and pricing policy.
2. To value work in progress and stocks as essential elements in the accounting process of profit ascertainment.
3. To assist managers in their functions of forward planning and controlling the operations for which they are responsible and to give guidelines for management in decision-making.

The fundamental purpose of a costing system is to assign costs to the various items of work in progress and hence to the finished stock when it is sold. Although this basic costing information is necessary for the purpose of drawing up the final accounts, it ought to be directed to the manager. The determination of costs is the accountant's function, while the control of cost is management's function. The job of the accountant is to provide managers with the financial information they require for controlling the factor affecting profitability. Managers are able to study the relative profitability of alternative products and take such action to redirect effort. The managers are concerned with controlling the current performance and planning the future activities which fall within their responsility (161). As the measures of performance are numerical by nature, the accounting system is generally used to provide the necessary data which give managers an indication of their economic performance and the direction in which they must move in order to improve efficiency. In addition, costing is concerned with the determination of accounting data that is useful in managerial decision-making (157).

The researcher believes that accounting information can help in making decisions, but that it does not replace judgement. The manager must look beyond the accounting analysis to be able to choose the best course of action. Managers need guidance in the interpretation of cost information if wise decisions are to be made. The more managers' decisions are based on accurate and reliable fact rather than on inspired guesswork, the better are the chances of success (162). Therefore, the contribution of the cost accountant is to provide management with the relevant facts in time for useful action to be taken (151).

Cost accounting might be considered as management accounting plus a small part of financial accounting, to the extent that its product costing function satisfies the requisites of external reporting (163). Horngern pointed out that an effective accounting system provides information for three broad purposes (164) :

1. Internal reporting to managers for use in planning and controlling current operations.
2. Internal reporting to managers for use in strategic planning. In other words, the making of special decisions and in the formulating of overall policies and long-range plans.
3. External reporting to stockholders, government and other outside parties.

It can be concluded that the "cost accounting system in its broadest sense includes all of the activities to provide management with information needed for planning, controlling and reporting the financial condition and operations of the enterprise" (165,p.19). Thus, as the costing system is serving different purposes, it is expected that modern accounting "ought to be multi-dimensional, both in recording and reporting" (166,p.71). Accountants and managers need different costs for different purposes. The types of data both of them need depends on the nature of their jobs and the nature of the decisions to be made. Consequently, each decision would be best satisfied by some methodology tailored to meet the information reauirements of that decision (167). There is no one cost accounting system which would satisfy all purposes of management, control, planning and product costing (168). There is no rule which can be given for the selection of accounting technique to be employed in a particular case. The only criterion for the selection is that the technique which is most appropriate to the circumstances should be chosen.

The next section is devoted to the different accounting techniques in order to identify how existing accounting techniques can prove useful.

6.2. The Classification of Costing Systems

6.2.1. Cost Classification

It will have been noted from the previous section that it is useful to think of cost accounting as "a system for collecting quantitative data and as a body of knowledge including methods and techniques concerned with the use of this data in making decisions" (169,p.76). The different accounting methods have an effect on the decision process (170). The output from the alternative accounting techniques depend upon the methods that are used (171). There are different ways of classifying costs, the way chosen being determined by the purpose which is to be achieved (172).

Harper suggests that the different cost data can be classified into two main categories : methods and techniques (157). Cost methods depend on the nature of the production and cost techniques depend on the purpose for which management requires the information. The information management needs for a particular purpose determines the technique to be used. It should be noted that methods and techniques represent the tools available to the cost accountant who is able to choose among them for any given task. They have their uses and their limitations and it is the cost accountant's responsibility to recognise when such limitations render a particular method or technique unsuitable (Ibid).

Another classification of costing data is provided by the Institute of Cost and Management Accountants illustrated in Figure 6.1. They highlight the need for knowing what the costs are, how and where they are incurred in order that (154) :

1. One can be aware of the significance of individual elements of cost and types of expense.
2. One can observe the trends of the various cost elements.
3. The costs of individual departments and/or cost centres can be calculated and related to output, to measure cost effectiveness and to calculate cost rates or unit costs.

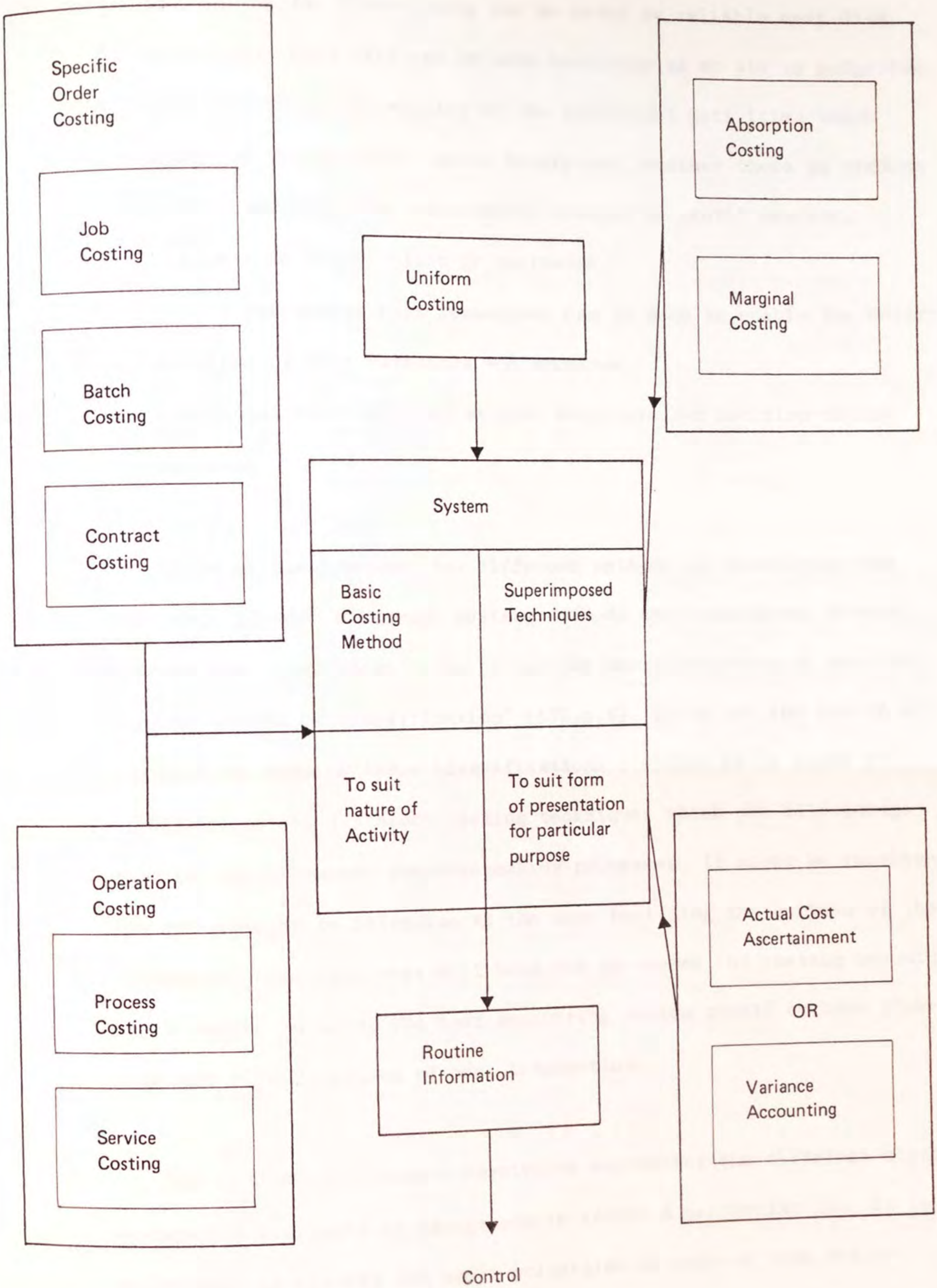


Fig. 6.1: Cost Accounting Methods, Principles and Technique
(related to the routine system)

4. Estimating for price-fixing can be aided by reliable cost data.
5. Historical cost data can be made available as an aid in budgeting.
6. The relative profitability of the individual activities which comprise the business can be determined, whether these be product groups and products, departments treated as profit centres, channels of distribution or customers.
7. Actual and budget cost comparison can be made to enable the determination of cost variances and excesses.
8. Historical cost data can be made available for decision-making purposes.

It is noticeable that the different methods of classifying the cost data provide different costing methods and techniques. However, Halford said that "there is no particular merit attaching to any particular scheme of classification" (172,p.6). It is not the aim of this research to examine these classifications ; rather it is aimed at highlighting the different costing techniques which can help management in the different decision-making processes. It might be important for any manager to determine at the very beginning the purpose of the information required that will help him to choose the costing technique which should be used. The cost accounting system should be both flexible and a ready source of cost information.

The following section is devoted to explaining the different costing techniques available to management to tackle a particular job. It is an attempt to clarify the basic principles of each of them and to guide the action of choosing or combining more than one technique for any given task.

6.2.2. Costing Techniques

1. Direct and Indirect Costing

According to this technique, "all costs fall into one of the two categories of direct and indirect costs"(157,p.9) :

a) "A direct cost may be defined as a cost that arises solely from the existence of whatever is being costed"(Ibid). It can be Identified with, and allocated to cost centres or cost units, such as direct materials, direct labour and direct expense (for example fringe benefits which are applicable to direct labour)(173).

b) An indirect cost is a cost whose existence does not depend solely on what is being costed. "It therefore implies some element of sharing a cost that is common or jointly incurred by two or more things being costed"(157,p.9). It cannot be allocated but can be apportioned to, or absorbed by cost centres or cost units.

Therefore, direct costing means the practice of charging direct costs to the products or process, leaving the indirect costs to be written off against profits, i.e. it is implied that they should be excluded from product costs (164). The term direct costing should not be consfused with the term marginal costing, "it differs from marginal costing in that some fixed costs can be regarded as direct costs in the appropriate circumstances"(161,p.8).

Under direct costing a cost unit will be charged with direct costs only. In other words, it will be charged with those costs it individually and exclusively causes to be incurred (174). Simini argued that since many costs in normal circumstances are incurred on a time basis and are not dependent on the production of individual cost units for their amount, such costs are not charged to production at all (175). However, there is a link between the cost units and the time based costs. Therefore, charging direct costs only to cost units is valid in the short term (173).

2. Marginal Costing

Economists define marginal cost as the additional cost of producing one additional unit (157), i.e. the difference between the total cost of producing some rate of output and the total costs of producing at a rate of one less unit. An increase of one or more units is not worth consideration in business, therefore, marginal cost has been defined by the Institute of Cost and Management Accountants as "the variable cost of one unit of a product or service, i.e. a cost which would be avoided if the unit was not produced or provided"(154,p125). In practice, this is measured by the total variable cost attributable to one unit. In this context, a unit may be a single article, a batch of articles, an order, a stage of production capacity, a process or a department. It relates to the change in output in the particular circumstances under consideration (161).

Marginal costing has been defined as :

" a principle whereby marginal costs of cost units are ascertained. Only variable costs are charged to cost units, the fixed costs attributable to a relevant period being written off in full against the contribution for that period". (154,p.12).

The essential feature of marginal costing is that it distinguishes between variable costs and fixed costs. Variable costs and fixed costs have been defined as follows :

" Variable Cost : a cost which, in aggregate, tends to vary in direct proportion to changes in the volume of output or turnover" (154,p.24).

" Fixed Cost : a cost which accrues in relation to the passage of time and which, within certain output or turnover limits, tends to be unaffected by fluctuations in volume of output or turnover" (Ibid).

In other words,"fixed costs are those costs which are constant in total amount regardless of changes in production volume within the limits of existing capacity of a function". (161,p.8).

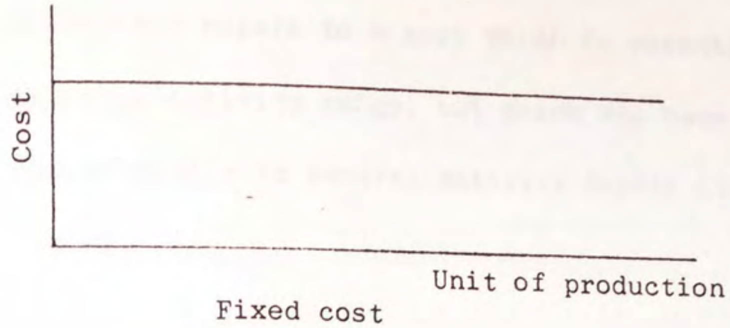
So, another main point concerning marginal costing is that it classifies the cost according to behaviour rather than function. Cost behaviour is independent of the direction of a cost. Therefore, fixed costs as well as variable costs can be direct costs (176). Consequently, marginal costing highlights the relationship of cost changes to changes in activity. The two factors which determine the behaviour patterns of costs are changes in activity and the passage of time. The terms fixed and variable are generally used to describe how a cost reacts to changes in activity (167) (see Figure 6.2.).

(i) A variable cost is a cost which is proportional to the level of activity (the cost increases as the activity increases).

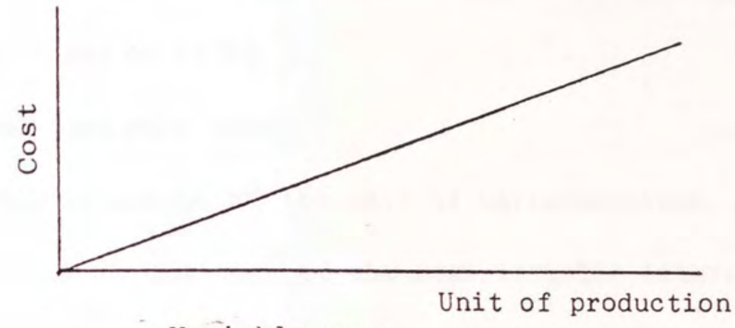
(ii) A fixed cost is a constant in total over the relevant range of expected activity under consideration.

However, costs do not behave in a linear relationship only (172), so the terms variable and fixed may be made more useful by the modified terms semi-variable and semi-fixed (177).

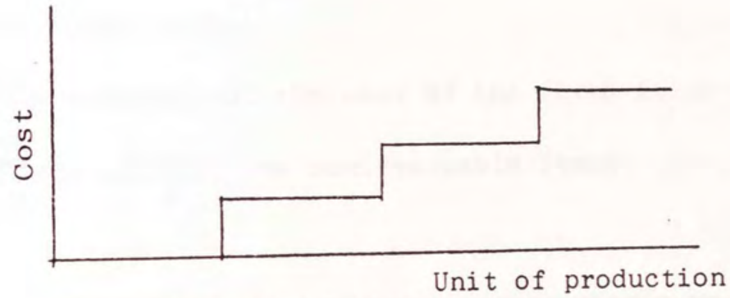
(iii) Semi-variable can be used to refer to a cost that is basically variable but whose slope may change abruptly when a certain activity level is reached.



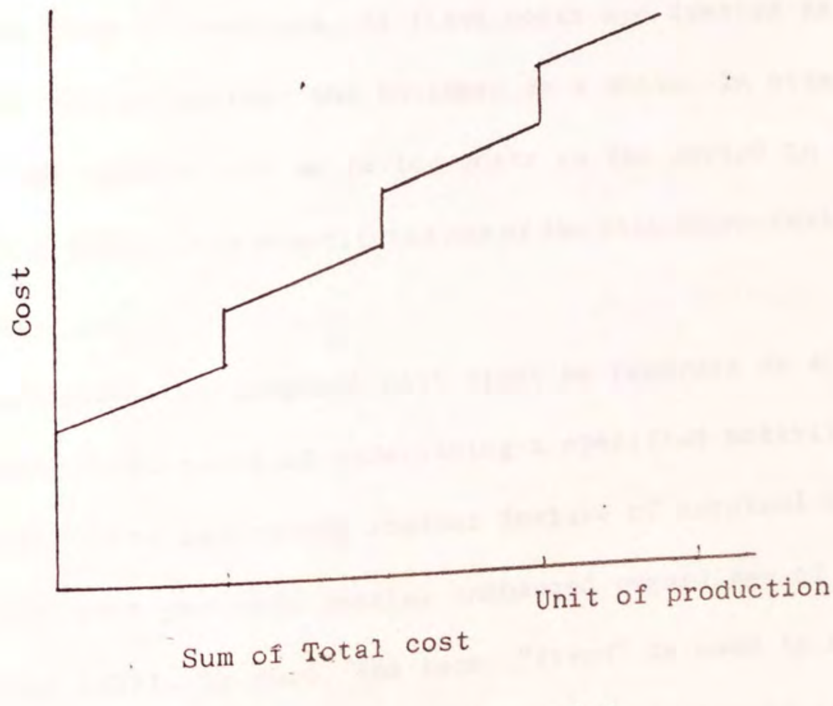
Fixed cost



Variable cost



Semi-fixed cost



Sum of Total cost

Figure 6.2.

Various Cost Behaviour in Relation to Time

(iv) Semi-fixed refers to a cost which is essentially fixed over the relevant activity range, but which may have to be increased substantially at several activity levels if production is increased.

According to these definitions, total cost will consist of two separate parts (172) :

a) The variable cost.

This consists of the cost of variable items, plus the variable parts of the cost of the semi-variable items. They will total a fixed amount of money which is called the unit variable cost.

b) The fixed cost.

This consists of the cost of the fixed items plus the fixed part of the cost of the semi-variable items.

Since fixed costs are quite unconnected with production, and their amount is quite independent of production, there is no point in apportioning them to products, so fixed costs are treated as an individual, overall charge against the business as a whole. In other words, fixed costs are written off as period costs in the period in which they were incurred (178). This constitutes one of the main characteristics of marginal costing.

Consequently, marginal cost might be regarded as a variable cost incurred as a result of undertaking a specified activity. This view of marginal costs represents another feature of marginal cost in that marginal cost per unit remains unchanged regardless of the level of activity (157). As such, the term "fixed" is used to mean that the expenses so classified are only fixed in relation to time, and they tend to vary in relation to the length of the period covered (160).

Therefore the tendency is for use in the short run and it is common to refer to marginal costing as short term costing (159). Thus, the decision to increase the volume of output from a given level would result in a change in total costs, but the only costs to increase would be the variable costs. This concept is allied with the concept of incremental cost.

3. Incremental and Differential Cost

It has been defined as the change in costs that will occur as the result of a change in activity from one base or reference level to another level (163).

In a broader sense, incremental or differential cost is the difference in cost between two alternatives (164). This provides the basic principle which is that when one must decide between two or more alternatives, only the costs that differ between alternatives need to be considered (161). The costs that remain the same should cancel out when weighing one alternative with another (157).

This concept provides the management - which is frequently confronted with a choice between alternative courses of action - with guidance in deciding which to adopt (155). In making such decisions, the management's prime concern is not with the absolute cost of each alternative, but with their relative merits. The relevant costs are the additional costs which will be incurred in the production of these extra units (151). Therefore incremental costs are the additional costs incurred in carrying out an additional task or undertaking the supply of an additional quantity of product or service (179). Accountants assume that the incremental cost is equal to the variable cost multiplied by the number of additional units to be produced (177). Then any fixed or semi-variable costs related to the production of the additional unit must be added. Incremental costs provide the basic costs needed for good managerial decision-making.

4. Total Absorption Costing

It has been identified as "A principle whereby fixed as well as variable costs are allotted to cost unit" (154,p.12). In other words, the technique of total absorption costing is based on the concept that all normal costs of running an enterprise should be charged in some way or another to the cost units produced (157). Thus it is the antithesis of marginal costing. It is the practice of charging all costs, both fixed and variable, to a process or operation.

The absorption of fixed costs requires the determination of normal capacity and the level of the capacity used in producing each product. This then ensures the absorption of fixed costs by the product unit on a fair and equitable basis (180). Consequently the cost of the period will be allocated to the production of the period and will be part of the cost assigned to the year-end inventory (175). This leads to a situation where some of the periods' fixed production costs are included in the end of the period and charged against sales of some future accounting period (163). In other words, some fixed costs are carried forward to the following periods.

Under the total absorption costing technique the cost unit absorbs the total costs. It is charged not only with their direct costs but in addition with a fair share of all overheads (181).

6.2.3. Overheads under Absorption Costing

Factory costs other than direct material and direct labour are lumped together as factory overheads (176). Overheads are indirect costs which cannot conveniently be allocated to cost units. These overheads include :"Payroll taxes, Vacation and sick pay, Directemployee fringe benefits, Indirect employee fringe benefits, Utilities, Telephones and communications, Insurance, Real property taxes, Personal property taxes, Value Added Tax, Depreciation, Royalties, Franchises, Repairs and maintenance, Rent and miscellaneous (all other factory costs not specifically mentioned above are considered as miscellaneous expenses)"(175,p.19).

Under the total absorption costing technique, fixed overhead costs are included with variable overhead costs in the total overheads and distributed over the production of the period. Factory overheads are assigned to production on the basis of "overhead rates". An overhead rate is "The simple ratio of overhead costs to an activity variable" (163,p.28). Overhead costs are assigned to production on the basis of some measure of activity that influences the level of overhead costs incurred. The basis of absorption of overhead cost is purely arbitrary, although there is usually some logical basis. There are at least eight fundamentally different methods for overhead costs to be absorbed :

1. Labour hour/rate ;
2. Machine hour/rate ;
3. Direct wage percentage rate ;
4. Direct material cost percentage rate ;
5. Prime cost percentage rate ;
6. Cost unit rate ;

7. Standard cost rate ;

8. Market cost rate."

(161,p.107)

The most typical overhead bases are direct labour/hours and direct machine/hours (163). However, the direct wage percentage is somewhat akin to the labour hour rate in that the overhead costs are related to labour input, but in terms of wages rather than hours.

It might be argued that one of the accounting techniques is superior to all, thus the selection of certain accounting techniques will lead to better planning and control (165). It is doubtful that any one cost accounting technique would satisfy all management purposes. Instead of trying to choose one best method, it might be better to develop a trend towards different costs for different purposes. An accurate understanding of the environment, the constraints, and the considerations involve in the election to use various accounting techniques would prove useful on two counts :

" First, it will determine more accurately when and how existing accounting techniques can prove useful.
Second, it will better define the problems and constraints in using existing techniques that would identify frontier areas upon which future accounting development might focus"

(171,p.45)

Management needs every available tool to help manage effectively. One of the best tools it can have is a good accounting system. A good accounting system should provide information about performance at the right time, be able to forecast results with some degree of accuracy, and should be able to help in analytical work so that decisions can be made about the course of action before the fact (182).

6.3. Evaluation of the Costing System Applied within the Highways Maintenance Departments

It is noticeable from the previous chapter that the costing system applied within the highways maintenance department is what is called the absorption or total costing technique. According to this theory all the normal costs of running the department should be charged in some way or another to all the units produced (183). That is because, according to the absorption cost theory, the fixed cost is not ignored (164).

Absorption costing has many drawbacks which affect its validity to provide management with information it needs to make the right decisions. The main drawback results from applying the departmental overhead rate in a lump to direct cost. The cost units are not only charged with costs which they have generated, but also with costs which they have not generated (163).

Absorption costing distorts the stated profit for a given period because it obscures the true relationship between price, costs and volume owing to the behaviour of period costs when calculated on a unit cost basis (173). A most important point to be borne in mind is that by the very character of period costs, net profit is not made on each unit produced ; rather, it is made on the total activity for a given period of time. Since fixed costs are quite unconnected with production and their amount is independent of production, there is no point in apportioning them to products (157). This technique is misleading to management and it might prevent the management from making the right decision. This is the likely result,"Since the incorporation of a fixed cost per unit usually overstates the change in costs in relation to change in output" (163,p.626).

Furthermore, using the total costing technique in the highways authority will lead to little use of the cost accounting information which is presented to management because it does not present the information needed for cost control and decision-making (184). Total cost is not a measure of performance and only has significance as an expense calculation (164). The information which management needs is not complete cost in all circumstances, but relevant cost, including only those cost factors which are significant for a specific purpose.

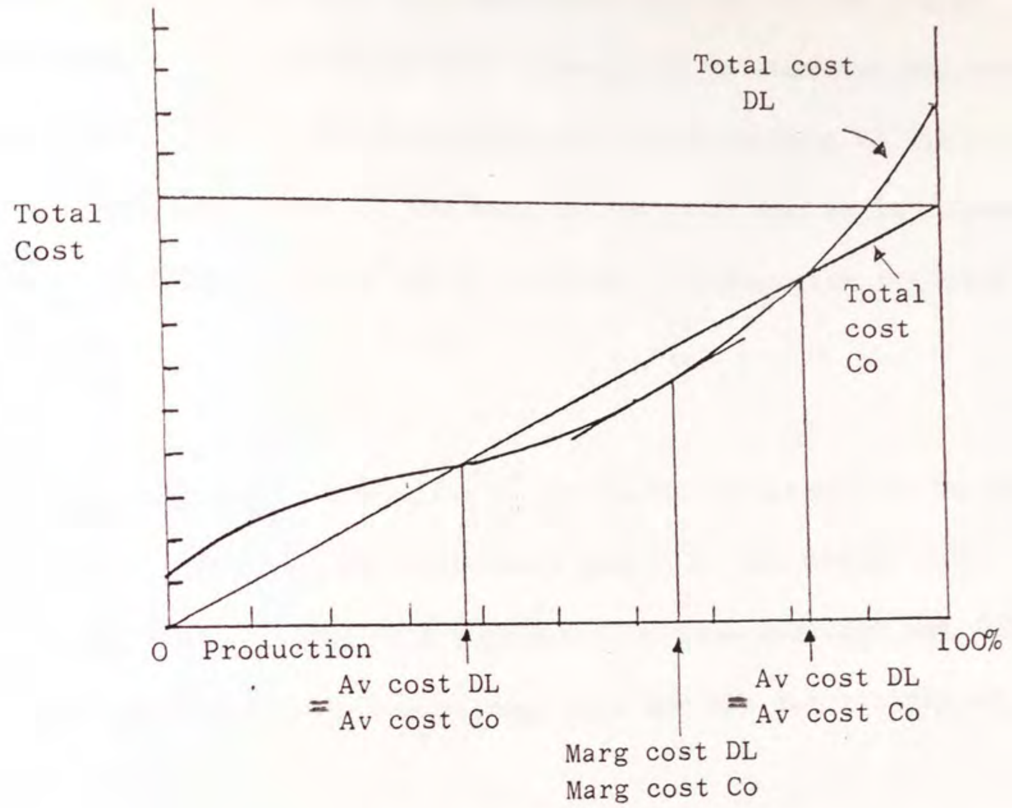
Using the total costing technique in pricing the direct work for highways maintenance in a competitive situation with a contractor can be confusing to the manager who is concerned with fixing prices based on cost. This confusion arises from the variation in the amount of overheads absorbed by production and the problem of over- or under-absorbed overheads when recovery rates are in use (184).

The direct labour organisation represents a source available to undertake maintenance work. Whether the work is carried out by them or by a contractor, the overhead expense will not change. As has been illustrated in the previous sections, the indirect costs or the fixed costs should continue once they are set up, regardless of the activity level (176). It has been explained as well, that in taking a decision the information needed is only that which alters between alternatives, or what are called the relevant costs (185). Therefore, the costs which will be the same under feasible alternatives are considered to be irrelevant data and may be ignored for particular decisions (164). The relevant cost concept cannot help determine how to compute costs, but it is "a useful reminder that the cost measured should be a function of how the measure is to be used." (167, p.22).

In pricing the direct labour organisation work for bidding in comparison with a contractor, the price should not be compared with total costs including a share of overheads, but only with variable and certain semi-variable costs which are considered relevant (186). In such circumstances, the decision of management to do the work by direct labour or not involves choices between alternatives. Therefore, when evaluating alternatives, there is little to be gained by including any factor which is common to all. To gain a more effective comparison between alternatives, common factors are better excluded, leaving only the differences between alternatives to be examined (157). In that sense, full total cost cannot be applicable to decision-making and will mislead the management, since in many decisions, fixed costs are the same.

The following example illustrates the necessity of using the marginal costing technique for the comparison between direct labour and a contractor. It shows clearly that total costs might mislead the decision-maker in reaching the right decision. Figure 6.3. demonstrates the importance of considering the marginal costing technique. This figure shows how relevant accounts help the direct labour work to be more efficient, and deciding whether DLO should be made smaller or larger (134). It explains this by considering the average and marginal costs of direct labour and contractors. The average cost per unit of output is the total cost divided by the total output where the marginal cost of unit of

DL = Direct Labour
Co = Contractor



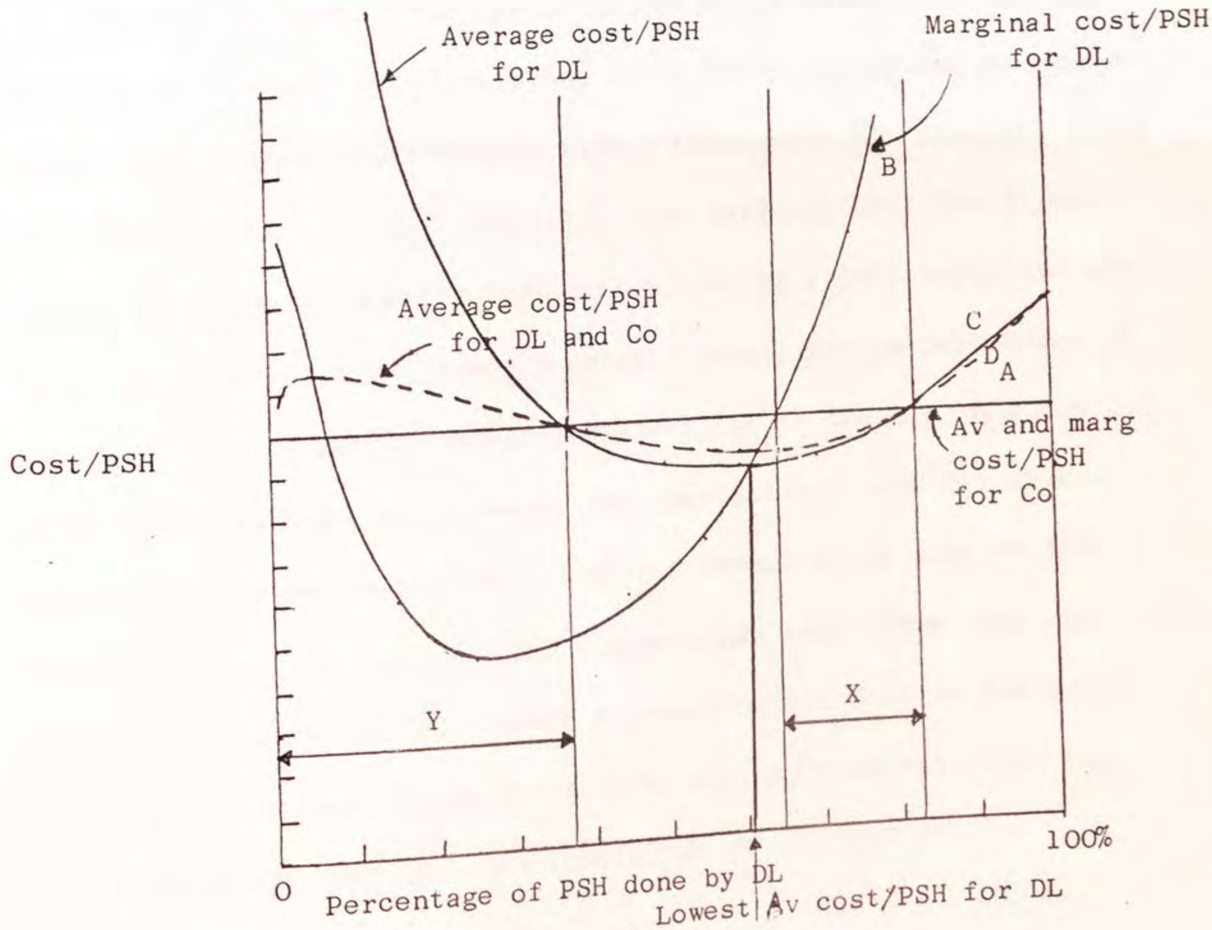


Figure 6.3.

Comparison between Average and Marginal Cost for Deciding Percentage of Work Done by DLO output is the extra cost of producing one more unit. As the output is changed the cost changes, but the amount depends on the length of time allowed. The graph has been constructed to show how the cost of using direct labour and contractor may vary according to the amount of work each does. It has been assumed that the total amount of work to be done is fixed and is measured in productive standard hours, PSHs.

The marginal cost per PSH for a contractor is assumed to be constant ; it is therefore the horizontal line A on the graph. Consequently, the average cost of a contractor is also constant and they are equal. Line A is also the average cost per PSH for contractor.

The cost structure for direct labour is different. It has been assumed that there are significant fixed costs in setting up even a small direct works undertaking. Line B represents the marginal costs per PSH of direct labour. Initially, the marginal cost for direct labour drops below the marginal cost of paying a contractor for the same increment of work. After a certain point, as the percentage of the work done by direct labour increases, it is assumed that the marginal costs tend to increase. The average cost line for direct labour, C, can be determined. It slopes downwards as long as the marginal cost line is below it. The marginal cost curve cuts the average cost curve at the latter's lowest point. This is the point at which the direct labour force works most efficiently, that is, output (PSH) divided by input (costs) is at its highest.

The total average cost per PSH line D, can be drawn taking account of the percentage of the work done by direct labour and contractors. It must always lie between the two average cost lines, being a weighted average of their value. The total average cost per PSH is lowest at that percentage of work done by DLO, when the direct labour's marginsal costs per PSH are equal to contractor's marginal costs per PSH. To the right of this point more work is done by direct labour but its marginal cost is higher than a contractor's so total costs increase. To the left, more work is done by the contractor, but the marginal cost is higher than direct labour so again, total costs increase.

The use of averages only might mislead the management in determining the size of its direct labour force. In the range marked X on the graph, the average cost per PSH of direct labour is less than that of the contractor, therefore, it would seem to be economic to increase the proportion of the work done by direct labour. However, the lowest total cost would be attained if the proportion of work done by direct labour were reduced. Consideration of the range Y reinforces this argument. Here, the average cost per PSH for direct labour is above that for a contractor, so according to the average cost, the correct decision is not to reduce DLO, as would be inferred from the accounts, but to increase it.

On purely financial grounds, the optimum size of the direct labour force is where total costs are lowest. That is at the point where the total average cost per PSH (line D) is lowest. In other words, the optimum size of the direct labour force is that size where marginal cost per PSH for direct labour equals that charged by contractors. Hence the full total costing technique applied within the highways maintenance departments, as it is designed, shows only the average costs, which is misleading to the decision-maker.

It can be concluded that the costing data provided for the management to take decisions either to carry out the maintenance work by direct labour or contractors is insufficient as far as this comparison is concerned. It does not differentiate between the variable cost incurred as a result of taking a decision to do the job by direct labour, and the fixed costs which remain unchangeable in either case. This is because management is more concerned with the cost differences between the two alternatives rather than the absolute totals. The costing data provided does not give the management a clear-cut answer to what is the cost if a decision is taken to carry out the work by direct labour. The management initially want figures relating to possible future costs. The cost structure for direct labour as explained is unsuitable for management decisions of comparisons between direct labour and a contractor. Therefore, the researcher believes that using the total costing technique will limit the use of the cost accounting information which is presented for decision-making. Consequently, the marginal costing technique can help management to make decisions with a fair assurance of knowing the likely consequences in advance.

The next section is devoted to explaining a suggested costing technique to be applied within the highways maintenance departments.

6.4. Suggested Costing Systems for Highways Maintenance Departments

The major problem facing highways maintenance departments is designing a costing system sufficiently flexible to meet all the demands which will be made on it. It might be impracticable for the reason of expense to design the cost accounts so that the answers to all the problems will be automatically available. Consequently, it is preferable that the system should be flexible enough to allow for existing data to be redrafted in any required form.

The marginal costing technique may be considered to be a powerful tool to help management in decision-making processes. It provides a sound basis for comparing alternative methods of carrying out the work by distinguishing between variable costs and fixed costs (161). This recognition is likely to be necessary in the provision of information which will be used as a basis for making decisions.

The separation of variable and fixed costs aids in current control of costs and facilitates the use of responsibility accounting (186). Furthermore, the identification of variable costs and consequently the controllable costs aids the person who is reponsible for controlling those costs to take corrective action.

The management of highways maintenance needs costing information for three main purposes :

6.4.1. Costing required for comparison between direct labour and contractor ;

6.4.2. Costing required for work to be charged out to other groups;

6.4.3. Costing required for the department's normal work.

Accordingly, and because of the circumstances of the highways maintenance department, it seems that marginal costing has conceptual merits in most situations. It is the basis of the most suitable costing technique applicable to the highways departments. The main merit of marginal costing is that it allows the relevant information to be abstracted to suit the different purposes.

To apply the marginal costing technique for the highways department, the elements of cost should be classified into variable and fixed costs. The variable and fixed costs will be defined in the highways department as follows :

Variable costs are those costs which have a direct relationship with the volume of the cost unit or the output of the cost centres. These costs should vary in the same proportion as the volume change. It covers the direct material, labour and plant which relate directly to the maintenance work, and in addition, any other costs which vary with the volume of cost units.

The fixed costs are those costs which have no direct relationship with the cost unit and do not vary with the level of activity in the cost centre. It covers the overhead costs and administration costs which remain constant regardless of the different activity levels.

To allocate costs to activities requires that each document which relates to some factor of production (time sheets and plant returns as well as invoices are involved) should be labelled. The part of the cost which it represents and which is attributable to the activity is then charged. It is necessary, therefore, to identify "cost centres" which relate to activities at a level that has a recognised identity to operatives, foremen and managers. Codes must be set up to identify each cost centre. According to the marginal costing technique, the variable costs only will be charged to the cost unit, job or operation. The appropriate cost elements should be allocated to it.

Without disturbing the costing system, once set up, the costing data can be arranged and rearranged to fulfill the different requirements as follows :

6.4.1. Costing for Comparison between Direct Labour and Contractors

As far as comparison between direct labour organisation and a contractor is concerned, the marginal costing technique provides the most suitable tool for this comparison. It concentrates only on the relevant costs which should represent, in this case, the variable cost of carrying out the work (as has been indicated in the previous section). The highways maintenance department is a direct labour organisation so that there is no point in considering the fixed costs in taking the decision to carry out the work by direct labour or contract. This is simply because the fixed costs represented in overheads and administration costs will not differ under alternatives, i.e. the relevant costs. The key question in determining relevancy is "What difference will it make ?" It should be borne in mind that including irrelevant costs in cost comparisons might lead to wrong decisions being taken (161). The accounting system for maintenance work carried out by direct labour should, as far as possible, be related to the similar cost of work being carried out by a contractor. It is of greater value to management in tendering to prepare the cost statement according to the marginal technique, than prepare it with a loading for a fixed expense.

Moreover, marginal costing is simpler and less ambiguous than total costing and avoids the complexities of apportionment which are only arbitrary divisions of individual fixed costs (184).

To highlight the advantages of marginal costing it might be useful to revise Example 2 of the previous chapter which has been prepared according to the total costing technique. This will define the difference between the two techniques.

As far as the original example is concerned, if a decision has to be taken to choose between direct labour and contractor, on purely financial grounds, the decision will be to carry on by contractor as its price is lower than direct labour. By re-examining the figures in much more detail, it will be noticeable that the cost of direct labour work incurs all the direct costs and indirect overheads as well. However, if the concept of marginal cost is applied, the cost might be less than the contractor's price because the fixed overheads which remain unchanged in either case will be excluded.

As is seen by Example 2, the cost of direct labour has been charged with 75 per cent as wages overheads. With more careful attention to the factor of overhead expenses, an attempt is made in Table 6.1 to differentiate between the variable overheads and the fixed overheads. According to the marginal costing technique, only the variable overheads will be chargeable to the cost of completing the work by direct labour. In other words, 21.8 per cent will be charged instead of 75%.

Table 6.2. shows a hypothetical, detailed material overhead cost to illustrate the variable material cost (6 per cent) which will be included in the total variable cost. Adding the overhead variable cost to the direct labour, material and plant costs will result in a revised statement for costing the work done by direct labour (see Table 6.3).

Table 6.1. City Engineer's Dept. Wage Overheads

1973 - 1974

	Variable Overheads		Fixed Overheads	
	£	%	£	%
Depot assistants salaries			26,617	2.3
Foremen - salaries - road*			107,775	11.9
Foremen - salaries - sewers			66,342	7.3
Foremen - wages - roads**	720	0.1	720	1.0
National Insurance	120,345	13.4		
Superannuation	74,854	8.3		
Sick pay - certified			30,003	3.3
Sick pay - uncertified			11,619	1.3
Accident pay			1,798	0.2
Holidays - Annual leave			64,217	7.1
Bank Holidays			47,081	5.2
Improved service pay			11,036	1.2
Training - apprentices			3,617	0.4
drivers			721	0.1
courses			1,179	0.1
highway workers			1,350	0.2
sewer training			1,166	0.1
O.H.M.S. Allowances			79	0.001
Absence with permission			1,094	0.1
First Aid payments			203	0.001
Waiting time/idle time			47,106	5.2
Guaranteed minimum earnings			239	0.001
Travelling and subsistence			4,835	0.5
Clothing			5,338	0.6
Safety equipment			3,538	0.4
Transport			37,209	4.1
Light plant and tools - repairs			4,570	0.5
new			30,518	3.4
	195,919	21.8	509,250	56.1
Total wages on which overheads are charged			£904,994	

* See notes on wages overheads

** See notes on Wage Overheads

Notes on Wages Overheads

* Foremen's salaries are considered to be fixed costs because when the workforce of the highways department has been set up, they would not change according to the level of activity. (This differs from the contractors point of view as he is free to hire and fire the men according to the trend of his activity. Furthermore, in some cases, the contractor might set up his workforce for only one operation and finish with them as soon as this operation has been completed. This might be true for major projects).

** Foremen's wages might be considered as a semi-variable cost. The reason behind this is that working foremen usually supervise the direct labour work based on some kind of routine work (such as wage sheet, bonus sheet, etc.). A foreman can carry on doing both duties even with an increasing activity level. When the activity level increases beyond his span of control, it might be then that he devotes all his time to one kind of work and completes the other with overtime. At that point, the foreman's remuneration will increase. Other occasions might necessitate the hiring of another foreman to carry on or to be an assistant. As has been said earlier, in practical situations there is no straight linear relationship between costs and activities in all cases, so the semi-variable cost may be treated in the accounts as a variable cost.

Table 6.2. Store-Handling Overheads

1973 - 1974

Cost	Variable (£)	Fixed (£)
Issuing site cost	24,104	
Cleaning materials	3,060	
Order cost	10,000	
Oil and lubricants	2,261	
Delivery to site cost	16,220	
L.M. Car	4,202	
Administration		46,574
Depot expenses		20,261
Salaries		70,441
Plant		10,000
Small tools		5,000
Stationery (Book-keeping)		2,859
	59,847	155,135
	6%	14%

Issues (£)

Stock	832,719
Less airport	8,700
	824,019
Direct	240,892
TOTAL	1,064,911

Table 6.3. The Cost of Work Done by Direct Labour

(for comparison with contractor)

I Estimated time labour cost :		
3-man gang for 8 hours each @ £1.98 per hour		£475.20
II Estimated time for plant cost*:		
Transport :		
1-3 tonne lorry, 120hrs @ £3.25 per hr.	£391.20	
1 footpath roller 120hrs @ £2.28 per hr.	£273,60	
1 compressor 120hrs @ £1.71 per hr.	£205.20	
Total variable plant cost		£870.00
Estimated material cost**		
$6m^3$ concrete @ £6.25 per tonne	83.30	
100m P.C. kerb @ £0.58 per metre	58.00	
8 tonnes dense bit. road base @ £8.92 per tonne	71.40	
Tack coat 2.2 gallons	1.00	
Catter - $3m^3$ @ £2.5 per tonne	15.00	
Medium temperature Asphalt - 2.5 tonnes @ £11.6 per tonne	29.25	
Footpath base $2.5m^3$	41.70	
Footpath surface dressing $1.5m^3$	30.00	
Total material variable cost		£322.00
		£1,667.20
Variable overheads :		
Variable wages overheads (21.8%)	95.00	
Variable handling materials overheads	19.32	
TOTAL VARIABLE COST		£1,781.52

* See notes on cost of work by DLO

** See notes on cost of work by DLO

Notes on Cost of Work by DLO

1. * The rate of using the plant has been revised to exclude the fixed overheads which were included before (40%).

   ** The rate of pricing the material has been revised to exclude the overhead percentage of handling the material which was calculated by the county and included before (20%).

2. There is no administration cost to be added to the estimated cost of carrying out the work by direct labour. The reason is that even in the case of doing the work by contractor, it is the highways maintenance department's responsibility to supervise the work. As has been illustrated earlier in this chapter, when there is a comparison between alternatives, the cost which ought to be calculated is only the one which will vary between the alternatives. This cost (the incremental cost) represents the relative cost which will affect the decision to be taken. Therefore it is this cost which the manager is concerned to know about.

According to the revised statement for costing the work done by direct labour, it is clear that it will cost less to carry out the work by direct labour as follows :

The cost by direct labour	£1,781.52
The cost by contractor	£2,087.52

So the direct labour is cheaper than the contractor, £306.00 less, or 14.7 per cent. Consequently, on purely financial grounds, the decision will be to carry out the work by direct labour.

6.4.2. Costing Required for Work to be Charged Out to Other Groups

The highways maintenance department is required to calculate the cost of maintenance to trunk roads and motorways carried out by its direct labour organisation, as an agent authority for the Department of Transport. In this case, it should calculate the full cost for carrying out this work : this requires the adoption of the absorption costing technique. The absorption costing technique allocates both variable and fixed costs to the output unit. The apportionment of fixed costs is based on some fair and equitable basis.

The point which needs to be highlighted is that the classification of costing data according to the marginal costing technique is still valid for applying the absorption costing technique. The only requirement is to rearrange the same cost data and to combine them to meet the different purposes for which it is required. The same technique of absorption costing will be used in the case of charging outside parties with the cost of repairing and maintaining plant and vehicles in the central repair depot service. Also, when charging outside parties with the cost of maintenance or improvement work carried out by the highways department's direct labour on their behalf.

The same example will be used to explain how the marginal costing technique is still valid to show the cost if we assume that the same operation will be carried out for an outside organisation.

Certain assumptions will be used to differentiate between the two cases.

Case A :

This represents the case where there is idle capacity within the highways maintenance department. In other words, the highways authority can carry out the work with its direct labour force without the need to replan its scheduled programme for its normal work, or it can shift the scheduled programme for the normal work to some other time without the need for overtime.

In that case, it is believed that :

1. The total cost is really the variable cost for carrying out the work. This variable cost should include the administration cost for supervising that work.
2. When calculating this administration cost it should only be the variable administration cost. To revise the administration cost

figure previously calculated in the example in the last chapter, one would proceed as follows :

a) The Direct Supervision

It is assumed that the supervisor spent 20 per cent of his time on preparation and routine work which is not attributable to this operation. As such, the direct supervisory cost will be :

$$\frac{80}{100} \times \frac{\text{Direct supervision and admin cost x anticipated expend.on Scheme}}{\text{Total Division budget (total expenditure on highways}}$$

$$= \frac{80}{100} \times 460{,}000 \times \frac{2{,}000}{5{,}990} = 122.864$$

b) Depot cost

All support in terms of the Divisional Depot function such as stock-keeping, depot improvements and maintenance, cleaning, lighting, security, delivery of men, plant and materials to site, and maintenance of plant are assumed to be within the rates for work items for costing purposes and not taken into account in overhead costing. If not, it can be calculated as a percentage of highways operation to total depot operation. Accordingly, the depot costs will be calculated as follows :

$$\frac{\text{Highway operation}}{\text{Total depot operation}} \times \frac{\text{Anticipated expenditure on scheme}}{\text{Total Divisional Budget}}$$

$$= \frac{80}{100} \times 438.360 \times \frac{2{,}000}{5{,}990} = 117{,}082$$

So the variable expense and administration will be £239.972 instead of £365.00.

Table 6.4 illustrates the costing estimation for work done by direct labour to charge it to an outside organisation.

Table 6.4. The Cost of Work Done by Direct Labour (Charged to an outside organisation) Case A

Variable labour cost	£475.20	
Variable Plant cost	870.00	
Variable material cost	322.00	
		£1,667.20
Variable overheads :		
Variable wages overheads	95.00	
Variable material overheads	19.32	
Variable expense and administration	239.98	£354.30
Total cost to be charged		£2,021.50

Case B :

This represents the case where the department is working to its full capacity and there is no advantage in carrying out the work for another party, except for its legal responsibility. It is believed in this case that the total cost for carrying out the work should absorb the fixed cost as well. The statement of the cost is illustrated in Table 6.5.

It is worth noticing here that the marginal costing technique is still valid to calculate the total absorption cost. Moreover, it is noticeable that it gives the management the answer to its different questions (to take different decisions) without distrubing the accounting record. This emphasises the idea of flexibility in the accounting system to help different decisions to be taken without misleading the management with irrelevant information.

Table 6.5. The Cost of Work Done by Direct Labour

(Charged to an outside organisation)

Case B

	£	
Variable labour cost	475.20	
Variable plant cost	870.00	
Variable material cost	322.00	
		1,667.20
Variable overheads :		
Variable wages overheads	95.00	
Variable material overheads	19.32	
Variable expense and admin.	239.98	
		354.30
Total variable cost		£2,021.50
Fixed overheads :		
Fixed wages overheads	260.00	
Fixed plant overheads	348.00	
Fixed material overheads	45.08	
		653.08
		£2,674.58
Fixed administrative expenses		125.02
TOTAL COST		£2,799.60

6.4.3. Costing Required for the Department's Normal Work

The use of marginal costing in day-to-day situations within the highways maintenance department will result in better control over work carried out by the department. It facilitates the preparation of the operational budget on the basis of physical factors which can help in the control of the work. It also helps in permitting the development of responsibility accounting, because each manager will receive relevant information on cost within his control. It provides the managers with the relevant costs in different areas, (such as the use of the County Council plant, or hiring of plant) without disturbing the management with tabulations of figures which they are unable to affect or control. That is because it gives the management statements which are influenced by their action and not obscured by the apportionment of fixed costs. Furthermore, the identification of variable costs, and consequently, the controllable costs, aids the person who is responsible for controlling these costs, to take corrective action. One of the main merits of marginal costing is that it can give the management fairly accurate information in the short run on the probable effects of decisions.

It is clear from the costing of work done by direct labour as it has been shown in Table 6.5, compared with Example 2 in the previous chapter, that marginal costing is simpler and less ambiguous than total costing.

Therefore, it can be concluded that marginal costing has conceptual merit in most situations. Because of the objectives and the circumstances of the highways departments, marginal costing might be the basis of the most suitable costing technique applicable to the highways department. The main advantage of marginal costing (as illustrated by the examples) is that it allows the relevant information to be abstracted to suit the different purposes.

Conclusion

It is noticeable from the discussion in this chapter that cost data is considered an essential tool for management to reach the right decisions. There are different techniques for classifying this data. No one technique can be adequate in every situation. No single technique can be relevant to all the different purposes. As management needs to make different decisions concerning planning and controlling, it is important to identify the relevant cost data to help manage effectively. According to the decision to be taken, one can arrange the costing data in different ways to provide the most accurate basis suitable to the problem needing to be solved.

By examining the different costing classifications and explaining the different costing techniques available, a conclusion can be reached that the total costing technique generally in use within highways maintenance departments is not suitable for maintenance work. The dependence on this costing technique not only prevents the management from taking the right decision but also misleads it. Therefore, it is suggested that the marginal costing technique might be a better alternative if adopted by the highways department. This technique is consdiered to be a powerful tool for planning, controlling and decision-making. It provides a flexible accounting system able to cope with different decisions taken by management and is suitable to the complex situation in the highways maintenance department. It has been shown in this chapter how the concept of marginal costing helps in making comparison between direct labour and contractor. In addition, the use of marginal costing in day-to-day situations within the highways maintenance department will enable the calculation of total cost and will result in better control over work carried out by the department for another organisation.

However, it should be borne in mind that it is not the costing results only which affect the decision of whether to carry out the maintenance work by direct labour or contractor. There are other considerations which are important, though they might be difficult to quantify.

Among these considerations are :

(i) The need to maximise the facilities in order to keep a stable workforce ;

(ii) The quality of the service offered by direct labour ;

(iii) The shorter time between the order and the execution of the work attainable by using direct labour, especially in emergency situations.

Besides costing information, a vital criterion of choosing between direct labour and contractor is availability of the direct labour with the skills to carry out the work. Therefore, it is important to investigate the efficiency of the direct labour organisation within the highways departments. By measuring their performance and recognising the factors affecting their productivity, a better solution can be provided to management to get full use of them.

Thus, the next part is devoted to the different aspects of direct labour productivity within the highways maintenance departments.

Part 4

PRODUCTIVITY OF DIRECT LABOUR ORGANISATION WITHIN HIGHWAYS MAINTENANCE DEPARTMENTS

CHAPTER 7

Productivity Measurement in Highways Maintenance Departments

Introduction

The aim of this chapter is to examine the technique of measuring the productivity of DLO's within the highways maintenance department in oder to find out if it provides the management with the necessary information needed about their performance.

In the highways maintenance departments the technique of work study has been employed as a means of measuring the productivity of DLO's. By highlighting some of the inefficiencies of this technique it may be possible to devise a better means of measuring productivity in order to better identify the resources and take remedial action to achieve their full utilisation.

7.1. Definition of Productivity

Productivity is a rather broad term. An examination of its meaning yields a number of different defintions. There ought to be a clear understanding of what is meant by productivity because one of the reasons behind the unsatisfactory progress in improving productivity to date is the lack of a clear definition (187).

Therefore, it might be useful to start with defining what is meant by the term productivity, as used in this thesis.

According to the dictionary, productivity can be defined generally as the quality or state of being productive (188).

Production is the means to the end of obtaining goods and services. The production process involves several resources (referred to as input) to be used or change to convert them to finished goods or services (referred to as output) (189). Better decisions regarding the utilisation of these resources could be made if it is known which resources and method of production produce the most goods and the most services. In other words, it is preferred to be known how productive is each factor of these resources. Therefore, if the productiveness of these resources could be measured quantitatively, more rational decisions regarding resource utilisation can be reached. Productiveness and productivity are an attempt to express the state or condition of being productive.

From this concept of productivity emerged the different definitions of productivity which can be classified under four basic approaches. These are (189) :

1. Productivity as a form of efficiency.
2. Productivity as the utilisation of resources or the effectiveness of the utilisation of resources.
3. Productivity as a rate.
4. Productivity as a rate of return.

In recent years there has been more understanding of the meaning of productive efficiency (190). In other words, productivity is synonymous with efficiency (191). So, productivity in its broadest sense is the quantitative relationship between what has been produced and the resources which have been used (192,193,194).

Throughout this thesis, the term productivity will be used as a measure of production efficiency, and as a ratio between input-output. The input and output have been defined as :

"Input : The stock of productive factors (labour and capital, including natural resources) employed in production over successive time periods, weighted by the compensation per time unit earned by each distinguishable type of factor in a particular base period.

Output GROSS : The physical volume (or value in constant prices) of goods and services produced for sales, intraplant transfer or for addition to inventories of finished or semi-finished in-process goods during the accounting period, sometimes called real gross output". (192,p.112)

In the light of this definition, the productivity ratio will be considered as a complex combination of all corresponding input joined together in order to provide the desired output. So it might be expected that no single factor of input can be used in relation to the output to measure the productivity of the final production (195). This point should be borne in mind when discussing productivity improvement.

Therefore, in seeking higher productivity, the management are concerned not solely with increasing output, but with increasing output with the same or reduced usage of all resources (196). This is especially true and important within the highways maintenance departments with restrictions imposed on their financial resources as a result of cuts in public expenditure.

The next section will be devoted to an explanation of the productivity factors which the management have to deal with in order to improve the productivity of their activity.

7.1.1. Productivity Factors

The maintenance work activity may be considered as a production system in which resources or inputs are transformed into a useful output. The resources used for any maintenance activity include labour, materials, equipment and capital. The output of a maintenance activity is the production of work units. It is important to consider, as far as maintenance work is concerned, the environment which surrounds it as an input factor since the output of a maintenance activity is influenced by it.

The following might be considered the major factors which affect productivity (197) :

1. The nature and quality of new materials.
2. Amount and efficiency of equipment employed.
3. Amount and utilisation of labour factor.
4. Availability of money.
5. Management concepts.

1. <u>Nature and quality of new materials</u>

The material input includes the sum of all material required. Maintenance work is considered as one of the durable products which needs many different kinds of materials in different quantities at different times, and requires the materials to be transported to the site (198). Durability implies strength, which in turn implies quality. Purchasing policies which achieve low prices at the expense of inadequate material quality or poor delivery may have a devastating effect on the actual output (191). In most cases the highways maintenance department cannot supply its own need of the different raw materials and it depends on suppliers. This implies costly transport services to get these materials to where they are needed. These factors demand better methods to eliminate the waste in the use of materials and to improve their handling. The feedback of information on quality of intake and of delivery scheduling are important.

2. <u>Amount and efficiency of equipment employed</u>

It is normally considered uneconomical from a productivity point of view to employ men to do any physical work which could be done more efficiently by mechanical equipment (197). However, with the limited financial resources available to the highways department, it is uneconomical to buy or hire any plant or equipment unless it fully utilised. Even if there are plenty of funds to invest in any new equipment, it is still necessary to ensure that capital resources are used to the best advantage for productive efficiency. To achieve these results, information about equipment and machine utilisation, idle time and cost must be available to all concerned. Cost factors should also show up the poor utilisation of equipment if break-down time and maintenance costs are recorded.

3. Amount and utilisation of labour factor

Labour is a necessary component of the inputs required to complete the maintenance activity. The term "labour" is meant to include direct and indirect labour and supervision. The amount of labour used in performing any activity determines that activity's productivity (191). However, it is important to determine the properties of each input which are necessary to complete the activity. Labour input might be used to mean the number of workers employed and their total cost (199). For productivity purposes, more detailed information about the total time during which labour is used might be useful. The analysis of labour time which breaks down the whole time into real productive time and unproductive time will indicate methods of improvement. The labour inputs for highways maintenance departments are considered to be an instrumental factor and the different labour skills required depend on the type of maintenance to be effected. Available skills must be known and additional training may be beneficial ; workers expect to be trained on the task they will be required to do. As a general rule, specialisation is required for higher productivity but it should not be pursued to the extent that the disadvantages of organisational and travel difficulties exceed the advantages of higher productivity (199). Therefore, the requirements of the different skills of labour should be determined and evaluated. As a first essential step, the present situation as to the number and quality of workers, should be examined by the management.

4. Availability of money

The amount of money available to a highways maintenance organisation is probably the most important factor affecting productivity. Limited financial resources affect the relative amounts of money available for the following purposes (191) :

Investment in plant.

Research into imporved methods of production.

Labour recruitment and training programmes.

This is in addition to money required for the purchase of materials, taking into account the quality and availability. In times of inflation, stockpiling of certain materials may offer a financial advantage. The same argument applies when out-of-season discounts may be offered. Such strategies, however, must be weighed against the cost of providing adequate storage and security for these materials. Hence, in the highways maintenance departments, when the amount of money available is limited, careful consideration should be given to the distribution of money in oder to ensure that the maximum value is obtained from their financial resources investment.

5. Management concept

The management concept which includes the philosophy, structure and techniques of management is considered to be an important factor affecting productivity (200). The efficiency of the management as a resource is related not only to the individual within the system but also to the whole system. The method of leadership, the structure of the organisation, the art of delegation of authority and the techniques adopted for the classical managerial functions of planning, organisation, direction, co-ordination and control are all important and affect the level of success of the productivity improvement exercise (201). The philosophy and behaviour of top management towards an individual within its system is a critical factor in the development of better management. In seeking improved productivity it is important to be at least as concerned with making management better as with getting the worker to work harder (202). Therefore, this will necessitate that management ought to reconsider and review much of the traditional concepts of management theory. The management will need to be better prepared than ever to cope with more behavioural, social, political and system problems (203). This view might be clearly stated as follows :

"If we are to have better managers from the viewpoint of relations we must have people who temper their applications of management technique with a deep understanding of the human problems involved. Our management leaders must give leadership in the creation of human values as well as material values". (204,p.696).

One of the major tests of management these days is to ensure that the maximum use is made of all available resources (205). In order to achieve this objective, the management will have no choice but to know how to evaluate the extent to which maximum use is made of the available resources (206).

In the highways maintenance department more information is needed to explain the different types of maintenance work which they do and what methods they adopt to carry it out. Moreover, information is needed in order to ensure that the work flow is smoothed and that idle time is minimised. This should help the department to run more easily and efficiently. Adequate information about how the work is planned, supervised and checked will provide an opportunity for assessing the scope of any improvement regarding the full utilisation of the available human resources. This is specially important because of the limited control which the highways maintenance department has over the size of their direct labour force and its recruitment. This is quite apart from the maintenance department's inability to recruit further workers because of the shortage of finance, even if they are required.

Consequently, the management has to recognise the need of measurement as a datum for planning and as a means of evaluation (207). Therefore, the use of appropriate methods of measurement will help the management to spot these processes by means of which the output may be raised, and to identify where improvements are possible (208). Additionally, without measurement there can be no certainty that progress and improvement are really being achieved.

The next section will be devoted to an examination of the different productivity measurement techniques available to the management.

7.2. Productivity Measurement : Conceptual Approaches

The term productivity can be measured in different ways using the concept of the input/output ratio. Productivity in a given period can be measured either by the ratio of the input to the output of the period, or by the ratio of the increment in output to the increment in input during the period, i.e. productivity may be average productivity or marginal productivity (209).

The ratio of input at a particular time and place has limited significance. Taken by itself it has to be compared with the corresponding ratio of another time or place in order to estimate the change or difference in productivity levels (188). This comparison is usually expressed in relative form as an index of productivity, which is a device for ,easuring proportional changes or differences in simple or complex quantities relative to their base magnitude (209). The index numbers of a time series is the most usual type, and represents magnitudes in given periods as percentages of their value in a base period.

Productivity may be measured as a total productivity ratio or as a partial productivity ratio (192). In the former, productivity is calculated as a comparison of an output with all the associated inputs, while in the partial productivity case the comparison is made between an output with only one or more of the input resources used in producing the output. One of these partial productivities is labour productivity where the input is frequently limited to the input of labour.

There is an increasing trend towards the wider use of labour productivity as a measure of productivity (210). This trend may have resulted from the difficulties of obtaining the necessary data for measuring productivity. It has been argued that the use of labour productivity as an indication of productivity requires the least information and is easier to calculate than the total productivity (187). However, another argument is that studying productivity necessitates the need to study the utilisation of the various elements affecting production, including technology, equipment and machinery, the quality of management and its organisation, and the skill and education of the workforce (211).

The term productivity reflects the realisation of many other objectives such as reduction of production costs, measures of the degree of specialisation and effectiveness of the capital investment. There are a number of different concepts and measures of productivity entailing certain definitions of input and output, as summarised below :

1. Measures of input.

In the following section the various methods of measuring the input parts of the productivity equation are discussed.

A. Output per man-hour of input.

In this ratio, the output is compared with the sum of all the hours of labour (the man-hours) spent in production (208). The calculation of those hours has to be modified to take into account the labour input of the auxiliary workers, service and managerial staff (212). However, its calculation still suffers from the following disadvantages :

a) There is considered to be a diverse collection of many occupational groups within any organisation (213). Moreover, this occupational group may change and differ over time in the production of the same unit. In addition, the different occupational groups differ in respect of the level of their pay and bonuses. These calculations are more complicated when the enterprise produces a different range of products using different materials, equipment and methods of production.

b) There are limited data available on the man-hours of supervisory, administrative, research and other non-productive workers (214).

c) There is a lack of clear criteria on the relative contribution of different official employees of different responsibility centres and levels which obscures the picture of overall interaction among different departments and prevents the calculation of the man-hours per unit of production to the degree of accuracy desired (215).

B. Output per unit of labour input

This ratio is a measure of labour productivity and converts all input factors into labour inputs. The output in this ratio is compared with the weighted sum of man hours employed. In this way account is taken of differences in : education, length of experience and other factors determining the quality of labour, i.e. an hour of high quality labour is counted as proportionately more than an hour of low quality labour (213). Furthermore, it involves the calculation of the labour content of the materials, equipment and any other facilities which may be used to produce the final product in order to give the total input in terms of units of labour. However, this way of calculating the input side of the ratio seems to suffer from the following disadvantages :

a) It might be impractical to convert all facility inputs to labour units. Any enterprise usually concerns itself with these facilities in terms of their cost, not their labour content.

b) The calculation of this ratio is more complicated and more costly than output per man hour and in the end might bring little in return for time and funds consumed.

c) There is a growing trend towards the important consideration of calculating not only the living labour but also the embodied labour. (This trend requires the calculation of the labour content of the materials and equipment used by other firms)(216). The main problem facing this approach is that the enterprise neither has the interest to involve itself in this calculation nor has it the statistical data for doing it.

d) Besides the above disadvantages regarding the calculation of labour productivity, the opponents of using it as a measure for productivity claim that it implies that the output is only a function of labour (217). They argue that improving the productivity depends not only on the increased effort of labour but also on the increased use of equipment, better methods of production, good quality of materials and better organisation (214). Moreover, they claim that labour productivity depends on particular circumstances such as the level of science and its technological application, and the social organisation of the production process (219).

As a result of studying the above disadvantages of using the concept of labour productivity, it appears necessary to consider not only labour productivity but also all factors of production (220). Therefore, in order to determine the improvement in output and calculate the level of the overall efficiency achieved from the maximum utilisation of all available resources, the total productivity ought to be measured. Consequently, the following ratio is considered.

C. Output per unit of total input

Output can be compared with the services of the tangible capital employed in the production as well as the services of the labour resources, each being appropriately weighted (219). This might be important because it is no longer sufficient to determine how much work the labourer can perform, it is necessary to determine how much work the labourer, with the aid of a piece of equipment and materials can perform (218).

The main disadvantage against using the productivity of all means of production is that it requires the most information and this is not an easy task (190). However, the total productivity ratio which resulted from relating output to all associated input will provide the management with information about the efficiency with which all resources as a whole are employed in production (192). Furthermore, the total productivity ratio reveals advances in overall productive efficiency, i.e. the same output with lowered total inputs. Therefore, the total productivity as a measure of the efficiency of any enterprise as a whole must occupy a central position in the spectrum of possible productivity measures.

The productivity ratio may differ, not only with the different meanings assigned to the input but also with regard to the output included in the numerator.

2. Measures of Output

Besides input problems, the measurement of output presents another problem which is choosing a suitable measure of the quantitative results of output. The choice of measurement depends upon the nature of the analysis and its subject. It may be (214) :

a) A physical unit (e.g. length of kerbing laid, in metres)

b) A standard unit (e.g. number of kerbs laid)

c) Total production expressed in comparable prices

d) Commodity production, that is, production earmarked for sale by the enterprise at comparable prices

e) Net production at comparable prices

f) Production expressed in terms of working time

g) Production expressed in terms of constant wages.

Generally, the output can be measured in physical units or constant price money value (when heterogeneous items are combined). The advantages of the value method over the physical are :

a) It is possible to obtain general indices of the volume of output, hence it includes both finished and unfinished products, and it also includes jobs of an industrial nature which do not result in new products.

b) It reveals not only the quantity of the goods produced but also their quality, since the evaluation of the output of a unit of goods of higher quality adds a greater magnitude to the total value than a unit of the same goods of lower quality.

c) It makes it possible to obtain indices of the volume of output and hence, of labour productivity for all levels, beginning with the enterprise and ending with industry as a whole.

The measurement of output expressed in terms of volume produced may not reflect the input of services which have no influence on current production (188). Moreover, problems of consistency and comparability exist between the data used to estimate output and those used to estimate inputs (188). In addition, changes in industry or plant integration may affect the statistics of output and might distort the estimate of productivity. In the meantime, one should be aware of the fact that using rough techniques of estimation may yield obscure results.

Besides these problems, which are inherent within the calculation of input/output ratio, there is another category of problems which is concerned with productivity measurement generally. These problems will be briefly dealt with in the following sections.

7.2.1. The Problems of Measurement

There is ample evidence from the different studies that productivity is difficult to measure in a meaningful way (208). Besides the problems of measuring productivity which are inherited within the different approaches of productivity, there are more general problems resulting from the following reasons :

1. The interpretation of productivity is inconsistent and diverse according to the different writings which come from accountants, economists, personnel managers, trades' unionists, engineers and politicians (191).
2. There are different purposes for which productivity measurement is used. The productivity is used in general economic analysis, making comparison with industry and within the individual company level (190). As it covers widely different areas, so its concept and measurement will differ according to the objective of the user. No-one can expect that the same method of measurement and analysis will be used at company level and national economy level.
3. Another reasons which contributes to the difficulty of productivity measurement syems from the inadequacy of the ststiatical techniques used in productivity estimation (207).
4. Another problem which ought to be considered in measuring productivity, is the deficiencies within the data available for productivity measurement. These deficiencies affect the accuracy of this method of measurement and hence the degree to which management can rely on it (221).

However, measurement techniques do not aspire to a degree of accuracy obtained in an exact science (207). The results are conditioned, to some extent, by the purpose of the particular measurement and might be considered to be correct within the limits which are considered satisfactory for the specific use. In short, the decisions regarding the usefulness of a method of measurement are based not only on its statistical limitations but also on the purpose for which the measurement is required. The next section will explain briefly the different techniques of productivity measurement.

7.2.2. Productivity Measurment Techniques

There are several different kinds of techniques for productivity measurement. Some of them are simple, well-known and accepted, others are sophisticated tools of modern management (191). The decision of choosing one technique rather than another depends on the purpose for which it is to be used. The purpose should be achieved in the most economic way because there is no point in choosing a very complex, highly accurate measurement where the costs exceed the benefits derived from its use (222). There are different ways of classifying these techniques, and they can be grouped into the following categories (223):

1. Operational research or mathematical techniques

These methods include operational research, dynamic programming, simulation-regression and multi-regression analysis. Operational research (OR) for example, is a massive, problem-solving technique which involves assembling all the known facts about a situation and collecting as much probability data as possible. After making certain assumptions, the probabilities of a situation may be assessed and, to some extent, tested (191). Assigning probabilities to forecasts is considered to be a powerful scientific aid leading to occasional productivity improvements.

2. Historic Data Techniques

The main characteristic of this category is the collection and structuring of past data. These techniques vary to the extent that some require the implementation of a productivity index number ; others require only simple mathematics. These methods include Dallavia and Page methods and estimating methods.

Dallavia and Page methods, for example, depend on the use of productivity elements and assign a productivity efficiency factor to each element. The overall efficiency of any activity is then determined by means of averaging the factors (224,225). Dallavia and Page methods differ only in the number and type of productivity parameter factors that are considered to be part of this method.

The estimating methods are similar to those of Dallavia and Page in that their calculation of operation cost is determined from an estimated crew productivity and the crew's wage rate. Typical of these estimating methods is the one covered in the Building Estimator's Reference Book which presents tables for many types of construction operations and methods (223). They are considered to be of more general application than those of Dallavia and Page.

Historical productivity ratios are particularly useful in the long range projection of labour, materials and capital requirements. However, they are recommended only as a supplement to the other statistical tools generally used by management (192).

3. Analysis Techniques

These methods include such techniques as time study, work sampling, learning curve methods, motion analysis and balancing methods.

The main characteristic of this group is that they attempt to measure productivity by means of an analysis of the operation while it is being performed. The amount of detailed analysis may vary from one method to another. The techniques within this category are fairly easily and cheaply implemented, but they do not pretend to achieve the degree of accuracy obtained by mathematical techniques.

The choice of a technique is, to some extent, conditioned by the purpose for which the measurement is required. One of the main purposes of productivity measurement is to use reliable numerical values as provided by the different techniques for comparison. This comparison might be (188):

(i) Comparison of current performance with a historical base performance. The historical methods for measuring productivity can be used,which, although they can help in comparing the changes in productivity trends, do not tell the reasons behind the change.

(ii) Comparison of performance between one unit (or individual job or section, or process) with another. Mathematical techniques can help in this comparison, in addition to the analysis technique.

(iii) Comparison of actual performance with a target.

This last form of comparison is considered to be the best form of measurement since it concentrates attention on objectives. It involves, however, the setting of standards by methodical means on which targets can be based, and which are understood and accepted by those responsible for achieving them. There are different ways of achieving the standards desired. Among them are time study techniques, using some form of activity sampling, preferably combined with rating, in order to establish the standard time, or pre-estimated standard time (222). All these techniques are included in the category of analysis techniques.

The next section will be devoted to an examination of the technique of measuring the productivity of highways maintenance departments in order to find out if it provides the management with the necessary information for measuring, predicting and improving its productivity.

7.3. Application of Work Study Technique as a Means of Measuring Productivity in Highways Maintenance Departments

In highways maintenance departments, the technique of work study has been employed as a means of measuring the productivity of its work. Work study has been accepted as an integral part of management's job and not an expert system superimposed upon them.*

The main objective of work study is to assist management to obtain

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* For more detailed information about the history and objectives of work study, see Appendix 7.1.

the facts about the utilisation of those human and material resources which are available for the accomplishment of the work upon which it is engaged, and then to use those facts as a means of effecting improvement under the prevailing circumstances (227). This objective can be achieved by a thorough understanding and proper application of work study techniques.

Work study is defined by the British Standards Institution as :

"Work study is a generic term of those techniques, Particularly method study and work measurement, that are used in the examination of human work in all its contents, and which lead systematically to the investigation of all the factors that affect the efficiency and economy of the situation being reviewed in order to effect improvement." (British Standard 3138, 1959).

The definition quoted above shows that the term "work study" is used to associate two distinct, yet completely interdependent groups of techniques : method study and work measurement. There is a tendency to think of method study and work measurement as being quite distinct from each other. This distinction may be convenient for instructional purposes. In practice, however, one cannot be used properly without the other(197). A realistic time for a task cannot be given until the method of working is known and understood (223).While work measurement enables one to quantify by measuring the length of time required to do the job, method study is concerned with how the job is done and how it can be done more efficiently by the elimination of waste in every form (197). Therefore, the procedure of work study embraces the coordinated procedures of both method study and work measurement (see Figure 7.1).*

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* The detailed definition, procedures and objectives of both method study and work measurement are discussed in Appendix 7.1.

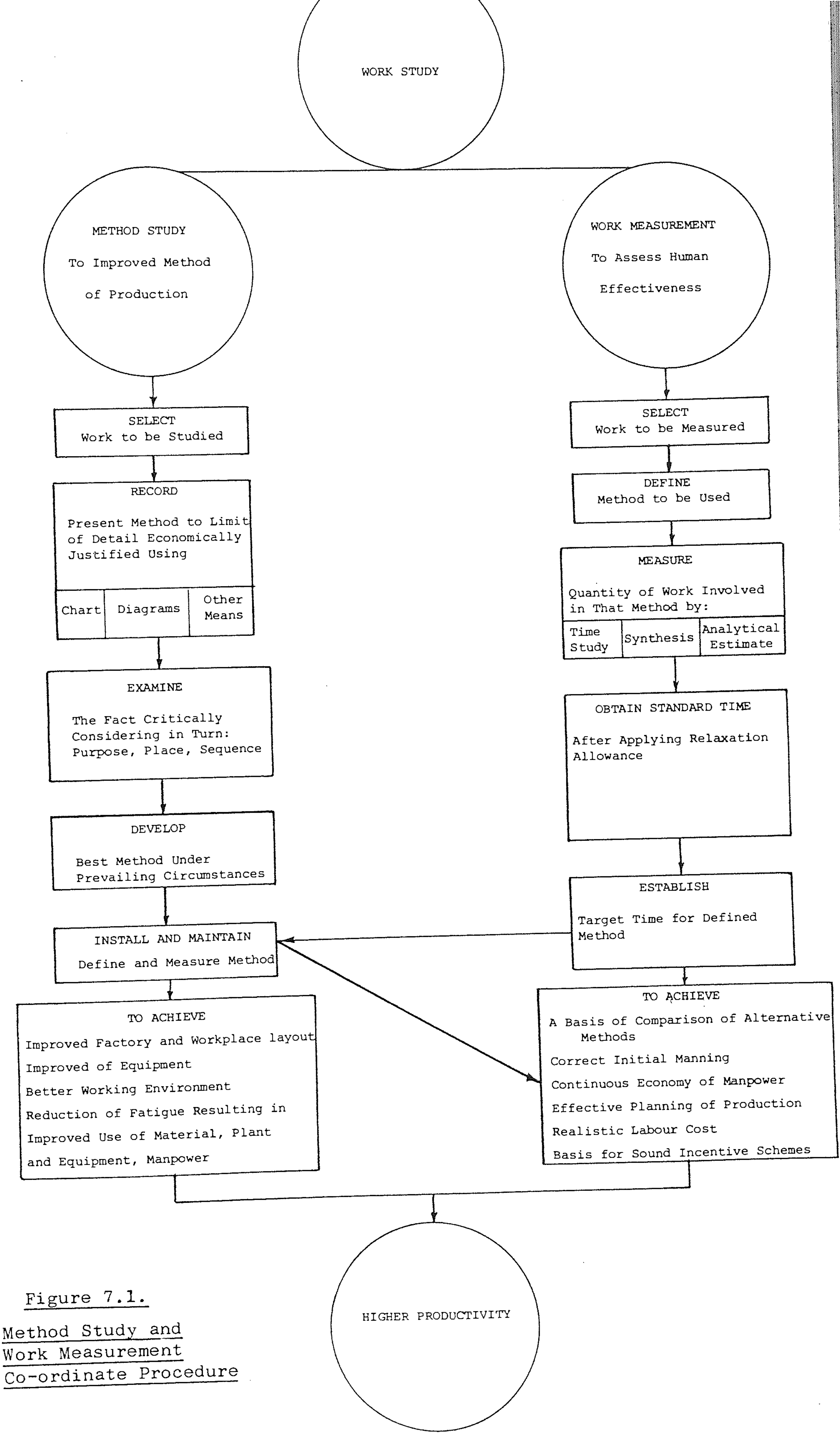

Figure 7.1.

Method Study and Work Measurement Co-ordinate Procedure

Work study technique is considered to be one of the group of Time Analysis Models (223). The main characteristic of this group is that it attempts to measure, predict or improve productivity by means of a detailed analysis of the operation. In highways maintenance departments managements believe that labour control based on work study schemes, tailored to local requirements and coupled with incentive arrangements, is the best way of improving labour productivity (111). They argue that the standard times for carrying out specific tasks which forms part of any work study scheme, is the best available measure for this purpose. The questionnaire showed that a majority of 90 per cent of the counties surveyed had adopted work study schemes. They believed that adopting such schemes would help them to determine the best method of carrying out maintenance work, as a result of analysing the work elements and eliminating any unnecessary operations. In addition, they stated that this would help in improving the utilisation of their labour resources (see Table 7.1).

Table 7.1

The Advantages of Adopting Work Study Schemes

Advantages gained by adopting work study	Reply %		
	Yes	No	Total
Reduction in the work content of the work	90	10	100
Better use of labour	80	20	100
Better plant efficiency	70	30	100
Others: Reducing non-productive work	40	60	100

However, one ought to accept this almost universal acceptance of work study with reservation, because the questionnaire proved that in most, if not all highways departments where work study schemes have been introduced, it entailed only one group of work study techniques, namely time study, without adequate use of the other group, method study. In the highways departments there is a belief that work study means time study only, despite the fact that the definition of time study reveals that accurate and reproducible times can only be achieved if the work is done using a consistent and standardised method. Method study involving an examination of all that the operator does, and all that he uses to perform his task, should precede time study (197).

It seems that the management of highways maintenance departments share the most common mistake made by time study analysts which is that of neglecting to record the method being studied in enough detail and then failing to analyse it adequately (223). When the counties surveyed were asked to explain how they set out the standard times for maintenance work, the majority said that it was by timing the work only without any studies being made as to the method of performing the work (see Table 7.2).

Table 7.2

The Way of Setting and Adopting Standard Time

Aspect	Reply%
Setting the standard time without method study either by : - Authority developing its own standard - Adopting other counties' standard	50
Adopting Marshall standard	40
Adopting no standard	10
Total	100

Despite their recognising the importance of having method study before setting up any reliable standard time, some counties argued that because of financial difficulties they were unable to carry out any method study at the present time. Other counties said that it would take a lot of time and staff to adopt any time study for their own work, and found it more practicable to adopt the schemes of neighbouring counties. The researcher noticed that these standard times were sometimes very old and there had been no attempt made to modify them to suit the local circumstances. Some other counties said that they adopted the standrad suggested by the Marshall Report. They considered this the best alternative until they could develop their own standards based on their own method time studies.

However, some method study should be considered essential, despite statements that it cannot be afforded by some authorities, if work study times are to be made the basis for many decisions affecting the spending of money and other resources. Even before adopting the standard times recommended by the Marshall Committee, sufficient method study must be done, at least to satisfy an authority that the methods do not differ significantly. The researcher believes that it is important to tailor the Marshall standards to suit the circumstances within the different counties before adopting them. These differences were highlighted by the questionnaire and resulted from the following :

1. The size of gangs differs between the counties for the carrying out of similar operations (e.g. patching gangs varied between 2-5 men)
2. The skill of the roadmen differs according to the training, experience, quality of supervision, and the personal factors of each worker within the gang.

3. The satisfaction of the roadmen with their work resulted from their personal motivation, the management's attitude and work relationship.

4. Another main factor to be considered depends on the work environment, the organisation of work, material to be used, types of tools used and the condition of the equipment.

As a result of neglecting such variations in circumstances when adopting standard times, the problems of application can be expected to exceed any advantages. The questionnaire showed that 50 per cent of the counties surveyed faced problems with operating their work study schemes. They said that the standard times applied for incentive schemes were, in most of the cases, unrealistic, inadequate and unacceptable to their roadmen.

Discussing this latter difficulty with the roadmen, the researcher found that the majority of them were dissatisfied with the standard times set in their work sheet. There was a belief among them that, in most cases, these standard times were unachievable and needed to be reset according to the nature of their job, the factors affecting it, and the circumstances surrounding it. Moreover, they expressed the feeling that their efforts had been underestimated and that the management was trying to compel them to work harder without reasonable rewards. The feeling of the unfairness of many standard times was more apparent in areas where the standard time of another county had been adopted without any adjustment being made to suit their local circumstances.

The researcher believes that most of these complaints necessitate consideration being given to the standardisation of methods, materials, tools and working conditions before time standards are established (197). It seems that the trend of adopting such time studies without using method study has resulted from the fact that the main purpose of introducing work study schemes was the installation of incentive bonus schemes. The questionnaire showed that these standard times were mainly used for the calculation of bonuses. The researcher noticed, during the survey, that although there was detailed weekly management control information produced covering all work performed, which was intended to enable management to monitor and control the work effectively, no analysis had been done to assess the reasons for deviations from the standard in order to take corrective action. As such, in most of the highways authorities there was no record kept nor statistical data available to measure or evaluate the rpoductivity of their direct labour.

As discussed in Appendix 7.1, one of the advantages to be gained by applying work study schemes is that the time derived can be used for different purposes, including incentive bonus schemes. The problems raised by the management and the roadmen seemed to be the result of splitting up the work study schemes, i.e. by attempting to use time study techniques without adequate use of method study. Only when these techniques are integrated will management be able to determine accurately the standard time for a job.

The following section gives an example of the procedures which could be followed in order to arrive at the standard time, developed from a detailed analysis of an actual work study.

7.3.1. Examples of Measuring the Productivity of DLO within the Highways Maintenance Departments

These examples were carried out for the purpose of incorporation within this thesis. They cover three different operations of maintenance : kerb-laying, patching and gully-emptying.* They were carried out by responsible work study officers within different highways maintenance divisions in two different highways authorities, "C" and "D". The main reason for carrying out such studies is to demonstrate the applicability of time study techniques as a means of measuring productivity in highways maintenance departments.

The measure of productivity used is the effective performance ratio (EP) where performance is evaluated by comparing the time taken to complete a task with the standard time allowed for the task.

$$EP = \frac{\text{Work completed in productive standard hours}}{\text{Time taken to complete the work in clock hours}}$$

The work study officers in both counties "C" and "D" adopted the following procedures in order to evaluate the work content of a job.

a) Break down each job into operations whose descriptions correspond with those in the Table of Standard Minute Values (SMV's) as established by the authority's work study section.

b) List the quantities of each operation completed, converting the unit of measurement if necessary, into that which corresponds with the SMV for the operation, e.g. m2 of surfacing, etc.

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* The research will discuss in detail kerb-laying examples at both counties "C" and "D". For the results of the other examples see Appendix 7.3.

c) With the aid of a stop-watch and clip-board (or other, perhaps electronic system), measure the time for the operation and book it adjacent to the quantity as the observed time.

d) Extend the observed time to the time the operator would have taken if he had worked at standard performance by rating the deviation from the standard.

Zero rating on the scale represents no work or no effort ; 100 rating represents the rate of output which qualified workers will naturally achieve without over-exertion as an average over the working day or shift, provided they are motivated enough to apply themselves to their work.

$$\text{Basic time} = \text{Observed time} \times \frac{\text{Observed rating}}{\text{Standard rating}}$$

e) Establish an allowed standard time to perform the operation, based upon the measurement of the work content allowing for fatigue, personal needs, special allowances and unavoidable delays.*

$$\begin{aligned}\text{Standard time} = \text{Basic time} &\times (1 + \text{Relaxation allowance}) \\ &\times (1 + \text{Contingency allowance}) \\ &\times (1 + \text{Special allowance})\end{aligned}$$

f) Determine the total work content of each operation in standard minute values

$$\text{Work content} = \text{Work quantity} \times \text{Standard time}$$

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* For more information about the different allowances, see Appendix 7.1.

g) Determine the total work content of the job by summing the work content of the constituent operations. To convert the standard hours, divide by 60.

Despite the fact that these procedures were followed to arrive at the standard time, during the field trip to "C" and "D" counties, it was noticed that the types of forms used and the information provided by each county differed to some extent one from the other.

Appendix 7.2 contains the forms used and shows the detailed calculation of kerb-laying production in both counties "C" and "D".

In county "C", Example 1, the results refer to footway edging kerbs. The results provided by work study officers gives only the basic time required for each element of work without the final calculation of the Effective Performance (EP). As such, the researcher carried out detailed calculations for this example in order to show the information at its final stage as it could be presented to the management for control purposes.

In county "D", example 2, the results refer to road kerbs. Here, the information provided by work study officers was more detailed and the forms used enabled direct calculation of operator performance to be carried out.

7.3.2. Comment on the Example Results

The researcher would like to point out that numerical comparison is not the purpose of carrying out these examples. The main aim is to examine the types of information provided by work study to the management of highways maintenance departments in order to measure and control the productivity of maintenance works. Although the summary of the study results presented by the work study officer at county "D" appears to be more explicit than that of county "C", both appear to suffer from the following disadvantages :

1. Both counties depend on standard times derived from the incomplete application of work study techniques in order to measure the productivity of the work. The information provided by work study was based on time study only, without adequate consideration being given to a study of the method used. The management cannot rely on the standard time unless method study is carried out beforehand. If the management are making the measurements for the purpose of overall control of the productivity, they need to ensure that the quantity and quality of the work done and the methods used are correct.

2. Both counties depend on calculating the Effective Performance in order to measure the rpoductivity. As explained before, the calculation of EP depends only on labour input without considering other input factors (such as material, equipment, management) which contribute to the output.

3. The Effective Performance term was interpreted in a different way in both counties. The researcher believed that the effective performance formula used in both counties needs to be modified to take into account the following factors :

   a) Occasions when the actual amount of work involved in producing one unit is greater than the standard time allowed, for reasons such as faulty materials which need more time to prepare for use, etc. Therefore, the formula may be modified to read :

Effective performance

$$= \frac{\text{Total control credit time+Excess work allowance time}}{\text{Time on work sheet - (Lost time due to reasons beyond the worker's control)}}$$

b) In practice, work often has to be carried out without the standard time having been set. This is because the standard times are not available for all the different types of work. Therefore, unmeasured work has to be excluded from the calculation of the time taken to finish the job. The formula, therefore, may be further modified to read :

Effective performance

$$= \frac{\text{Total control credit time+Excess work allownace time}}{\text{Time on work sheet - (Lost time on unmeasured work and for reasons beyond the worker's control)}}$$

4. It was argued in both counties that the information provided by work study could be used for the purpose of control. The work study officers in County "C" provided the researcher with an example of this information (see Figure 7.2). The work study officer of County "D" said that they produced a weekly control summary to the management for control purposes (see Figure 7.3).

In County "D", different ratios were calculated for different purposes, such as pay performance and capacity ratio. However, the work study officer said that it was not possible to calculate these ratios for Example 2 as they had to wait until the end of the week in order to calculate them. Nevertheless, the work study officer provided the researcher with an example of a weekly control sheet in order to explain how these ratios can be calculated (see Figure 7.4).

In County "D" they calculated the pay performance for the purpose of bonus as :

$$\text{Pay performance} = \frac{\text{Total credit time}}{\text{Total attendance minutes(AMS) on work sheet}}$$

$$= \frac{4196 + 113 + 376}{5278} \times 100$$

$$= 89\%$$

The management judge this ratio against a target of 100.

In addition, they calculated the overall efficiency ratio to give an Efficiency Index :

$$\text{Efficiency Index} = \frac{E}{AMH} \times 100$$

$$\text{Efficiency Index} = \frac{\text{Total credit time}}{\text{Available man hours}} \times 100$$

$$\text{Efficiency Index} = \frac{\text{Total control credit time+Total uncontrolled credit time+total lost time}}{\text{Total man hours} - \text{Non-controlled hours}}$$

This ratio measures how the labour and other resources have been organised and used. It measures the departmental performance, therefore it ought to be changed to exclude the lost time added to the total credits. Even then, the information provided by this ratio is unreliable in giving an indication of the overall efficiency of the work done. As calculated, this ratio depends only on the labour input and its relation to the output to measure the overall productivity.

The researcher has assumed that it is possible to calculate similar ratios for the examples studied in both counties in order to provide the management with the information needed for control purposes (see summary of the results of the examples, Figure 7.5).

From Figure 7.5 it is noticed that the information provided to the management at both counties is not self-explanatory because it gives only the end results without the reasons behind them. Management should be concerned not only with the levels of the different performance rates but also, and more importantly, the reasons behind the deviation from the standard. It is important to use good measurement to show to what extent variations in skill, supervision and working conditions have caused the output of work to differ from the target. It is unlikely that information provided by work study techniques in the form of standard times for the different work elements gives the responsible manager the required information.

In addition, productivity reports provided by work study of both counties were unsatisfactory for control purposes. There were time delays between the execution of the work and the report. (In both counties "C" and "D" this information was delayed by two weeks following the completion of the work).

As a result of the above discussion, it seems that using standard times to measure the productivity of maintenance work gives unreliable and incomplete information to the management. The methods of measurement which are needed should provide the management with information of the activities concerned rather than the end results. Therefore, the method of measurement should, accordingly :

- show what is happening at all times
- take into consideration what happened in previous periods and their influence on current activities.
- recognise happenings that will influence activities in coming periods
- measure the efficiency of current activities.

The next chapter will explain an alternative method of measuring, predicting and improving the productivity of highways maintenance departments. This alternative method is also based on the use of time study. However, the way it is adopted to observe and record the time differs from the traditional approach. In addition, more consideration is given to the factors which affect the work output. It provides management with the reasons behind the results so that it should become an effective aid in the decision-making process.

Engineers Dept. County Productivity Control Statistics Weekly Summary Week ending 22.11.77.

Division	Total Prod.	Total non-prod	Total Lost time	Total credits	Hours		SMs / hour		
					Meas.	Total	Prod	Non-prod	Total
a	19802 75267 95069	7402 36702 44604	90 3822 3912	27794 115791 143585	518¾ 2069¼ 2588	521 2374½ 2895½	38.2 36.4 36.7	15.2 17.7 17.2	53.6 55.9 55.4
b	101260	28149	918	130327	2246½	2398½	45.1	12.5	58.0
c	110674	43775	4916	159365	2734	2958½	40.5	16.0	58.3
d	70602	29383	1224	101209	1903¼	2097	37.1	15.4	53.2
County highways	377605	145911	10970	534486	9471¾	10349½	39.9	15.4	56.4
Bridge works	33154	8169	882	42205	792	807½	41.9	10.3	53.3

Figure 7.2.

County Productivity Control Statistics at County "C"

Management Service Unit Weekly Control Summary All Divisions	Work Study Section		
	Target=100 The ratio of actual man hrs on work sheets to the total possible man hours Actual m/hrs / Poss m/hrs x 100	Target=100 Standard hrs produced as a percentage of hrs taken to produce them Output / Input x 100	Target=100 A combination of capacity and perf. to give the over-all efficiency Cap. ratio / Pay perf. x 100
A	97	76	74
B	98	82	80
C	90	76	68
D	97	82	79
E	100	88	88
F	98	83	81
K	100	92	92
X	100	98	98
County Average	98	83	81
Y. Mat.lab/Boring rig		81	
Z. C.W.D. Drivers		94	
Repair Depot		80	
Repair Depot		99	

Figure 7.3.

Weekly Control Summary at County "D"

STREET LIGHTING SECTION - WEEKLY CONTROL SHEET									Week Ending 11 February 1977				
Foreman	Name	a A.M.s on work sheets	b Total Control Credits	c Total Uncontr. Credits	Lost time credits			d Total L/time credits	e Total Credits	Pay perf. $\frac{e}{a} \times 100$	Op. perf. $\frac{b}{a-(c+d \text{ ams})}$	f Mileage credits	Mileage Percentage $\frac{f}{e}$
					Weather	Wait for material	Other						
A	a	5278	4196	113	75		301	376	4685	89	91	1512	32.27%
	b	2160	1774	191				-	1965	91	93	188	9.57%
	c	1140	672	191	146			146	1009	89	97	74	7.33%
	d	8770	6833	113	1080		240	1320	8266	94	100	1384	16.74%
	e	1036	1040	-			34	34	1074	104	105	140	13.04%
	f	570	637	23				-	660	116	118	86	13.03%
	g	960	991	-				-	991	103	103	180	18.16%
	h	2700	2698	23					2721	101	101	-	-
	i	1020	471	326			135	135	932	91	116	211	22.64%
	j	6619	4974	293	788		47	835	6102	92	97	832	13.63%
	Total	30253	24286	1273				2846	28405	94	98	4607	16.22%
B	x	4800	3879	270	225		45	270	4437	92	96	1436	32.36%

TMH Total man hours excl foreman	AMH Available man hours TMH-NCH	3053 A Total hours on W/sheets	B Total Control Credits	C Total Uncontr. Credits	NCH E=547.5 32942 Breakdown of non-controlled hours					D Total L/time Credits	Capacity Ratio $\frac{A}{AMH} \times 100$	Div.Pay. Perf. $\frac{E}{A} \times 100$	Efficiency Index $\frac{E}{AMH} \times 100$
					Depot	Holidays	Sick	Absent	Others				
657	584	584	28183	1543			40		8 T.C. 25	3116	100	94	94

Figure 7.4.

Example of Weekly Control Sheet at County "D"

Example 1 : County "C"

Total prod. min.	Total non-prod min.	Total Lost time min.	Total Credits min.	Hours		SM's/Hour		
				Measure	Total	Prod.	Non-prod	Total
587.26	85.87	52	706.13	7.68	8	76.5	11	88

Example 2 : County "D"

Capacity ratio	Pay performance	Efficiency Index
Target=100	Target=100	Target=100
The ratio of actual man hours on work sheets to the total possible man hours	Standard hours produced used as a percentage of hours taken to produce them.	A combination of capacity ratio and performance ratio to give the overall efficiency
$\frac{\text{Actual man hours}}{\text{Possible man hrs}} \times 100$	$\frac{\text{Output}}{\text{Input}} \times 100$	Cap.ratio x pay perf.
$\frac{6}{8} \times 100 = 75$	$\frac{905.8}{1002} \times 100 = 90$	75 x 90 = 675

Figure 7.5.

County Productivity Control

Statistics of Examples 1 and 2 :

Kerb Laying at Counties "C" and "D"

CONCLUSIONS

There are a number of different concepts and measures of productivity entailing certain definitions of input and output. In this thesis, productivity is defined as a ratio between all input and output. Although there are several techniques of measuring productivity, it is apparent that no one technique can be used for all the different purposes. Rather, each of them may only be appropriate for a particular objective.

In highways maintenance departments, the technique of work study has been employed as a means of measuring the productivity of its work. Work study is basically a management aid, the various techniques within work study (method study and work measurement) taken together comprise one of the most powerful tools at management's disposal in the day-to-day activities of developing and directing an organisation. However, a major portion of the benefits derived from applying work study will be lost if attempts are made to rely on the use of method study or work measurement technique alone without adequate respect to the other.

It was discovered through the questionnaire that in most, if not all of the counties surveyed, where work study schemes have been introduced, only one technique (time study) was used without adequate use of the other technique (method study). The main reason for introducing work study was the installation of incentive bonus schemes which has created a tendency for them to consider that work study means time study. Moreover, they related the main reason for adopting it to be the calculation of bonuses.

They considered that the standard times for carrying out a specific task, which forms an essential part of work study, to be suitable for the measurement of the productivity of their work. As for setting standard times, the managements of some counties argued that it would consume money and time to carry out method study, which could be especially difficult in the present financial climate. Some other counties adopted either the Marshall standard or their neighbour's standards, without any attempt being made to tailor them to their local circumstances.

As a result, the times derived from such schemes and used as a basis for incentive schemes have caused dissatisfaction among the workers. In addition, using standard times to measure the productivity gives incomplete information about the reasons behind the different results and misleads management in its decisions. Moreover, productivity reports provided by work study were unsatisfactory for control purposes because of the time delays between the execution of the work and the report.

Chapter 8

Application of the Method Productivity Delay Model to Measure the Productivity of DLO

Introduction

In this chapter, the researcher attempts to apply a new method of measuring the productivity of DLO's. This method is called the "Method Productivity Delay Model" (MPDM). Several field studies were carried out using MPDM.

The main aim of these field studies was to provide a demonstration to the highways authorities of the possibility of the application of MPDM to the maintenance work within their counties. It should provide them with a useful tool to measure the productivity of their DLO's and provide the information needed to explain the reasons behind any un-satisfactory levels of performance in order that corrective action can be taken without undue delay. This is important, because unless the management can measure in quantitative terms the rpoductivity of work done, it will be unable both to judge the efficiency of the work and to plan and control the resources available to achieve its desired objectives.

It is suggested that the method offers an improvement over tradition-al methods of measuring productivity and enables delay factors to be identified and quantified.

8.1 Summary of the Method Productivity Delay Model "MPDM"

This productivity model had been developed in an American thesis*. Its main aim is to provide management with a means of predicting, measuring and improving its productivity. It is not claimed that the model will optimise method productivity but, however, it should provide the potential for substantial increases in method productivity.

The model is broken down into four derivation elements, as follows :

1. Collection element
2. Processing element
3. Structure element
4. Implement element.

1. Collection Element

The collection element is a field operation in order to collect operation data that will be used as a basis for modelling the method productivity. In MPDM the gang is observed, studied and recorded as a single entity.

The individual collecting data in the field is required to document two sets of data. For one, he characterises the type of production process taking place by means of identifying the method's production unit, production cycle and leading resource. The production unit is identified as the quantity that is characteristic of the

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* For more details see James, Joseph Adrian, Modelling Construction Method Productivity (unpublished PhD, University of Illinois at Urbana, Champaign, 1974).

production of the method and which can easily be visually observed and measured. The leading resource is that resource which most dictates method productivity and is considered to be the main factor in determining the productivity of the method. Generally, it is the fundamental type of labour or equipment used for the method. If the leading resource is to be changed, the method productivity is likely to be changed, thus resulting in a new method. If the leading resource remains unchanged, the structured productivity equation and method indicators can be used for the predicting and improving of method productivity in future operations.

The production cycle is the time interval between successive occurrences of the production unit.

The second set of data concerns itself with the documenting of production time and the occurrence of production delay. Both are carried out by means of a sampling technique. While the types of delay identified may vary, depending on the production process involved, it was found that five types of delay could easily be documented. These are as follows :

- Environment delay : A physical change in a method condition, e.g. change in soil conditions, change in roadway alignment.
- Equipment delay : Equipment in transit, equipment breakdown and equipment maintenance.
- Material delay : Material not available (including lack of fuel, etc.) for plant, and low workability of material.

- Labour delay : Gang incomplete, resting, attendance to personal needs, "chatting" and inexperience.
- Management delay : Poor planning of method layout and unbalanced resources.

MPDM is not aimed at uncontrollable delays. For example, environment delays identified by MPDM do not include consideration of daily changes in weather conditions. As such, MPDM focusses on those parameters that can be controlled in order to improve method productivity.

There are two different procedures for the documentation of production delays. For one, only the occurrence of a delay is documented. In this case, if more than one productivity delay type is observed, a percentage of the total cycle delay time is booked against each delay type. The other procedure involves recording the times of each type of delay. Any unusual events that characterise a given production cycle are documented.

A typical data collection form entitled "Production Cycle Delay Sampling" (PCDS), together with example data is shown in Figure 8.1.

2. Processing Element

Once the collection element is completed, the process element begins. The purpose of this element is to calculate the average non-delay productivity times, average delay times, and certain indicators to potential productivity improvement. This is done by processing the previously collected field data by means of relatively simple mathematics, i.e. adding, subtracting, dividing and multiplying.

Page of PRODUCTION CYCLE DELAY SAMPLING

Method: Intrductory example Production Unit: Unit

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	900						✓	
2	1000		50%	50%				
3	750						✓	
4	750						✓	
5	1600					✓		
6	1000		✓					

The above shows collection elements before start of processing. Ticks in "Notes" column denotes a non-delayed cycle

The above data may be processed as follows :

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	900						900	100
2	1000		100	100				200
3	750						750	50
4	750						750	50
5	1600					800		800
6	1000		200					200
SUM	6000		300	100		800	2400	1400
OCC.	6		2	1		1	3	6
Mean	1000		150	100		800	800	233.3

For non-delayed cycle

SUM	200
OCC.	3
MEAN	66.7

The above shows how the processing of the data is carried out. In practice, it would be useful to photocopy the collection elements and carry out the processing in red ink.

Figure 8.1. Collection Elements of MPDM

The processing element of MPDM is carried out by means of the processing forms, as shown in Figure 8.2. The example data has been entered. For more information about the detailed calculation procededures, see Appendix 8.1.

The processing derivation elements of the MPDM provide the connection between the model's collected data and the structured method productivity equation and accompanying measures of risk and variability.

3. Structure Element

It follows directly from the process element. The purpose of the structure element is to determine **a method** productivity equation and method indicators.

The first part of the model is the method productivity equation which relates overall or actual method productivity to ideal method productivity as a function of the five identified delay types.

Ideal productivity is the number of ideal cycles in one working hour, i.e. for this example :

$$\text{Ideal productivity} = \frac{60 \times 60}{800} = 4.5 \text{ unit/h}$$

Having determined the ideal productivity, this productivity and the processed production times, and delay occurrences and times are incorporated into the method productivity equation. This equation takes the following form :

$$\text{Overall productivity} = f(\text{Ideal productivity, Average delay times})$$

M P D M PROCESSING

Method : Introductory Example

Production Unit

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\sum \frac{\lvert(\text{Cycle Time}) - (\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	(900+750+750) 2400	3	(2400/3) 800	($\lvert 900-800\rvert + \lvert 750-800\rvert + \lvert 750-800\rvert$) OR (100+50+50/3)
B	Overall Production Cycles	(900+1000+750+750+1600+1000) 6000	6	(6000/6) 1000	($\lvert 900-800\rvert + \lvert 1000-800\rvert + \lvert 750-800\rvert + \lvert 750-800\rvert + \lvert 1600-800\rvert + \lvert 1000-800\rvert$ /6) 233

Delay Information

		Environment	Equipment	Labour	Material	Management
C	Occurrences	0	2	1	0	1
D	Total Added Time	0	(200+100) 300	100	0	800
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	(0)	(300/2) (150)	(100/1) (100)	(0)	(800/1) (800)
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0	(2/6) 0.333	(1/6) 0.167	0	(1/6) 0.167
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0	(150/1000) 0.15	(100/1000) 0.100	0	(800/1000) 0.80
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	0	(0.333x0.15) 5.0	(0.167x 0.100) 1.7	0	(0.167x0.80) 13.3

The detailed processing data is shown in brackets.

Figure 8.2. Processing Element of MPDM

The second part of the structured MPDM is merely a duplication of several of the types of information determined in the processing form. The second part of the structured model is entitled "Method Indicators". This is because the types of information set out in this segment of the model will be used as indicators in regard to prediction and improvement of method productivity. An example of the structure of MPDM is shown in Figure 8.3.

The structured method productivity equation and method indicators serve as the means of implementing the MPDM.

4. Implement Element

The purpose of the implement element is to obtain the overall model objective of providing a means of measuring, predicting and improving productivity.

The use of the MPDM for improving method productivity is accomplished by means of several features of the model. For one, the mere calculation of the different delay factors focusses attention on the amount of production time that is lost due to these delays. As a result, attention can be drawn to them for the purpose of reducing or eliminating these non-productive times.

As to the example for which the productivity equation is shown in Figure 8.3, the results indicate that the management delay is considered to be the most important delay factor which affects the overall productivity.

M P D M STRUCTURE

Method : Introductory Example — Production Unit

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (4.5 unit/h) x (1 - 0.0 - 0.05 - 0.017 - 0.0 - 0.13)

= 3.6 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 67/800

= 0.84

Overall Cycle Variability = 233/1000

= 0.233

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.0	0.33	0.17	0.0	0.17
Relative Severity	0.0	0.15	0.10	0.0	0.8
Expected %age Delay Time per Production Cycle	0.0	5.0	1.7	0.0	13.3

Figure 8.3. MPDM Structure Element

Assume that it has been found that one can eliminate the management delay by employing a foreman to devote his time to planning, organising and controlling the work. This predicts a delay factor of zero for the management delay. Given this prediction, the productivity equation is used to predict an overall productivity of 4.2 unit/h (see Figure 8.4). Assume that the benefit/unit is £30/unit. Comparing the increased cost as a result of hiring a foreman with the saving due to increasing the output as a result of improving the productivity, this yields a net gain of £14/h.

The researcher would like to emphasise the following points :

a) It is convenient to add or to delete from the five types of delay.

b) The frequency and types of delay that are likely to occur during a production cycle vary from one method to the other.

c) The MPDM list of delay types is not meant to be exhaustive.

d) The main difficulty associated with the application of MPDM is identifying the production unit. However, if the model user recognises the two guidelines for identifying the production unit as being that it should be measureable and characteristic of productivity, he should have little difficulty in using MPDM. The researcher believes that it is the highways engineer's responsibility to be able to identify accurately the production unit of any maintenance work after studying the method of carrying it out.

Method Improvement and Prediction

Delay in question : Management delay

Probability of occurrence = 0.167

Relative severity = 0.8

Expected % delay time = 13.3

Proposed total elimination of management delay :

Prediction :

Predicted overall productivity = (Ideal productivity)(1-Een-Eeq-Ela-Emd-Emn)

= (4.5 unit/h)(1-0.0-0.05-0.017-0.0-0.0)

= 4.2 unit/h

Work improvement

Cost : Foreman @ £4/h

Benefits :

Increased benefit/h = (change in productivity/h)(benefit/unit)

= (4.2 - 3.6 unit/h)(£30/unit)

= (0.6 unit/h)(£30/unit)

= £18/h

Net benefit = £18/h - £4/h

= £14/h.

Figure 8.4.

MPDM Implementation Element

8.2. Application of the Method Productivity Delay Model (MPDM) within Highways Maintenance Departments

During 1978 the researcher carried out several field studies in order to apply the MPDM technique to measure the productivity of the highways maintenance.* This technique was applied in three different counties, one Metropolitan and two non-metropolitan, and was concerned with three different types of maintenance work (kerbing, patching and gully-emptying). The researcher carried out these studies personally, after she had trained herself to use the stop-watch in timing similar operations before the actual ones started. While she applied this technique, work study officers were carrying out independent timing studies in order to compare the types of information obtained by their methods with the one suggested by the researcher.

This situation happened in two counties but the independent work study was not carried out in the third county due to a shortage of staff. However, the management of this county was interested enough to let the researcher apply the suggested technique to their work to illustrate the kinds of information provided, and allowed her to accompany their maintenance gang in order to measure their productivity. All the gangs taking part in these field studies were assured that the timings would not affect their bonus level, nor be used to alter the standard times applied, nor affect the performance level required to be achieved.

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* As mentioned in the introductory Chapter 1, the researcher attended several meetings of the highways maintenance group at Warwick University, arranged by PTRC. At the second meeting, in 1977, following some discussion of MPDM with several county officers, the researcher was offered facilities at a number of counties to apply the model to a variety of maintenance operations.

Appendix 8.2. contains the method statements, the collections of MPDM cycle times and the processing element for all the examples covered in the field study. The various forms relating to the following examples are collected together at the end of the section.

8.2.1. Kerb Laying

This section includes three examples of kerb laying within three counties (two non-metropolitan and one metropolitan, referred to as "C", "D" and "B" respectively).

The principal aspects of all kerb laying methods are specified as :

"The operation of kerb laying consists of the placing, jointing, fixing and backing, by hand tools and equipment only, of straight, pre-cast concrete kerbs to B.S.340 on a pre-existing plastic concrete foundation to a pre-determined line and level derived from a string line normally erected by the operator from site reference points provided by the engineer." (228, p.2)

However, the method of kerb laying employed by authorities varies because of differences in the dimensions and weights of kerbs used, the nature of the foundation on which they are located and the methods of setting out.

Kerb laying is considered to be one of the skilled maintenance operations. The leading resource is the kerb layer who is, normally, also the charge-hand or ganger. The production unit for the MPDM was chosen as the placing of four kerbs. This was chosen because of the fact that the workers were placing their kerbs simultaneously. If the placing of a single kerb had been identified as the production unit, it would have been difficult to document the successive completion of production cycles and would have diminished the model user's ability to identify delays.

A production cycle is considered as the time interval between consecutive placement of four kerbs.

Example 1. Kerb Laying at County "C"

This example is concerned with placing kerbs in position at the back of the footway on a wet bed concrete foundation ; kerb size 150 x 50 x 900mm. The line of kerbs was pre-determined by some person other than the kerb layer. Site reference points were provided for the operative from which he derived the eventual reference line to which the kerbs were laid, using traditional setting-out, equipment and techniques. The material used for the foundation was ready-mixed concrete which was delivered to the site by truck mixer.

The gang consisted of two men : a kerb layer who acted as ganger, and a roadman who also acted as lorry driver.

The structure element is shown in Figure 8.5. The ideal productivity is 12 unit/h (i.e. 48 kerbs/h) and labour delay represents the highest delay factor at 18 per cent.

Example 2. Kerb Laying at County "D"

This example is concerned with placing road kerbs to the edge of the carriageway ; kerb size 250 x 125 x 900mm. The gang was a general construction gang which dealt with the excavation of trenches, pipe-laying, kerb laying and other construction work. This example covers only part of the complete laying operation and does not cover the initial trench excavation. The engineer's pegs were established as a known offset distance from the face of the kerb. Ready-mixed concrete was used for the kerb's bed and backing. The gang which dealt with kerb laying consisted of a ganger who also acted as kerb layer, a roadman and a labourer's mate.

The structure element is shown in Figure 8.6. The ideal productivity is 13 unit/h (i.e. 52 kerbs/h), while the overall productivity is 10 unit/h (i.e. 40 kerbs/h), and labour delay is 11.6 per cent, which is the highest of all delay factors.

Example 3. Kerb Laying at County "B"

This example is concerned with the kerb laying operation : strip and re-lay carriageway edging kerbs. The kerbs used were granite road kerbs including the re-usable old ones which had been stripped. The gang was employed on stripping in addition to the laying of the kerbs. As the definition of the preferred method of kerbing refers only to the handling and placement of the kerbs in their final location, this example will not cover the strip operation.

Ready-mixed concrete was delivered to the site by lorry and cement mortar (site mixed) was used for kerb joining. The gang consisted of four men : a kerb layer who acted as ganger, a roadman, a labourer's mate and a lorry driver.

The structure element is shown in Figure 8.7. The ideal productivity is 16 unit/h (i.e. 64 kerbs/h), while the overall productivity is 10.9 unit/h (i.e. 44 kerbs/h) and the labour delay represents the highest percentage at 17.4 per cent.

County C

M P D M STRUCTURE

Method : Kerb laying

Production Unit : 4 kerbs

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (12.08 unit/h) x (1-0.037-0.014-0.175-0.035-0.006)

= 8.8 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 126.9/297.6

= 0.41

Overall Cycle Variability = 187.6/407.5

= 0.46

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.149	0.035	0.471	0.092	0.023
Relative Severity	0.246	0.393	0.372	0.377	0.258
Expected %age Delay Time per Production Cycle	3.7	1.4	17.5	3.5	0.6

Figure 8.5.

MPDM Structure Element, County C, Example 1

County D

M P D M STRUCTURE

Method : Kerb laying

Production Unit : 4 kerbs

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (12.868 unit/h) x (1-0.02-0.031-0.116-0.03-0.028)

= 10 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 64.5/203.3

= 0.3

Overall Cycle Variability = 180.7/360.8

= 0.5

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.048	0.095	0.357	0.119	0.048
Relative Severity	0.416	0.326	0.325	0.252	0.582
Expected %age Delay Time per Production Cycle	2.0	3.1	11.6	3.0	2.8

Figure 8.6.

MPDM Structure Element, County D, Example 2

County B

M P D M STRUCTURE

Method : Kerb laying

Production Unit : 4 kerbs

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (16.35 unit/h) x (1-0.04-0.027-0.174-0.079-0.014)

= 10.9 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 75/220

= 0.38

Overall Cycle Variability = 177/331

= 0.54

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.03	0.05	0.48	0.05	0.04
Relative Severity	1.77	0.53	0.37	0.54	0.37
Expected %age Delay Time per Production Cycle	4.4	2.7	17.4	7.9	1.4

Figure 8.7.

MPDM Structure Element, County B, Example 3

8.2.2. Patching Operations

This section includes three examples of patching operations within the same three highways authorities, as described under kerb laying. The term patching is ill-defined in highways terminology. It may cover all, or some, of the range of activities of the treatment of pavement surfaces, ranging from emergency patching to machine resurfacing. It may be limited to treatment of the pavement surface only, in the form of sealants, or extended to the repair of all the layers of construction. It can include the term reinstatement, either generally or specifically related to trench reinstatement with the work of statutory undertakers. Whatever the term may include, the work may range from methods employing labour and hand tools only, to methods almost exclusively involving plant.

No one method could possibly be described to cover this variety of activities, and any attempt to do so would result in a compendium of methods of pavement surfacing, sealing, maintenance and replacement. Consequently, within the range of activities that the term patching may cover, the team which the Marshall Steering Committee has formed to consider and recommend to it methods of construction, defined as follows the aspects of patching that their method describes:

"The patching envisaged is the replacement of defective, flexible pavements with new flexible material, hand-laid,to any depth not less than the wearing course thickness, or greater than 150mm to effect a permanent restoration of the stability and/or riding quality of the pavement." (229, p.3).

The study of patching operations within the three authorities showed that no two authorities had adopted the same technology, methodology, equipment or organisation. Nevertheless, there is a common core of practice towards which most authorities tend to operate.

The leading resource of a patching operation has been identified as the size of the lorry, which must carry sufficient material to complete the work. The production unit of the patching operation has been identified as the individual patch, regardless of its size.

The researcher carried out a regression analysis of patch area against time. In example 4, which relates to the work at County "C", there was no significant correlation at the 95 per cent level, between the size of the patch and the time consumed in placing the material (see Figure 8.8). In example 5, at County "D", there was significant correlation between the size of the patch and the time consumed in placing the material (see Figure 8.9). The researcher would like to point out that there was a real difference between the types of patching studied in Counties C and D. In County C, the patches were mostly rounded. In County D, the area of the patch is likely to be most dependent on its length since it involved trench reinstatement. Hence, a degree of correlation could be expected in the case of County D. On the other hand, over the range of sizes of patch examined, an intuitive consideration of the patching method suggests that no significant correlation between patch size and cycle time should be expected for the "round" patches in County C.

However, there were not enough examples to reach a definitive, quantitative conclusion concerning the correlations.

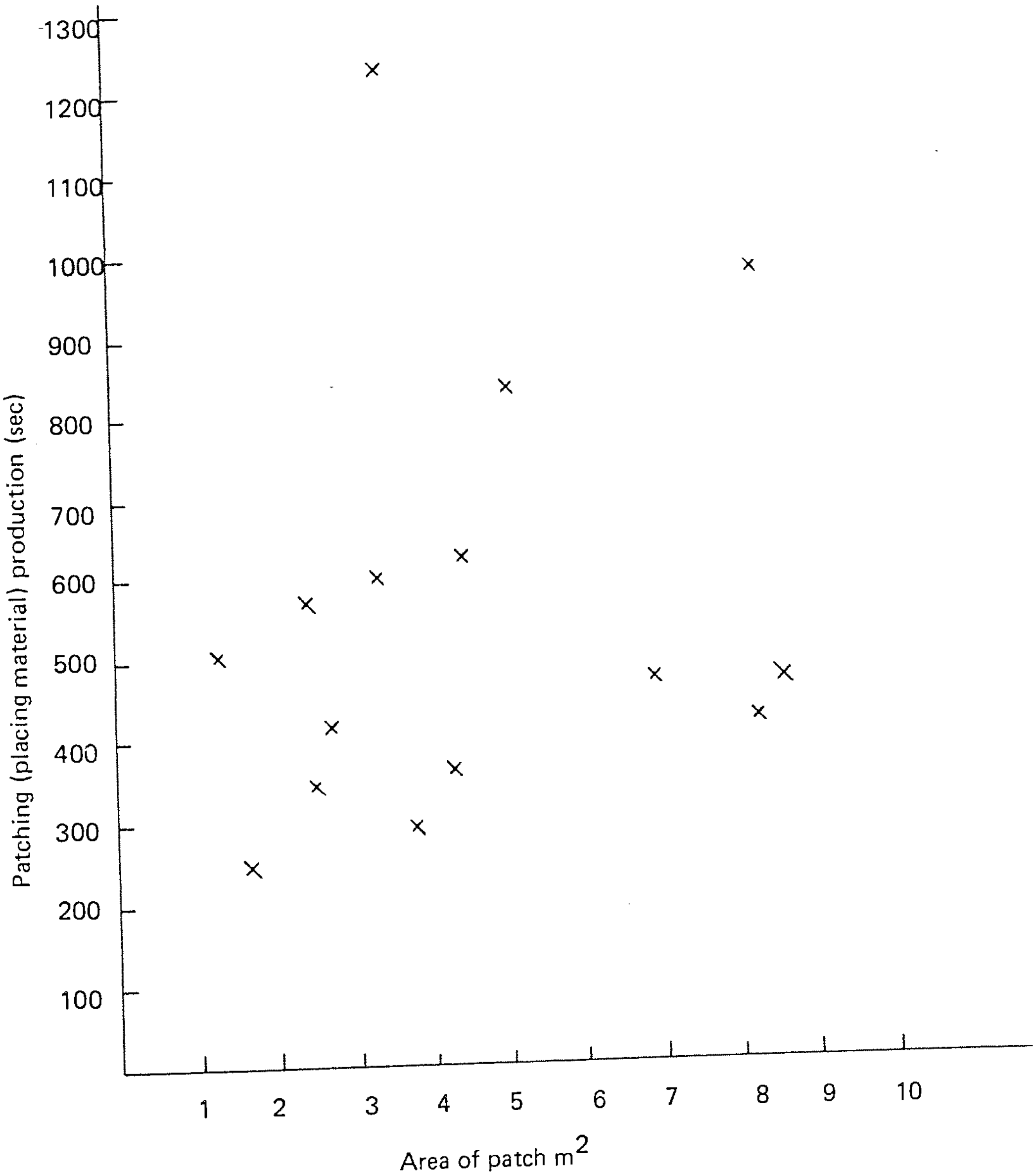


Fig. 8.8: Patching operation (placing material) in County 'C'
The Relationship between the patch size and the time consumed to finish it.

N.B: There is no significant corrolation at 95% level between the size of patch and the time consumed in placing material.

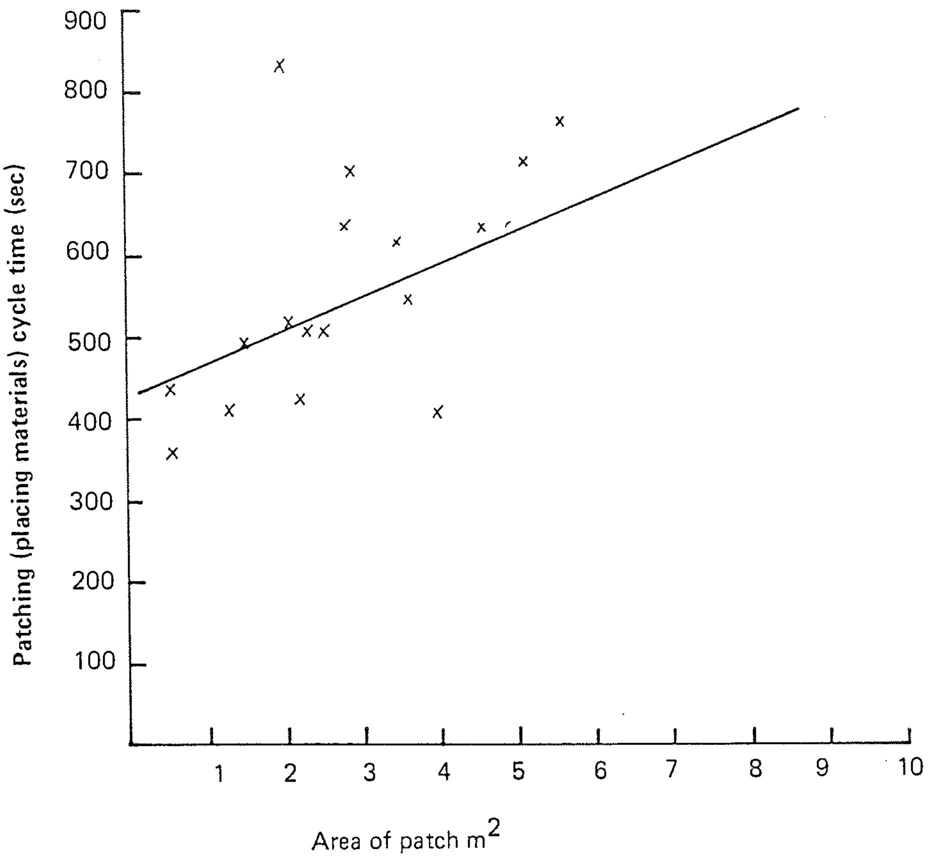


Fig 8.9: Patching operation (placing material) in D county
The Relationship between the Patch size and the
Time consumed to finish it.

N.B. There was significant correlation at the 95% level between the patch size and the time consumed to finish it.

The production cycle was identified as the time consumed between starting the work on a particular patch and finishing it.

Example 4. Patching Operation at County "C"

Patching in this example refers to preventative patching and remedial patching.

a) Preventative patching refers to the sealing of "crazed", "hungry" or "fretting" surfaces where loss of aggregate is about to occur.

b) Remedial patching is the action taken when holes have formed or when erosion and edge failure have taken place, and it is necessary to replace defective material. It also includes alleviation of depressions and repairs around ironwork (at gullies, manholes, etc.)

The gang consisted of two men : one ganger (also acting as driver) and a roadman. The production unit was identified as the individual patch. In this example, the average size of the patches was 4.4m^2. The production cycle was identified as the time consumed between starting the work on a particular patch and finishing it.

The structure element is shown in Figure 8.10. The ideal productivity of this example is 9.8 unit/h, the overall productivity is only 7.5 unit/h. Labour delay represents the most important kind of delay at 10.2 per cent.

Example 5. Patching Operation at County "D"

The example of patching, in this case, involves the application of fine cold asphalt wearing course to the reinstatement of trenches for services. This operation started a week before the observation took place, when the base course had been laid down and compacted by the same gang.

The gang consisted of three men : a ganger (who also operated as driver), a roadman and a labourer's mate.

In this example, the average patch size, which was identified as a production unit, was $3.7m^2$. Fogure 8.11 shows the structure element where the productivity equation has been derived. Although the ideal productivity is 11.7 unit/h, the overall productivity is only 7.3 unit/h. Labour delay represents the most important kind of delay at 14.8 per cent, per production cycle. Material delay represents the second most important kind of delay at 14 per cent per production cycle, due mainly to the low workability of the material used.

(During the study of this example, the patching material had been delivered to the work location directly by the supplier. The gang had to continue working in another location whilst the material was left in the street until the next day. When the gang wished to start using it for the next operation, it was not suitable for direct use. The ganger directed one of the roadmen to prepare it for use which, of course, meant more delay occurring to the operation, which ultimately affected productivity).

Example 6. Patching Operation at County "B".

This example describes a trench reinstatement operation to footways and carriageway, associated with the work of statutory undertakers. It was noticed during the study that this gang did not adhere to the procedure every time they performed the work. When they were patching some areas, the underlying ash was not rolled prior to placing the base course macadam.

The gang consisted of four men : a ganger, a roadman, a labourer's mate and a driver. The structure element is shown in Figure 8.12. The ideal productivity is 13.6 unit/h and the overall productivity only 8.4 unit/h as a result of the occurrence of the different types of delay. The labour delay represents the highest expected delay at 29 per cent.

Comment on Patching Example

The three examples of patching operations indicated gang sizes which varied from 2 to 4 men. Although the Marshall Report recommends a gang size of 3 men, there is no direct data available to prove that such a size is more efficient than 2 or 4-men gangs.

The researcher noticed that the variable site circumstances and organisational work of the different authorities affected the method of delivering the material. In most of the shire counties surveyed, the material was collected from the depot first thing in the morning, and then the patching gang began their journey to the work site. The workability of the patching material is very important ; the material, which is stored at the depot, should be protected to prevent loss of volatiles, and hence, loss of workability.

County C

M P D M STRUCTURE

Method : Patching

Production Unit : Individual patch

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (9.80 unit/h) x (1-0.028-0.048-0.102-0.052-0.009)

= 7.5 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 98.5/200.8

= 0.49

Overall Cycle Variability = 322.2/481.9

= 0.67

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.134	0.254	0.463	0.194	0.045
Relative Severity	0.208	0.188	0.220	0.266	0.190
Expected %age Delay Time per Production Cycle	2.8	4.8	10.2	5.2	0.9

Figure 8.10.

MPDM Structure Element, County C, Example 4

M P D M STRUCTURE

County D

Method : Patching

Production Unit : Individual patch

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (11.7 unit/h) x (1-0.039-0.0446-0.148-0.123-0.0196)

= 7.3 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 147.9/374

= 0.395

Overall Cycle Variability = 208.9/490.3

= 0.43

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.102	0.102	0.571	0.225	0.091
Relative Severity	0.386	0.440	0.259	0.550	0.48
Expected %age Delay Time per Production Cycle	3.9	4.5	14.8	12.4	2.0

Figure 8.11.

MPDM Structure Element, County D, Example 5

County B

M P D M STRUCTURE

Method : Patching

Production Unit : Individual patch

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (13.60 unit/h) x (1-0.022-0.027-0.291-0.044-0.00)

= 8.4 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 59/217.7

= 0.27

Overall Cycle Variability = 235.4/430

= 0.55

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.07	0.15	0.54	0.14	0
Relative Severity	0.326	0.178	0.537	0.361	0
Expected %age Delay Time per Production Cycle	2.2	2.7	29.1	4.9	0

Figure 8.12

MPDM Structure Element, County B, Example 6

8.2.3. Gully Emptying Operations

This section includes three examples of gully emptying within the same three authorities. The method observed consisted of starting from the depot and following certain routes to check and clean gullies and catchpits.A labour crew consisted of two labourers,one of them being a driver and the other operated the gully suction pipe. The production unit for the method was the cleaning or checking of a gully or catchpit. A production cycle is considered as the time interval between consecutive cleaning of the gullies. The leading resource for the method is considered to be the gully emptying machine.

Example 7. Gully Emptying at County "C"

This example covers completely emptying gullies located on a trunk road. The crew started their work of cleaning gullies by following certain routes.

The crew consisted of two men, one worked as a driver for the machine and the other operated the gully suction pipe.

The structure element is shown in Figure 8.13. The ideal productivity is 41 unit/h while overall productivity was 32 unit/h ; labour delays, material delays and environmental delays were at 7.5 per cent,6.4 per cent and 6 per cent respectively.

The researcher noticed the following points during the study at County "C":

1. The gang worked very hard and continuously, despite showery weather. The gang explained that they were rapid because they were working on a trunk road and the gullies required less effort to clean than was the case for a country road.
2. This method has an inherent kind of delay because usually, one of the two men did nothing while the other was working.

Example 8. Gully emptying at County "D"

This example covers cleaning, emptying and inspecting catchpits and emptying gully pots.

The crew consisted of two men, one worked as machine driver and the other operated the gully pipe ; they changed their roles every other week. They started from the depot and followed pre-determined routes.

The structure element is shown in Figure 8.14. The ideal productivity is 18.9 unit/h while the overall productivity is 16 unit/h. Labour delay represents 7.9 per cent of the total production cycle, having the highest percentage above all the other delay types.
It was noticeable that the rate of production of this crew was not very high due to their having to inspect and clean catchpits as well as gullies, the former needing more time. In addition, on the day of the study, the gang dealt with gullies on country roads which need more travel time and more actual emptying time because many of them were full of detritus.

Example 9. Gully-Emptying at County "B"

This example covers emptying gullies in a carriageway and a market area.

The crew consisted of two men, one worked as machine driver and the other operated the gully suction pipe. The structure element is shown in Figure 8.15. The ideal productivity was 22 unit/h, while overall productivity was 12 unit/h.

It was noticeable that the output of this gang was lower than the other two gangs of the previous examples, due to different things which happened on the day of observation :
First, there was a breakdown of the vehicle which prevented the completion of the first half-day's route. The vehicle had to be returned to the depot for repairs.
Secondly, after lunch-break, the gang re-started the route in the

market area where gullies needed to be filled with clean water after cleansing. This necessitated refilling the tank with clean water at short intervals.

As explained above, because of the special treatment of the gullies in the market area, and the breakdown of the vehicle, the highest delay factor was material delay at 22 per cent, followed by equipment delay at 9.6 per cent. (Equipment delay percentage covers the delay time during working hours, and does not include time the vehicle was at the depot.

County C

M P D M STRUCTURE

Method : Gully-emptying

Production Unit : Gully

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (41.2 unit/h) x (1-0.06-0.025-0.074-0.064-0.0)

= 32 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 24.2/82

= 0.30

Overall Cycle Variability = 50.6/112.5

= 0.45

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.110	0.018	0.083	0.026	0
Relative Severity	0.544	1.444	0.894	2.430	0
Expected %age Delay Time per Production Cycle	6.00	2.5	7.4	6.4	0

Figure 8.13

MPDM Structure Element, County C, Example 7

LIBRARY

County D

M P D M STRUCTURE

Method : Gully-emptying

Production Unit : Gully

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

= (18.9 unit/h) x (1-0.046-0.01-0.079-0.012-0.046)

= 16 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 56.07/156.3

= 0.36

Overall Cycle Variability = 109.4/224.5

= 0.49

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.15	0.033	0.15	0.017	0.017
Relative Severity	0.308	0.306	0.527	0.724	0.268
Expected %age Delay Time per Production Cycle	4.6	1.1	7.9	1.2	0.5

Figure 8.14

MPDM Structure Element, County D, Example 8

M P D M STRUCTURE — County B

Method : Gully-emptying — Production Unit : Gully

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emm)

= (22.05 unit/h) x (1-0.029-0.096-0.048-0.222-0.0)

= 13.3 unit/h

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability = 55.6/147.3

= 0.378

Overall Cycle Variability = 158.2/269.8

= 0.586

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence	0.119	0.075	0.119	0.45	0.0
Relative Severity	0.241	0.129	0.403	4.948	0.0
Expected %age Delay Time per Production Cycle	2.9	9.6	4.8	22.2	0.0

Figure 8.15

MPDM Structure Element, County B, Example 9

8.3. Comments on the Practical Application of MPDM Within the Highways Maintenance Departments

The researcher constructed a MPDM for each of the three types of maintenance methods. These methods include two labour-intensive methods (kerb laying and patching) and one plant-intensive method (gully emptying.)

8.3.1. Comparison between MPDM and Time Study

1. Like time study, MPDM documents production time, although addressing different data. In particular, it documents the production cycle as either having no productivity delay, or it detects what type of productivity delay exists.

2. Like time study, it can be applied to most, if not all repetitive maintenance work if the production unit can be properly defined.

3. MPDM differs from time study, which focusses attention on the production time of individual workmen, to the extent that in MPDM, the whole gang is observed and recorded as a single entity. Its main objective is to smooth the flow of work.

4. Another main difference from time study is that MPDM is aimed at documenting the different delay factors which can be controlled by management.

8.3.2. The Advantages of MPDM over Time Study

Using MPDM to measure the productivity of three different maintenance operations within three counties is considered to be the best means of presenting the advantages expected to be gained by its application. From an inspection of the results of the examples studied (see Figure 8.16), one can conclude the following :

1. The adoption of MPDM for measuring the productivity of maintenance work will permit the productivity to be measured in terms of the resources used in producing output. When measuring the productivity of DLO's the human factor, as well as other factors such as material, plant, management and environment are considered. It gives, therefore, a more accurate and reliable basis for measurement.
2. By using MPDM it should be possible not only to measure, in a reliable way, the productivity of DLO's, but also to predict their productivity beforehand. When the overall productivity, ideal productivity and delay times are documented for different types of activity, this should make it possible to calculate indices which could indicate the expected performance of any gang, and allow targets to be set. Once the new productivity for the method is documented, the prediction can be analysed as a means of achieving better future methods of productivity. It informs the management

Method	County	Gang Make-Up	Production Unit	Non-Delay Productivity (unit/h)	Overall Productivity (unit/h)	Overall Cycle variability	% Environment Delay	% Equipment Delay	% Labour Delay	% Material Delay	% Management Delay
Patching	C	1 Ganger 1 Lorry Driver	Patch Average size 4.4m^2	9.8	7.5	0.67	2.8	4.8	10.2	5.2	0.9
	D	1 Ganger 1 Lorry Driver 1 Labourer	Patch Average size 3.7m^2	11.7	7.3	0.43	3.9	4.5	14.8	12.4	1.97
	B	1 Ganger 1 Lorry Driver 2 Labourers	Patch	13.6	8.4	0.55	2.2	2.7	29.12	4.4	0
Kerb Laying	C	1 Craftsman 1 Lorry Driver	4 kerbs footway edging	12.1	8.8	0.46	3.7	1.4	17.5	3.5	0.6
	D	1 Craftsman 1 Kerb layer 1 Labourer	4 kerbs Road kerb	12.9	10.0	0.50	1.98	3.1	11.6	3.0	2.8
	B	1 Craftsman 1 Lorry Driver 2 Labourers	4 kerbs Road kerb	16.4	10.9	0.54	4.4	2.7	17.4	7.7	1.4
Gully-Emptying	C	1 Machine Driver 1 Labourer	Gully	41.2	32.0	0.45	5.97	2.5	7.5	0.6	0
	D	1 Machine Driver 1 Labourer	Gully	18.9	16.0	0.49	4.6	1.01	7.9	1.2	0.5
	B	1 Machine Driver 1 Labourer	Gully	22.0	13.0	0.59	2.9	9.6	4.8	22.2	0

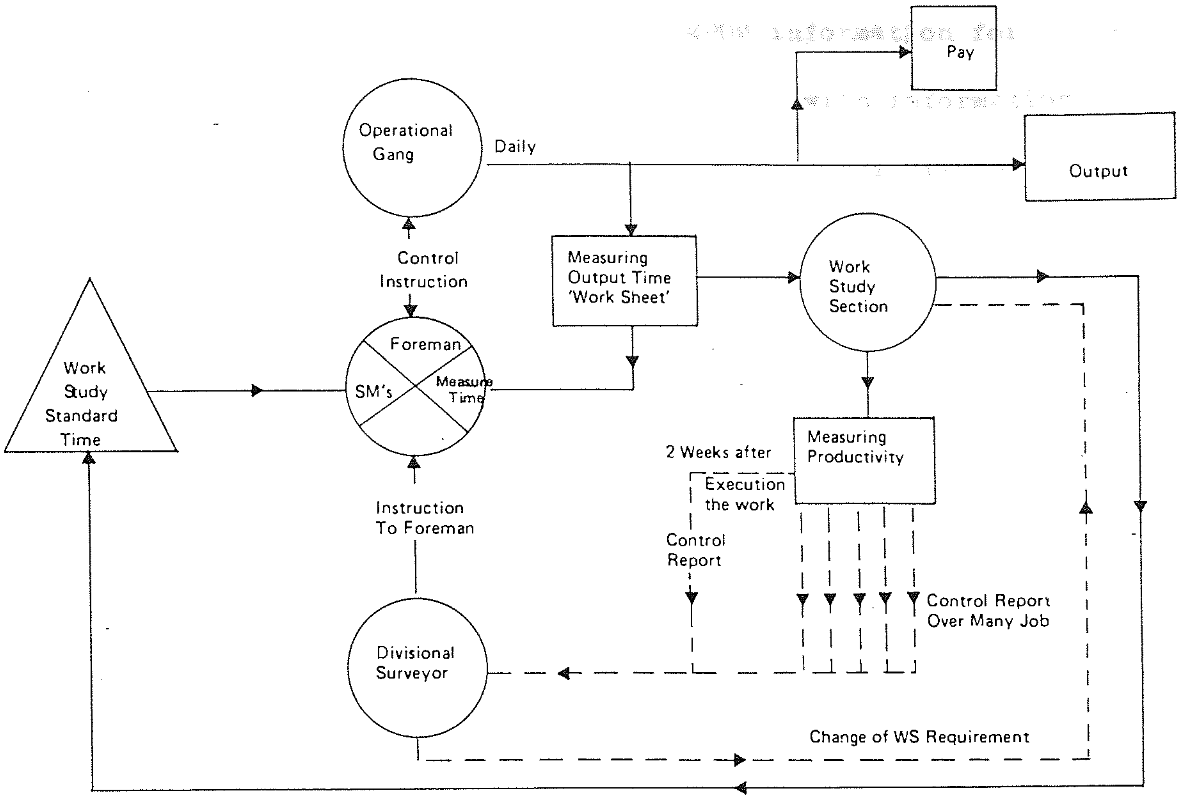
Figure 8.16.

Summary of the Results of the Examples of MPDM of the reasons behind the results whcih are predicted so that management can enable the reduction or elimination of any past delays, and thereby increase productivity.

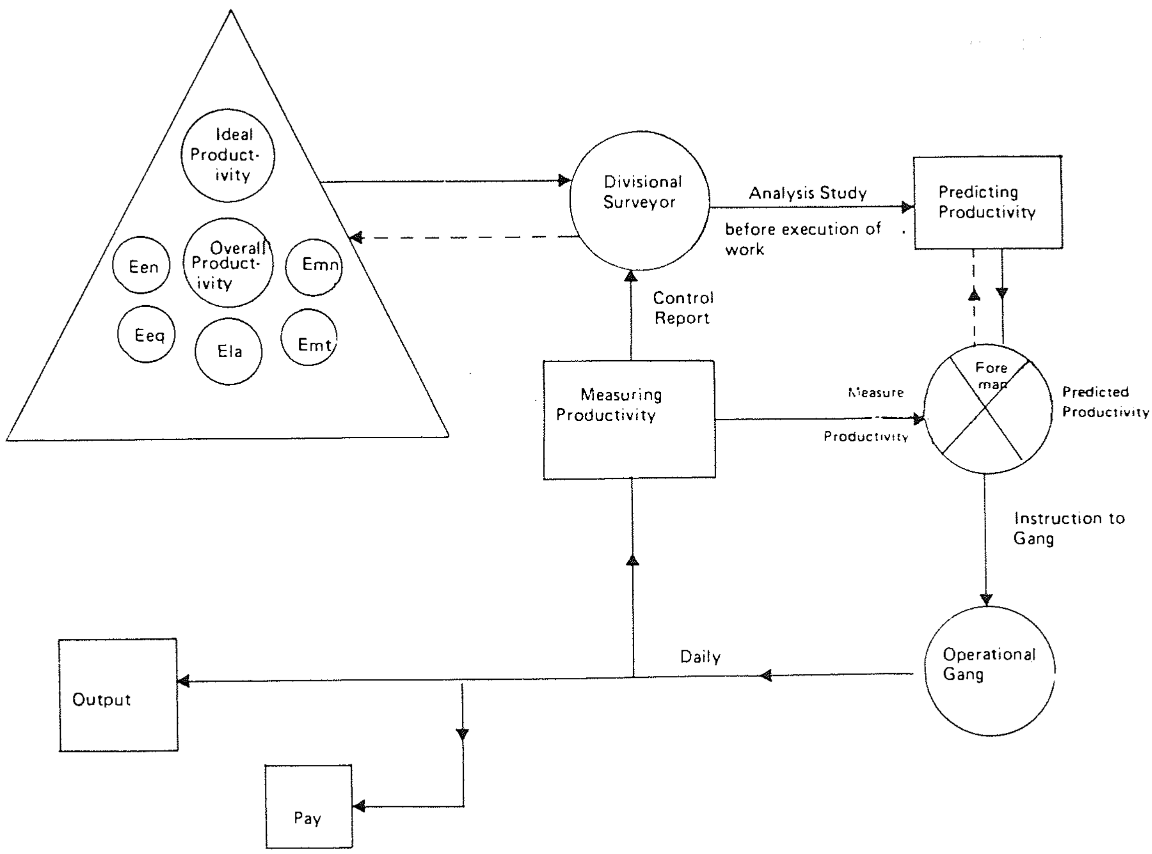
In order to explain the importance of this information as guidance to management, and in order to provide a better means of control, a comparison will be made between the usefulness of work srudy information and MPDM data regarding this aspect. (See Figure 8.17).

A. Control system using work study information :

In Figure 8.17a, the standard time derived for one operation (after appropriate method study and time study had been carried out) will be provided for the foreman. He will give his instructions to a particular gang regarding these standards, and will explain the details of carrying out the job. After the work is executed, the output is measured in time and the amount of gang payment will be decided. The foreman will compare the measured output of time and the standard time and give any control instructions needed if there was an unacceptable variation. Two weeks after the work has been executed, the work study section provides a "Control Report" for the Divisional Surveyor, explaining the different calculated performance of such a gang compared with other, similarly occupied gangs. In cases of unsatisfactory performance the management can contact the work study section asking for detailed information about the reasons behind the results. If the inefficiency is proved to have resulted from wrong or unachievable standards, the management might give instructions to the work study section to change the standard.



A. Management Control Over One Job using work study information



B. Management control over one job using MPDM information

Fig. 8.17: Comparison between work study and MPDM information as a means of management's control.

B. Control systems using MPDM information

Figure 8.17b illustrates the effective role of MPDM information for control purposes. It provides the Divisional Surveyor with information regarding the expected ideal productivity, overall productivity and productivity delay factors. The calculation of these productivity delay factors (Een, Eeq, Emt, Ela, Emn) focusses attention on the amount of productivity time that was lost due to these delays. As a result, attention can be drawn to reducing or eliminating the non-productive time. Accordingly, the Divisional Surveyor can predict the productivity expected to be achieved after his analysis, and after having taken the necessary procedures to reduce or eliminate all, or some, of the delay factors. He will give his instructions to the foreman who can take part in suggesting practical procedures, or approve the practicability of applying any suggestion. The foreman will give his instructions to the ganger in charge of this operation after all the necessary action has been taken to improve the expected productivity. In other words, the management should study the job and plan carefully the procedure which minimises the delay affecting the productivity of this gang.

In this way, the management helps the workers to achieve higher pay, provided they are efficient in carrying out their work, before the actual execution of the work. After the work has been executed, the measured productivity will serve as a means to control the work in question, suggest any improvements, and reconsider any new information provided by the actual measurement.

3. The application of MPDM provides the management with the information needed for comparing the work content of alternative

methods of the work performed. By focussing on the similar, yet different methods for the work process, the difference in method productivity can be a valuable aid to the management in evaluating the alternative methods as to productivity, cost and expected variability of productivity. As noted in the examples, there were different gang sizes used in performing the same operation. In road kerb laying, the overall productivity of a gang of 4 men in County B, at 10.9 unit/h was about the same as that for the gang consisting of 3 men in County D at 10 unit/h. More detailed analysis of the cost of carrying out these methods may result in management decisions to use a gang size of 3 instead of 4 men. In another case for a patching operation, the overall productivity of a gang of 2 men was 7.5 unit/h in County C, which was nearly the same as that for a gang of 3 men in County D. This means that the structure of MPDM offers a ready means of making comparisons, and helps the management to take such a decisions that, where two alternative methods seem equally advantageous, the one which requires the lower cost for completion will be the more efficient.

4. The information provided for the management forms a reliable basis for control and a means of ensuring the use of resources to maximum capacity. It focusses management's attention on those controllable delay factors where effort should be spent in order to reduce or eliminate them, if any desired improvement is to be achieved. This can be achieved by characterising production delays against the classification of the various types of work being performed. The documentation of delay factors, with regard to the type of work performed, facilitates the processing of the delay indicators which can be used to indicate potential improvement. By analysing the

amount of ideal and ineffective time inherent in a job, the management should be able to take correct decisions for the efficient allocation of work.

However, the researcher suggests that some level of delay may have to be accepted. The management of highways maintenance departments need to establish some guidelines as to what is to be considered an acceptable delay.

In order to illustrate the above, the researcher will assume that the following are considered to be acceptable and non-acceptable delay time percentages - although in practice, it is likely that the level of acceptance will vary according to the delay type.

0 to 5 per cent	- Acceptable
6 to 10 " "	- Some work improvement potential
11 to 30 " "	- Work improvement analysis essential
Over 30 " "	- Another method should be considered.

Applying these percentage guidelines to the results of the example studied (see Figure 8.16) the following conclusions can be drawn.

A. Environment delay

Most of the environment delays are considered acceptable, except for Example 7 of gully-emptying at County C. In this case, the delay was due to the effect of parked cars, many gullies located in housing areas which required more emptying time as they were full of detritus, also, the gully-emptier had to be re-routed by the police because it was causing traffic delays.

Although the management might consider the first two reasons to be circumstantial, the third may be reduced by considering the timing of cleaning of busy roads to coincide with expected low traffic flows.

B. Equipment delay

All equipment delays may be considered to be normal, except for Example 9 of gully-emptying at County B. Here, delay was caused by a breakdown of the vehicle which prevented the completion of the first half-day's route. No communication with the divisional office was possible in order to report the breakdown. This could have been avoided if easier-to-maintain plant with readily available spares had been used, and the operators had been given a basic training in mechanical maintenance.

C. Material delay

Materials delays were considered unacceptable in four of the examples studied. The main causes were :

- Late delivery of material (such as ready-mixed concrete)
- Low workability of "stale" bituminous material
- Insufficient quantity of material delivered.

Improvement in material ordering procedures and distribution control should reduce the causes of this type of delay.

D. Labour delay

Labour delays are considered to be high and unacceptable in all cases. The high labour delay was due to reasons such as :

- Oversized gangs
- Inexperience of one or more members of a gang
- Boredom

- Excessive relaxation
- Lack of physical fitness
- Unnecessary loss of time through undue discussion between members of the gang
- Weak supervisor
- Contingency and personal needs.

The highest delay percentage occurs in Example 6 of the patching operation in County B. The gang consisted of 4 men. It was observed that one operative was inexperienced, and another one was poorly motivated. The gang lost a considerable amount of time waiting for materials and were unwilling to use this time preparing the trench ahead. In addition, the ganger was old and appeared to tire easily.

The high labour delay factors, in all cases, indicates that management's efforts should be focussed on reducing the labour-related delay in order to improve productivity.

The researcher would like to emphasise the fact that the labour force is considered to be the agent of production, which most markedly affects the quantity and quality of finished output (93). It is considered to be the most complex and unpredictable factor encountered in the production system (230). This means that the human resource is that one of the inputs which is incalculably involved with all other inputs which, together, contribute towards the final output (89).
Since it is evident from the field studies that the principal delay type is labour delay, then it may be more appropriate to

categorise delay acceptance levels for labour only, particularly for the labour-intensive highways maintenance operations of kerb laying and patching.

The next chapter is devoted to the means of improving the productivity of DLO's within the highways maintenance departments.

E. Management delay

The management delay is considered to be acceptable in all cases. The reasons for the management delays cited with the examples studied were :

- Inadequate supervision
- Inaccurate assessment of the work content of the job
- Under-estimation of the quantity of materials required (in one case leading to an extra day's work)
- Unavailability of foreman (to explain methods, etc.)

The researcher believes management is responsible indirectly for most high delay percentages. Management should be responsible for accurate measurements of materials requirements and for ensuring correct delivery times of materials. This is particularly important for some weather-sensitive operations where the final decision on deliveries can only be made on the day scheduled for the work to take place. Management should also be responsible for the condition of all equipment and the correct matching of equipment and material according to the requirements of the work specification. Therefore, what has been cited as material, equipment and labour delays could, in part, be entered under management delay. Ensuring the adequate smoothness of work flow and efficient organisation of the work is one of the major tasks of management. This should not only reduce material and equipment delay but should also result in improved motivation of the workers. More efficient management should lead to greater respect of management by workers, which should result in higher productivity.

From the above discussion , the researcher would like to emphasise the following :

1. MPDM is easy to implement and does not require any further financial resources or more skilled work study officers. It does not require any complicated mathematical calculations which deter the application of some other methods.
2. In order to facilitate more detailed analysis of the various types of delay, the researcher suggests that the following modifications be made :
   (i) The "Notes" column in Production Cycle Data Sampling (PCDS) original form can be changed to "Remarks on delay". The model user can then record his notes concerning any peculiar circumstances characteristic of the production cycle in question. This should provide the management with a useful tool with regard to work improvement and facilitate checking the reasons for any excessively long delays in the production cycles.
   (ii) Include an additional report sheet which may be called the "Daily Record of Working Conditions and Delay Factors". See Figure 8.18 which is completed as outlined below :
      - Make a detailed record on a separate sheet of the different kinds of delay under the five types of delay. This

Method : Gang Size : Material used : Equipment used :																									Date : Time started : Time finished : Total Recorded Time :
Delay Factor																									
1. Environment Delay (Een)					2. Equipment Delay (Eeq)				3. Material Delay (Ema)				4. Labour Delay (Ela)								5. Management Delay (Emn)				
Provision of pedestrian access	Provision of access to certain working areas	Interference from moving vehicles	Effects of parked cars	Change in road conditions	Breakdown	Operating below normal production rate	Maintenance	Not available	Defective	Not available	Insufficient quantity	Material placement constrains equipment	Over-sized gang	Relaxation	Waiting for another mate	Lack of physical fitness	Inexperience of one or more members	Over-chatting among a gang	Contingency and personal needs	Boredom	Inaccurate assessment of work content	Inadequate or weak supervision	Underestimated quantity of material required	Late arrival of foreman	Excessive chatting with Gangs
✓	✓		✓	✓		✓		✓		✓	✓			✓	✓	✓	✓		✓	✓	✓	✓	✓		
Working conditions : Very cold weather Un-working time due to wet weather :																									

Figure 8.18.

Daily Record of Working Conditions and Delay Factors

*N.B. The delay information entered on this sheet represents the delay factors cited with Example 1 - Kerb Laying at County "C".

may be done twice daily.

- Document the weather conditions of the method in question and record the unworking time due to wet weather in a separate column. This kind of delay will not be calculated to derive the productivity equation, as MPDM is aimed at only the controllable delays. The documentation of this uncontrollable delay, together with the starting times and finishing times, will give the management some indication of the way the whole time is consumed.
- Record the starting and finishing time, the gang size, the material and equipment used, on the same sheet, in order to get complete information about the operation in question.

Adopting any of the above suggestions would not change the MPDM technique.

Conclusion

This chapter is mainly devoted to demonstrating practically, the application of the suggested technique of the Method Productivity Delay Model (MPDM) on three different maintenance operations within three different counties, in order to convince the management that it can be used to measure the productivity of their work.

The aim is mainly achieved through : studying the method of the work ; identifying the leading resource ; identifying the production unit ; recording the time for completing the production cycle and any kinds of delay occurring during that time ; calculating the overall productivity by taking into consideration the effects of other factors which contribute to the final output. By measuring DLO's productivity with MPDM, the management should be able to satisfy the requirement of the decision regarding the use of DLO's to carry out the maintenance work in the most efficient way.

In addition, the types and kinds of information obtained from the application of this method should permit the prediction of the level of productivity likely to be achieved, before executing the work. The documenting of delay factors as to the types of work performed, facilitates the processing of the delay indicators which can be used to indicate potential improvements. Thus, the information provided should form a reliable basis for planning, controlling and improving the work.

Another advantage, besides its accuracy as a management tool for decision-making, is its simple mathematical calculation. This means that its application will not require either any change of the skills of work study officers, or more money (which is considered a critical factor in the highways maintenance departments, and which prevents the application of more sophisticated methods).

Chapter 9

Improving the Productivity of Direct Labour Organisations

Introduction

The main aim of this chapter is to seek a better understanding of the way in which human resources can be used more effectively within the highways departments. The management have to bear in mind that when individuals join the organisation, they have their own aspirations and expectations. An understanding of the way they perceive and react to their environment is considered to be essential for management understanding of the ways in which they work, providing information for planning and improving the utilisation of human resources. This is important because there is evidence that one of the reasons behind the failure of productivity programmes is its failure to match the external and internal individual perception of productivity.

9.1. The Importance of the Human Factor in Improving Productivity

The findings of the researches provide different approaches that can be adopted to tackle the problem of improving productivity, according to the different circumstances. The following approach may provide alternatives for improving productivity (231) :

1. Increasing the capital expenditure
2. Increased motivation to encourage better effort
3. Combination of 1 and 2
4. Some modification in the imposed system, plus open encouragement to raise productivity significantly.

The Management has to choose among them according to their circumstances in order to improve the level of productivity. However, it is important to keep in mind that the "rare factor", i.e. that factor of all others which is most effective in determining productivity - must be used as efficiently as possible in order to achieve the improvement desired (232).

The researcher believes that although these alternative ways can be combined to affect the level of productivity, imrpoving human resources within the organisation has a greater impact on productivity than has capital investment (233). There is strong evidence that the human resource is generally accepted as the critical resource upon which the economic future depends (234). Many of the studies carried out in different countries show that the main reason behind productivity increases was not due to the capital investment, but due to such aspects of human factors as better techniques and better organisation (235). This result emphasised by another study suggested that productivity can be represented by a cube consisting of three dimensions : the method of work, the speed of work and the utilisation of work people and equipment (236). The volume of this productivity cube can be increased by better motivation of the work force, by better planning of the work load, and analytical study of the method of work will highlight areas for improvement to ensure that there is no waste of effort or time. The researcher would like to point out that the methods and processes employed are considered to be not only the method of producing the output, but also the ways and means of organising and managing all facilities available from existing resources.

Therefore the management's major task will be to optimise use of all resources as effectively as possible. This is important, because productivity (according to its definition in this thesis) can be considered as a measure of the efficient use of all resources (237). The management can achieve this responsibility by assessing the resources and opportunities available, defining the objectives of the organisation, and efficiently managing the resources allocated to meet these goals (238).

The researcher believes that it is the people in any organisation who provide its competitive edge, and the future of any organisation depends on the future of its individuals. As it has been said :

"If you wish to plan for a year, sow seeds ;
If you wish to plan for ten years, plant trees ;
If you wish to plan for a lifetime, develop men." (239, p.171)

As the human resource in any organisation influences the whole process of production, it has as great an effect in deciding how to achieve the objective of any system as any other technical aspects of a given situation (240). This is particularly important because it substantiates the fact that :

a) The financial problems, "cuts in expenditure" facing the highways authorities will affect decisions to increase capital expenditure in order to improve productivity.

b) The highways maintenance works are labour intensive. This means that productivity is likely to be determined largely by the workers rather than the machines.

c) Another factor that is necessary to stress on studying the human element stems from the fact that labour costs generally represent about 50 per cent of the total maintenance costs (according to the answers of the counties surveyed).

d) Moreover, the human is considered the most valuable of all other resources because the cost of human effort is increasing relatively faster than any other (77).

e) Also, it has been proved through the results obtained when measuring labour productivity with MPDM in the previous chapter, that labour delay is the major factor determining the productivity of maintenance work. In other words, these results indicate that by improving the labour productivity, the overall productivity of maintenance work can be improved.

Therefore, it is important to consider how to obtain, maintain and develop a certain level of human resources which is considered one of the organisation's assets, and to recognise its impact on overall management systems (241). The improved utilisation of the available human resource is considered a key to significant productivity.

It is claimed that the human contributions to productivity are considered to result from ability and motivation (89). Motivation is considered to result from the interacting forces in the physical conditions of the job, social conditions of the job, and individual needs. Ability is deemed to result from knowledge and skill. Knowledge, in turn, is affected by education, experience, training and interest. Skill is affected by aptitude and personality as well as by education, experience and training. The labourer's output is limited not only by his sensory and mental abilities, but also by his attitude, interests and adjustmental abilities (188). Attention should be paid to the way the labourer performs tasks, the time taken to complete them, the wage paid for their performance and the work environment, in order that labour productivity can be improved.

So, within the highways maintenance departments there is a need to study the incentive schemes and training programmes in the light of greater concern for improving productivity.

The next two sections will be devoted to an examination and evaluation of the importance of incentive bonus schemes and training programmes of DLO's within the highways maintenance departments.

9.2. Improving Productivity Through Motivation

9.2.1. The Rewards System as a Means to Improve Productivity

The individual is employed in the production system for the work he does. His behaviour in any situation is the result of a complex pattern of cause and effect relationships. Many studies have been carried out to discover the reason an individual expends effort. The amount of effort he expends on a job depends on his own personal desires and aspirations which he will work to achieve. So the needs of the individual can be viewed as a positive force that pushes man to achievement. On the other hand, until management discovers why an employee is not producing more, they cannot create the right system of motivation.

There are different schools of thought aimed at helping management to understand workers' needs and to explain how they are likely to react to various types of motivation designed to achieve satisfaction at work. Among the most important and acceptable are (242) :

1. Rational, economic man
2. Social man and self-actualising man
3. Complex man.

1. Rational, economic man

The main assumption of this approach is that behaviour is motivated by the desire to restore equilibrium by satisfying the need (234). It is suggested that in any situation, an individual compares his rewards from his job with the effort necessary in order to reach a certain level of satisfaction. This leads to consideration of what the individual expects from working, and the relationship between those expectations and the actual rewards. The concept of equity rests on an individual's perceived balance between his input into work, his age, education, experience, skill and effort, and his output rewards (pay, fringe benefits, satisfaction)(92). It argues that individuals reach equlibrium in the balance between two ratios : on one hand, effort and reward, and on the other, effort and performance. Management has to make assumptions as to how to motivate the employee to work harder by rewarding his effort. It argues that the motivated behaviour depends on three conditions (234) :

a) Subjective belief of the individual that by exerting effort, he will be able to accomplish a given task.

b) Subjective belief that by successful accomplishment of a task, he will obtain the reward he seeks.

c) The individual must perceive that there are attractive rewards available to him if he successfully accomplishes the task.

Both the first and the second types of expectancy will be influenced by the individual's perception of the task and of his own skill, and also by his previous experience of similar situations. This theory described by Porter and Lawer clearly states that if the individual is not attracted by the available rewards, he will be less likely to exert effort (234). The three conditions or expectations are multipicative, but given the existence of all of them, effort is likely to result. Figure 9.1. describes this theory diagrammatically (234,p.56).

The main criticism of this theory is that it is too rational (242). The relationship between effort and successful performance is mediated by the influence of an individual's ability and the accuracy with which he has understood the total situation, and knows how to direct his effort. It implies that individuals look at the relevant factors, weigh them up and arrive at the best decision.

Another criticism results from the fact that the main assumption of this motivation theory relies fundamentally on the economic motive of buying a man's time (242). But individuals do not work for money alone, and the economic theory proves to be at a disadvantage in motivating people to work harder.

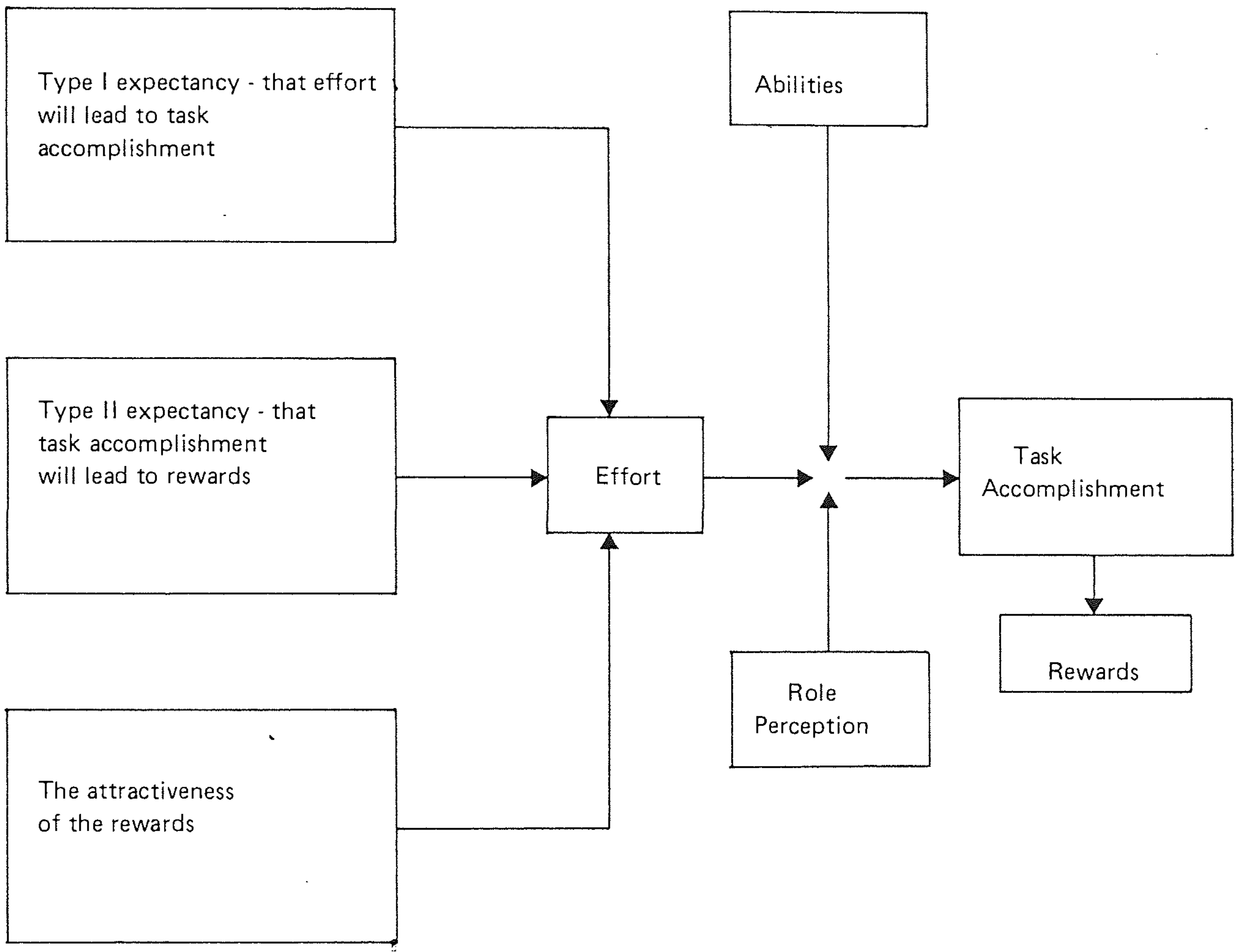


Fig. 9.1: The Porter-Lawie Expectancy Model

One group of writers said that money is the most important, while another group claims that interesting work and job content is most important (243). To test this idea with the highways departments, the researcher presented two statements to the roadmen and asked them to pick the one which most suited their needs. One of these statements suggested that satisfaction resulted from the kind of job they do regardless of the money they earn, whilst the other stated that satisfaction resulted from the amount of money they receive. The majority of the roadmen picked the first one (see Table 9.1).

Table 9.1.

People's Satisfaction

Statement	Reply %
1. A great deal of satisfaction in people's lives comes from the job they do. No matter how much money they get, if the job itself is not a satisying experience they remain discontented	63
2. People work so that they can lead a satisfying life away from work. No matter what this is, if the money is right they won't worry.	37
Total	100

This result agreed with the findings of research in that there is a growing number of workers who are beginning to demand improvements in both economic and non-economic rewards from their jobs. In the meantime, the importance of non-economic rewards is increasing relative to the importance of economic ones (77).

In addition it should be pointed out that there is no one particular set of needs that is most important for everyone, and the importance of any varies among workers and over time (243). This difference in needs results partly from the different experiences people have in different jobs, and partly from differences in personality, values, life style, social class, family and educational background (77).

The questionnaire revealed that the management of the highways departments tend to think in terms of the traditional value of their workers' needs, and less in terms of the actual needs of their employees. Thier policies suggest that what motivates the roadmen is only economic values, whilst the values of the roadmen are show to be quite different. For example, young workers think more of being given time off, being allowed flexible hours of work, having a choice about their financial rewards, recognition for their contributions or the opportunity of more challenging work than they think of the economic aspects. The questionnaire proved that there is a gap between what management think more important to the roadmen, and what the roadmen themselves think important (see Figure 9.2). While 61 per cent of the management think that the economic incentive is important to their workers, the majority of the roadmen consider that friendly relationships and good human relations are more important to them (see Table 9.2).

Table 9.2.

Roadmen's Incentives

Aspect	Reply %
Economic incentive	34
Good human relations	56
Other (both of them)	10
Total	100

The researcher believes that it is not a matter of choice between economic or non-economic motivation. Rather, individual desires vary so widely that it is necessary to look beyond mere economic motivation.

2. Social man and self-actualising man

This theory argues that individuals have psychological needs which

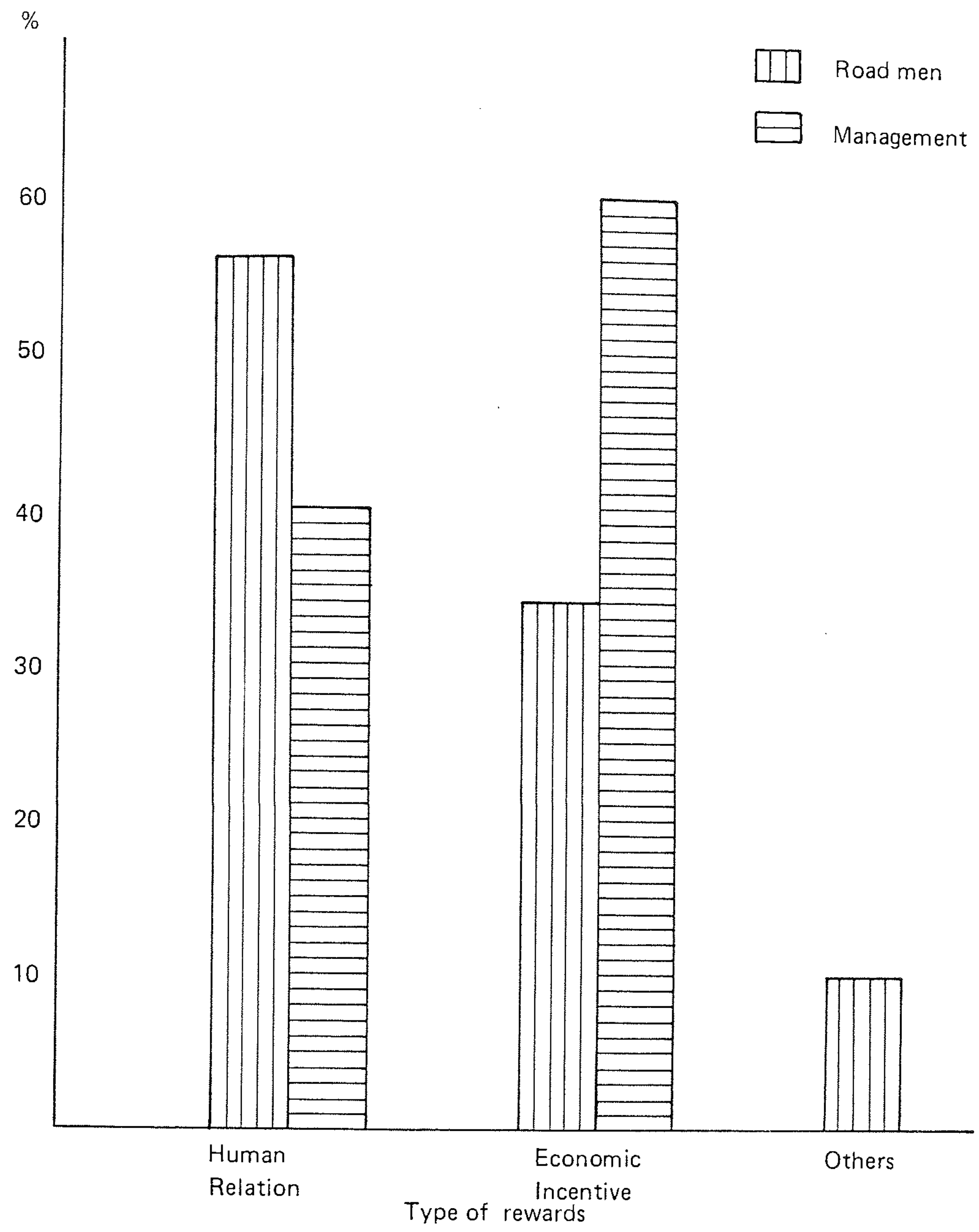


Fig 9.2: Road men and Managements views on the importance of various work incentives

they wish to satisfy at work. If they do not satisfy these needs, they will not achieve job satisfaction.

Maslow developed the concept that men's needs should be considered as a hierarchy, at the base of which lies his primary physiological need for security and nutrition (244). When these needs are satisfied, they are replaced by higher social and egoistic needs, culminating in his desire for self-fulfillment, i.e. the ability to realise and use one's potential to the full (92). The needs they have found to be important in satisfaction are the relationship and self-esteem, and self-fulfillment needs. These needs are indicated by requests for status, achievement, co-operation, recognition, responsibility, challenge and growth.

Maslow's theory has been examined by the work of Herzberg to determine the factors which motivated a wide range of people in employment. As a result of his research, he distinguished between factors which lead to employee satisfaction at work and those which created feelings of frustration and dissatisfaction in the employment situation (244). His theory was known as the Two Factors Theory or Motivation/Hygiene Theory (92). The hygiene factor or "dissatisfiers" tended to equate with the lower level of Maslow's hierarchy of needs. These are concerned with the job and include pay, working conditions, security, company policy and other job extrinsic factors (233). The absence of these factors led, not to a state of dissatisfaction, but neither to a positive feeling of satisfaction. The positive, satisfying factors, or the Motivator factors, were related to Maslow's higher needs. These include the intrinsic aspects of the job such as achievement, recognition, and the nature of the job itself. The absence of these Motivator factors will prevent satisfaction. However, it does not necessarily lead to active dissatisfaction. The work of Herzberg agreed with the group of behavioural scientists who distinguish between the extrinsic and instrinsic factors of job satisfaction. The argue that the extrinsic are secondary to the intrinsic, and that the design of jobs and control over jobs are the clues to increasing satisfaction (245).

To test the situation at the highways departments and the extent to which these factors are present, the roadmen were asked to state what they feel are the different opportunities provided by their jobs. Table 9.3 represents their answers.

Table 9.3.

Rewards and Opportunities Offered by One's Job

Aspects	Reply %
Security of employment	84
Good working conditions	56
Good pay	14
Warm, friendly relationships at work	57
Recognition of personal service to the dept.	34
Opportunities for upgrading or promotion	33
Recognition of training or qualifications	34
Opportunities to learn new things in the trade by using training	33
A feeling of control over one's own work	49
Convenient hours so one can follow one's own out-of-work interests	67
Opportunities to develop abilities	30
A chance to call someone else any time things go wrong	74

The majority of roadmen at highways departments find most of the hygiene factors of work are already present. This is most clearly the case for security of employment, convenient hours and friendly relationships, except that most of them consider that their pay is very low. However, from the inspection of this Table, it is clear that the motivator factors - like opportunities for development, recognition for previous skills, control over their work, etc. are rarely present with their jobs.

The main criticism of the Herzberg theory is that one cannot clearly separate the two groups of factors, as so many of them are overlapping. For example, lack of satisfaction may result from loss of control, freedom and power rather than challenge or pay, or supervision. Hunt suggested the following two groups of factors which affect satisfaction and dissatisfaction, which are similar but not identical to Herzberg's factors (238) :

a) Factors which encourage satisfaction :

- Challenge, recognition and freedom
- Control over one's own work, power and status
- A complete job
- Knowing what the goals are
- Individual growth
- Working with compatible people
- Developing 'satisfying' relationships with those people belonging to a worthwhile organisation
- Being rewarded at a level commensurate with expectations
- Succeeding.

b) Factors which encourage dissatisfaction :

- The formal structure, control, rewards, rules
- Bosses
- Salaries and wages
- Working conditions

- The people we work with
- Boring work
- No contact with users of the product or service
- Poor communication within the hierarchy
- Limited opportunities for promotion
- Loss of control over one's life (i.e. power)
- Failing.

However, it needs to be remembered that the extrinsic and intrinsic rewards cannot be directly substituted for each other, because they satisfy different needs (230). Therefore, it is not a matter of choice between extrinsic and intrinsic aspects of a job. Rather, overall job satisfaction is influenced by the degree of employee satisfaction of both the intrinsic and extrinsic rewards they receive from the job.

3. Complex man

This theory argues that man is a more complex individual than rational, economic man, social man or self-actualising man (246). The management should be aware, not only of the complexities of human motivation, but of the dynamic processes which occur as the person enters into the organisation. It has been difficult to resist the temptation to infer motives from observed organisational behaviour. Motivation is not the only determinant of effective performance. The ability of the person, the nature of the work setting and the supply of materials, the nature of the job itself and the ability of management to co-ordinate the efforts of many, all determine organisational effectiveness (247). The theorists like Crizer, Golunder and Likert approach satisfaction from different angles. They argue that the managerial philosophy of the senior executive is the clue to satisfaction because the climate that executive creates encourages an overall feeling of satisfaction (76). Blacke, Mouton and Fiedler argue that the climate of the work environment which is the product of managerial style is the important determinant of satisfaction (245). In addition, there are a growing number of researches which suggest that there is no simple, direct relationship between organisational incentives (rewards), employee satisfaction and productivity. Smith and Cranny argued that "employee performance is a function of employee effort, and that effort may be controllable by organisational incentive and vice versa" (242, p.75).

However, effort by itself does not necessarily produce higher performance due to insufficient talent or skill. If there is sufficient talent, one can hypothesise that incentives produce in the employee the setting of higher targets or goals which, in turn, produce more efforts whcih produce goal achievement and satisfaction. However, Smith and Cranny pointed out that "satisfaction may also be directly produced by organisational rewards without any increase in effort and performance (Ibid.). Figure 9.3. shows the potential complexity of the relationships.

Consequently, one can conclude that individuals are not only complex but highly variable and differ widely from each other in, for example, skills, manual dexterity and the capacity to take responsibility (238). According to the degree to which they differ, they will expect different rewards. In addition, the findings of the researches proved that job satisfaction is determined largely by how well an individual's actual rewards and experience on his job compare

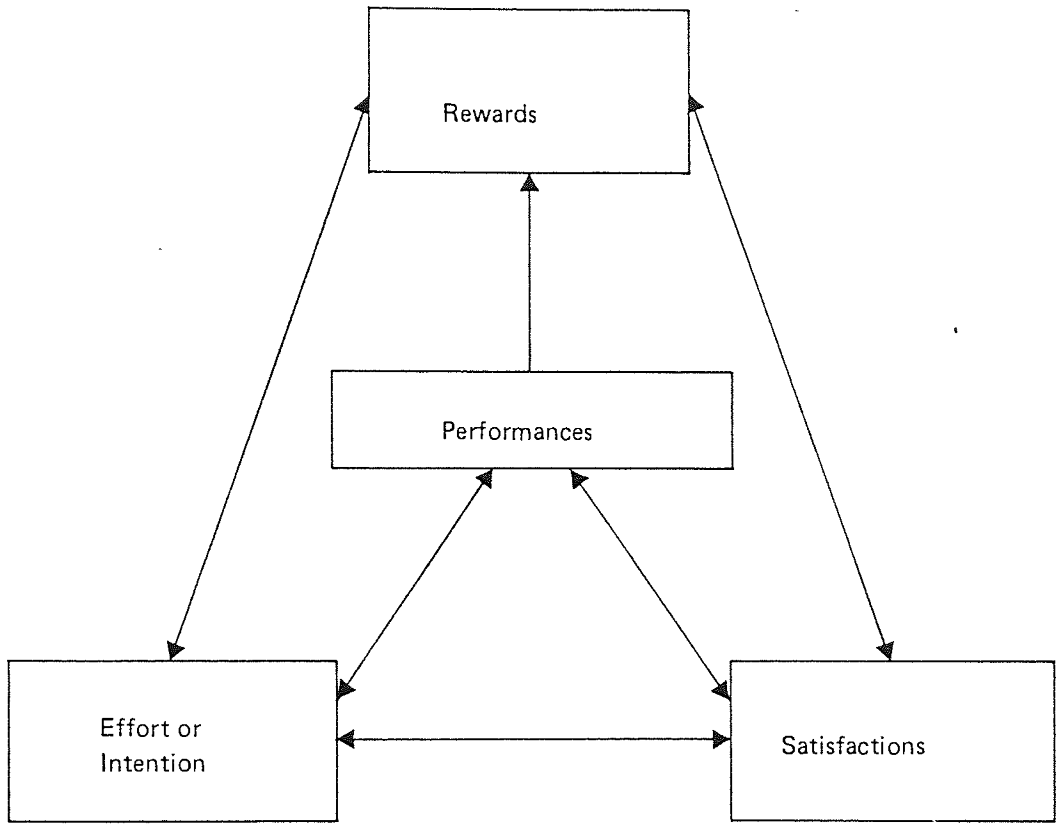


Fig. 9.3: Interrelationships among dimensions of work behaviour and attitude

with his desires or expected rewards (246). In the light of this, the management of highways departments should be able to look upon the rewards system which is required, from the individual's point of view rather than the management's point of view.

The management have to assess their own value and the employee's value and make assumptions of what they are seeking in the way of rewards in order to design the appropriate reward system that meets the needs of both (77). This reward system will help to achieve results that meet human expectations and to gain benefits by employment of more satisfied and more productive workers (248). This depends, besides other factors, on the extent to which the members of a work organisation are able to satisfy important personal needs through their experience in the organisation (80). When individual needs are satisfied by job related activities, positive feelings are expressed which could lead to greater involvement and improved job performance (249). The findings of the research proved that there are several factors which affect the level of employee satisfaction. The following list gives an example of such factors :

" Formal structure

- Job design
- control
- rules
- hierarchy
- span of control
- rewards

Informal structure

- peer group relationships
- informal leaders
- group norms and controls

"Individual variables

- intelligence
- sex
- needs and expectations
- age
- abilities
- education
- marital status
- number of dependants

External pressures

- socio-economic
- community size
- culture

Technical system

- mass production
- autonomy of operators

Leadership style

- task oriented
- human relations oriented." (238, p.171)

In addition to the above list, the work environment has an effect on job satisfaction, especially on the type of maintenance work.

In conclusion, satisfaction is determined largely by the intrinsic and extrinsic factors of the job, the management style, the management philosophy, the work group, the formal and informal organisation, the technical system and the external environment. Many of these factors are overlapping and there seems to be no line of separation which can be drawn among them. They contribute and co-operate together to affect the level of satisfaction desired rather than a dominant one, depending on the situation being analysed. However, as far as this thesis is concerned, the following section will be devoted mainly to an examination of the system of reward within the highways department, to find out if it is suitable to motivate the roadmen to perform their tasks effectively and contribute to their satisfaction in order to ensure improved productivity.

9.2.2. The Financial Incentive Scheme within the Highways maintenance Department

The system of financial incentive in industry today yields a net gain in productivity. The report of the Marshall Committee recommended that a work study scheme tailored to local requirements is the best available way of improving productivity (1). It seems from the questionnaire that the majority of highways maintenance departments are convinced of the need to have an incentive bonus scheme working within their departments. However, the majority of the counties applied this scheme to the roadmen alone, and did not include the foremen (see Table 9.4). Even in some counties where there was a separation between roadmen and sewer men, it covered only the roadmen.

Table 9.4.

Workers entitled to Inecentive Bonus Scheme

Type of worker	Counties									
	A	B	C	D	E	F	G	H	I	J
Roadmen	✓		✓	✓	✓	✓	✓	✓	✓	✓
Foremen	✓			✓			✓	✓		

The payment system which is adopted by highways departments is the time rate plus an incentive bonus scheme. The setting of incentive rates has been considered a technical problem, usually carried out at the work study section, and based on fixing the standard time for carrying out specific tasks. If a workman succeeds in doing the job in a shorter time, he is still paid the same rate per hour for the time he works on the job, and in addition, is given a premium for having worked faster. For most cases, this premium consists of a third of the difference between the wage earned and the wage paid, had the job been done in the standard time.

The main criticism of the establishment of a day's work is that it is neither easy nor practicable to obtain, through either a systematic or a scientific time study, exact information as to how much an average worker can achieve in a day (250). This criticism is due to the management failure to be aware that setting a standard has important human aspects that cannot be resolved through the enforcement of technical standards alone (251). Therefore, management needs to re-examine its incentive scheme and focus on worker reaction to the financial system.

9.2.2.1. <u>The effectiveness of incentive schemes</u>

To design a reward system that is effective and gives the desired rewards, the following factors ought to be taken into consideration (230):

A. Adequate rewards to fulfill basic needs. The size of reward affects the importance attached to it. There must be fair compensation to ensure equity within the organisation and external to the organisation.

B. Lucidity of the system to ensure that the individual within the organisation can make a decision about how much different individuals will be rewarded. This means that the rewards must be based on the performance to ensure that the better the performance, the greater the rewards.

C. Flexibility of the system to ensure the treatment of each individual in terms of his needs.

This section will be devoted to an examination of the effectiveness of the rewards systems within highways departments in order to discover if these factors are built into the system.

A. Adequate rewards to fulfill basic needs

The rewards must be adequate, fair and sufficient to reward effort within the organisation as compared to equivalent opportunities outside the organisation.

The questionnaire proved that there is a lack of satisfaction about the payment system among the roadmen. Table 9.5 shows that only a minority regarded their payment as good.

Table 9.5.

Payment Satisfaction

Aspect	Reply%
Bad	37
Average	49
Good	14
Total	100

From a review of the reasons roadmen answered as above, the following facts emerge :

1. Roadmen who considered their payment "Bad" :
   - Wages were said to be bad compared with payment for equivalent jobs carried out by private contractor.
   - Take-home wages were insufficient to live on and support a family (especially for married workers).
   - Compensation for conditions of work was considered insufficient.

Table 9.6 shows their objections to adverse working conditions.

Table 9.6.

Objections to Certain Adverse Working Conditions

Working conditions	Reply%
Hot weather	92
Cold weather	96
Wet weather	92
Dusty	86
Noisy	91
Gaseous	51

It was observed during the research that the roadmen work under difficult weather conditions. Whilst the majority of people enjoy the warmth of working indoors, they are out of doors working in extremely cold weather in the winter period in order to ensure the safety of the road network for passengers and vehicles *.

During the cold weather, the clothes they are issued with are not enough to protect them from the cold during severe winters **.

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* The researcher herself was frozen from cold and falling snow during some interviews when carrying out the survey. Some of the landlords sympathised with her, and offered all the gang some tea. But, as they remarked, it was because of her, and they commented, "Please join us, at least for the wintertime."

** During the application of MPDM it was necessary for the researcher to join the gang observed at an earlier time of starting work until they finished. As it was again winter time, the researcher had been provided with one of the roadmen's coats and asked to wear it all the time. However, it was not warm enough because the researcher began to turn a blue colour. After a while, the work study man noticed that she started to lose colour because of the cold, and gave her a reserve coat from his car. She continued the observation with three coats on, and was still shaking from cold.

In addition, the facilities available to the roadmen for a hot meal, washing up etc. were not suitable to match their working conditions in different places. They have cold meals in the street because in most of the cases it consumed a lot of time returning to the depot to have their meal (especially with the shire counties).

Moreover, the researcher noted that the safety conditions were neither adequate for safety requirements nor available to them in their working location.

2. Roadmen who considered their pay either about average or good, claimed it to be mainly because of the bonus scheme. Most of them were either single or old people who thought that it was fair compensation for the effort they employed.

It can be concluded that the lack of satisfaction of the roadmen with their payment made them rely heavily upon the incentive bonus scheme to improve their earnings. As shown in Table 9.7, the majority of the roadmen rank highly the importance of having an incentive bonus scheme (see also Figure 9.4).

Table 9.7.

Bonus Scheme Importance

Aspect	Reply%
Yes	67
No	33
Total	100

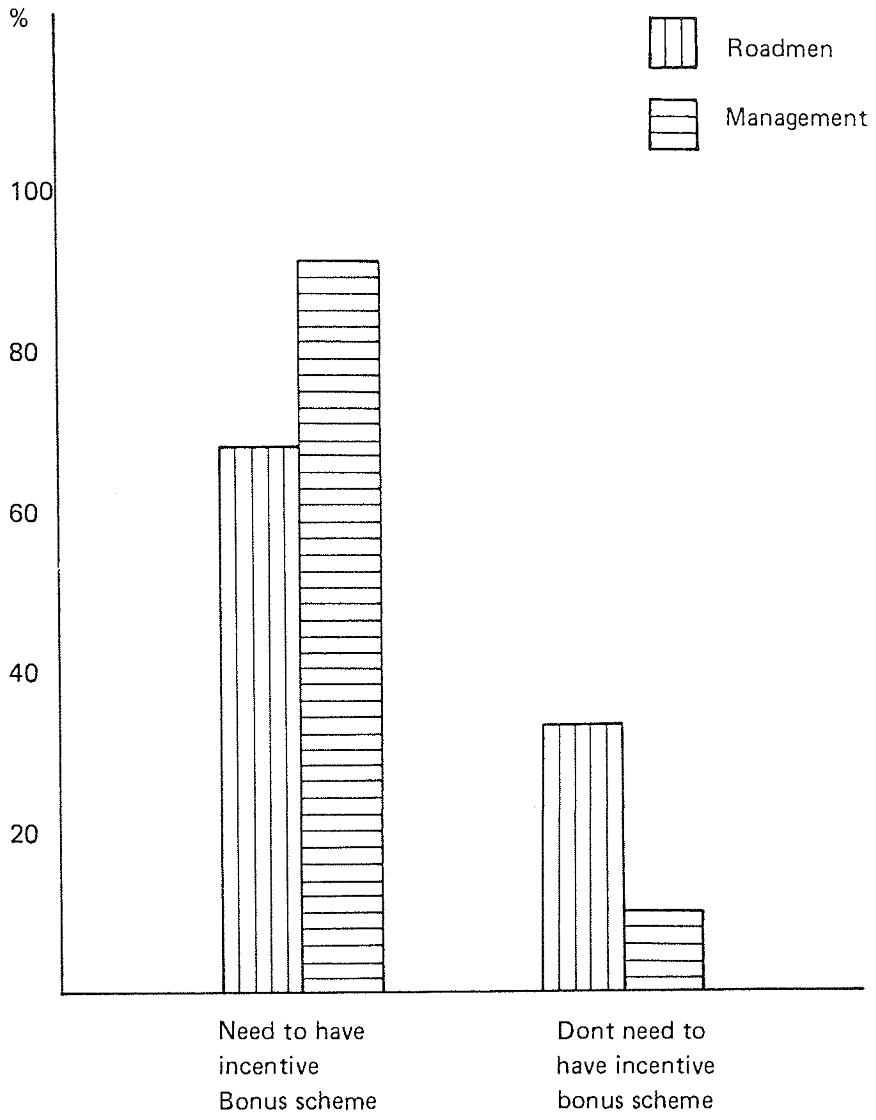


Fig. 9.4: The roadmen need for an incentive bonus scheme as expressed by roadmen and management

The roadmen suggested the following advantages which can be gained from applying the incentive bonus scheme :

1. It is regarded as a defence to the low wage rate.
2. It helps to stabilise earnings and maintain a steady level of effort throughout the working day.
3. It gives a measure of control over the relationship between effort and reward. The worker can raise effort to an incentive level in return for increased earnings.
4. It encourages team working and a reasonable interchange of jobs.
5. Use of machinery and equipment to full capacity.

To these advantages one can add :

6. It can be used as a source of psychological satisfaction by giving workers a sense of being in control of the situation (253).

These advantages which the roadmen claimed to expect from incentive bonus schemes encourages the majority of them to be satisfied with the extra rewards they gain from their recent incentive bonus scheme. Table 9.8. shows their replies to the question of their satisfaction with the extra rewards.

Table 9.8.

Satisfaction with Extra Rewards

Aspect	Reply%
Yes	63
No	31
Don't know	6
Total	100

The roadmen who were dissatisfied with the incentive bonus scheme gave the following reasons :

1. The variation of the jobs they have to carry out affects their earning capacity. Sometimes they have to move from one gang to cover emergency work which is not applicable to the bonus scheme.
2. Sometimes they lose bonuses for reasons beyond their control when they do certain types of unmeasured work.
3. Their bonus is also affected by waiting time due to inclement weather. Moreover, at other times they have to wait for reasons resulting from the unorganised work programme and management cobtrol *.

Table 9.9. illustrates those factors which affect their earning capacity.

Table 9.9.

Factors Affecting Earning Capacity

Factors	Reply%
Waiting time	60
Faulty material	40
Waiting for equipment	30
Allocation of work	30
Something else : weather conditions	50

* During the aplication of MPDM by the researcher, the work had to be stopped completely for more than one hour to wait for materials. The gang consisted of four. The driver and one of the workers went to fetch the materials from the depot. The charge-hand and another worker stood chatting, doing nothing, just waiting for them. The researcher noted that although, at that time, they could have continued with another stage of work, they did not bother.

In discussion with the management, they said, "Nothing can be done to control the weather conditions, we pay them to work in such conditions." However, others said that "Consideration of the above tabulation of facts is built into the rate, which is set in the first place by the work study sections". In the meantime, the management of highways departments in some authorities admitted that dissatisfaction with the incentive bonus schemes may result from adopting them in the wrong way. They recognised that before introducing the incentive bonus scheme, the standard time ought to be set after a method study has been completed, which is not the case in most of the counties.

However, the majority of the management believe that the majority of the roadmen are satisfied with the incentive bonus scheme, according to their experience during the period of its application. The management of the highways departments who consider the incentive scheme works satisfactorily suggested the following reasons :

1. The incentive bonus scheme helps to raise the productivity level as a result of increasing the total output of the worker. In the meantime, the unit labour cost in real terms is reduced following introduction of the scheme. However, there was no available data to support this suggested advantage.
2. It is possible to achieve the same output (i.e. to carry out the same work programme) with fewer workers. One of the authorities surveyed provided information that DLO of an estimated number of 455 were producing the same output that would have required 975 roadmen before introduction of the scheme.

   However, there was no quantitative data available to measure the quality of the work being carried out or the cost of carrying it out.

3. There is a reduction in the work done by contractors. However, they did not provide information to explain whether this was due to cuts in the maintenance programme or a real improvement in the productivity of the DLO in competition with the contractors.

The point that needs to be stressed here is that the researcher is not trying to doubt the advantages which might be expected from the incentive bonus scheme. Rather, it seems that the management lack information in measured terms to support these advantages.

B. Lucidity of the system to ensure that the individuals within the organisation can make a decision about how much different individuals will be rewarded.

To test this requirement, information was gathered on the availability of information regarding the incentive scheme, and the extent of understanding of the formula of bonus calculation. The following facts were revealed :

1. The questionnaire proved that the majority of the roadmen did not recognise the method of payment system applicable within the highways department (see Table 9.10).

Table 9.10.

Roadmen's Interpretation of Method of Payment System

Payment system	Reply%
Premium bonus	40
Time rate	35
Team work	20
Other (piecework)	5
Total	100

In addition, the questionnaire proved that there was a lack of understanding of the calculation of their earnings, as shown in Table 9.11. They also said that there is no immediate relationship between the work they had done and the amount of money they received, and commented, "Perhaps the work study men can explain it to you."

Table 9.11.

Roadmen's Knowledge of How the Incentive Bonus Scheme is Calculated

Aspect	Reply%
Yes	41
No	59
Total	100

When discussing these difficulties with the management, they admitted the lack of this information to the roadmen (see Table 9.12.) Figure 9.5 shows the relationship between the answers of roadmen and the management graphically.

Table 9.12.

Information about the Incentive Bonus Scheme (Management's View)

Information	Reply %			
	Yes	No	Don't know	Total
Do the workers know how much time they have in hand ?	40	50	10	100
Do the workers know the formula for translating time saved into percentage bonus and from percentage bonus to cash ?	50	50	-	100

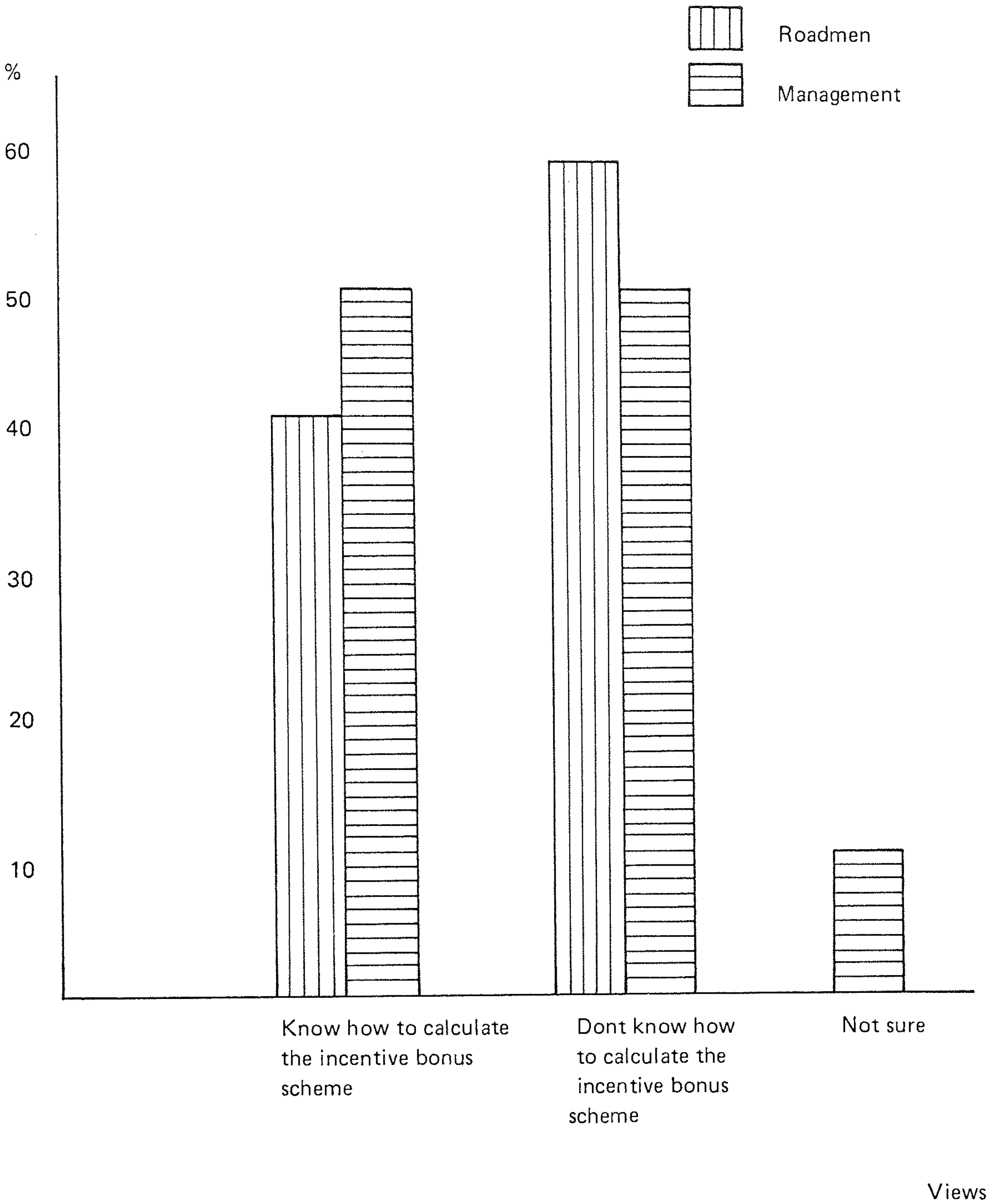


Fig. 9.5: Knowledge of how the incentive bonus scheme is calculated as expressed by roadmen and management

Despite this lack of understanding, the highways management said that there was no problem arising in operating such schemes and they worked satisfactorily.

However, it seems that difficulties facing the roadmen in understanding the incentive bonus scheme affected the attitudes of the roadmen regarding its application within the highways department. The majority of the roadmen considered that the incentive bonus scheme does not apply successfully and that it does not work satisfactorily (see Table 9.13).

Table 9.13.

Roadmen's Attitudes to Bonus Scheme Application

Aspect	Reply%
Satisfactory	37
Not satisfactory	60
Don't know	3
Total	100

The majority of roadmen who considered that the scheme does not work satisfactorily gave the following reasons for their answers :

1. The basis of distribution was not acceptable because it is tied to a national payment rate according to grade, and was not related to their effort. During the questionnaire a number of roadmen said that they sometimes worked twice as hard as the ganger, but their bonus was less than the ganger because the pay grade was different. Consequently, they said that they gain nothing from extending their effort and working harder.

2. It is regarded as unadequate as there is no direct relationship between the individual workers effort and his bonus. The criticism mainly resulted because it is dependent on gang performance rather than the individual.

It can be concluded that there is a gap between both the management view and the roadmen's view regarding satisfaction with the application of the incentive scheme, as shown in Figure 9.6. The researcher believes that the roadmen's dissatisfaction resulted mainly from the lack of knowledge about the system and the basis of applying it. Consequently, the management has to face these problems in order to be able to gain the expected advantages from having an incentive bonus scheme within the highways department.

C. Flexibility of the system to ensure the treatment of each individual in terms of his needs.

Tailoring the rewards to the needs of the individual will help in both satisfying personal needs and motivating performance, so aiding an efficient operation. The management of any organisation rely on reward systems to contribute to organisational effectiveness through (230) :

1. Motivating the employee to join the organisation
2. Motivating the employee to come to work
3. Motivating the employee to perform effectively
4. Reinforcing the organisational structure by indicating the positions of different individuals in the organisation.

In addition, the findings of different researches show that the

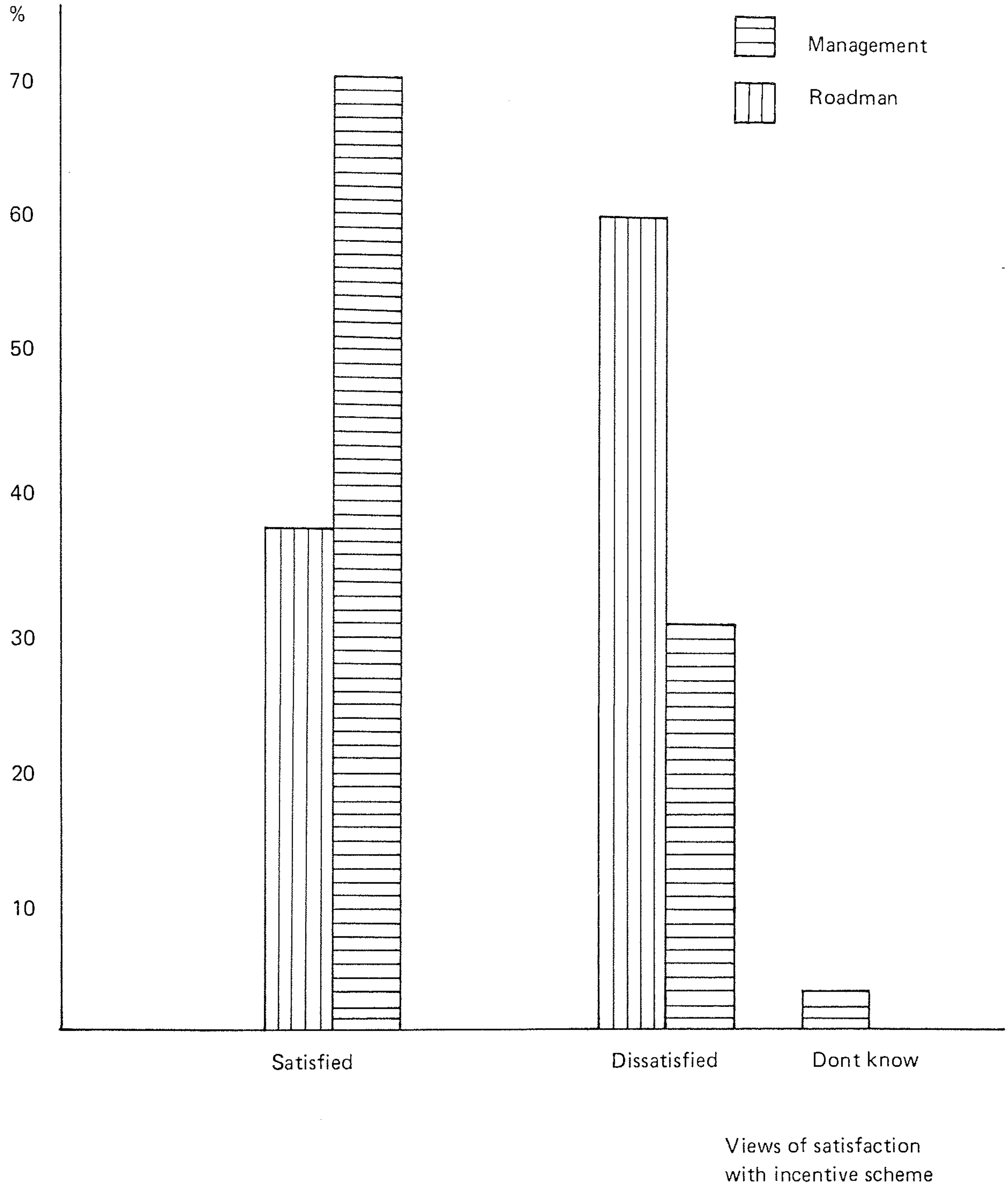


Fig 9.6: Views on satisfaction achieved by roadmen with existing incentive bonus schemes as expressed by roadmen and management

rewards any organisation offers affect decisions made about whether to join an organisation as well as decisions about when and if to leave (246).

The results of the questionnaire agreed with this, and the majority of roadmen said that the main factor which affected their decision to consider another job was higher pay (see Table 9.14).

Table 9.14.

Aspects Affecting Decisions to Change Jobs

Aspect	Priorities		
	1	2	3
Higher pay	✓		
Better hours or nearer home			
Promotion chance		✓	
Chance to get right kind of experience in a job or to use qualifications.			✓
More interesting or different sort of work			
To be nearer friends			

Despite this, the roadmen of the highways departments were generally highly satisfied with their work and considered it favourable (see Table 9.15).

Table 9.15.

Job Satisfaction

Aspect	Reply%
Favourable	89
Unfavourable	11
Total	100

One might agree that this high degree of satisfaction only agreed with the findings of most of the researches of human science in that it is difficult for any employee to admit his disapproval of the kind of work he does, the difficulties he faces, and the bad conditions he works in. All the researches ranked the favourable attitude to work very highly (252).

Despite the acceptance of this argument, to a certain extent, the researcher believes that it may express the real feelings of the roadmen. The questionnaire showed that the things the roadmen most liked about their work was : "The work type itself ; its variety ; being out in the open air, and the interest of moving between places and seeing different people."

Moreover, the attitude of the majority of the roadmen to work was affected by the type of supervision they have. The researcher noticed that in some cases, the management faced difficulties in transferring the roadmen to a different group. Some of the roadmen refused to move to another gang because of the bad relationship with that supervisor.

As said earlier in this chapter, the satisfaction of the employees with their work resulted from several factors which the management style and philosophy affects in their attempt to create the right climate of work, and is a crucial element in affecting the level of employee satisfaction.

The efficiency of the first-line supervisor was the real key to improved labour efficiency in many projects. Therefore, the next section is devoted to an examination of the attitudes of the roadmen towards supervision in order to complete the picture of how they should be motivated to improve their productivity by satisfying their different needs.

9.2.2.2. Attitude to Supervision

The questionnaire showed that the majority of the roadmen within the highways departments considered their relationship with their supervisors or foremen affected their satisfaction with their work to a considerable extent. They considered it important to have a warm relationship with their foremen. They said that having an informal relationship made it easy for them to dicuss together problems concerning their jobs (see Table 9.16).

Table 9.16.

Dealing with Workers' Queries

Aspect	Reply%
Make suggestions to improve productivity	63
Complain about the work conditions	53
Make a point about overtime levels	50
Complain about being given a particular job	41

In addition, they were aware of his duty as a means of communication between them and the management in order to organise their work, keep the work flow, and to ensure the application of management policy (see Table 9.17).

Table 9.17.

Roadmen's Concepts of Foremen's Duties

Foremen's duties	Reply%
Maintaining flow of work	81
Maintaining discipline	77
Dealing with workers' queries	70
Communicating with management	57
Keeping records	50

It seems from Tables 9.16 and 9.17 that there is a direct and easy communication between foremen and roadmen.

To examine the acceptance of foremen's ruling and methods of supervision, the roadmen were asked to indicate what the behaviour of their foremen would be, given a number of issues (see Table 9.18).

Table 9.18.

Roadmen's Views of Supervisory Behaviour

Supervisory behaviour	Reply%			
	Yes	No	Some times	Total
Close supervision	10	81	9	100
Pressure to work harder	6	86	8	100
Detailed instructions on how to do the job	57	34	9	100
Rigidity to rules	67	33	-	100
Overall involvement in decisions which may affect work	76	24	-	100
Consultation about plans which may affect job	70	30	-	100
Talking about things not related to the work	18	66	16	100

From this table, the following points emerge :

a) A majority of the roadmen were highly satisfied with the present behaviour of their foremen with regard to involving them in decisions, although they sometimes felt that the foremen could be more precise in the instructions he gives regarding any particular job. They are quite satisfied with the foremen's behaviour in the area of consultation about plans which might affect their jobs.

b) Most of the roadmen were fairly satisfied that the foremen tend not to put pressure on them to work harder, or watch over them closely. They are quite happy to let the foremen watch over them should he wish to, so long as no changes are required in the operation of jobs.

c) The two major areas of dissatisfaction were the giving of detailed instructions on how to do the job, and asking them to stick to the rules (see Table 9.19).

Table 9.19.

Acceptance of Detailed Instructions

Aspect	Reply%
Yes	14
No	86
Total	100

It seems that the refusal to accept detailed instructions resulted from the fact that it deprived the roadmen of their freedom to do the work in their own way, as long as they achieved the objective set by their supervisors. This agreed with the findings of research that people tend to refuse close supervision because it deprives them of an important source of self-esteem (252). Therefore, within the highways departments there should be greater concern about giving the roadmen more freedom and initiative.

9.2.2.3. The Requirements of a Successful Incentive Scheme

In order to ensure that the scheme works satisfactorily, it is necessary to follow certain procedures prior to introduction.

1. Clear explanation to the roadmen of the objective of applying such a scheme, to them and to the management.
2. Establishing the procedure of standard time after ensuring that method study has been carried out to determine the suitable work procedures. Alternatively, if they had to apply the standard of another county, or the Marshall standard time, they have to ensure that they are tailored to suit local circumstances, worker skills and working conditions.
3. Involving the roadmen as individuals and group workers with the management in agreement as to what is a reasonable day's work.
4. Encouraging the roadmen and motivating them to suggest any improvement of the methods of work . The expected improvement in productivity can be reached largely by improving the method of work (252). Both management and workers can gain from the advantages of increasing and improving output.
5. Establishment of the basis of the rule of bonus distribution in order to ensure adequate, fair and sufficient compensation in response to effort. This might necessitate management having to change the relationship between the amount of bonus and the pay grade. This will ensure the immediate relationship between effort and reward which is considered an important requirement of successful incentive.
6. It is important for the management to tailor the system of motivation to the fulfillment of the needs of their roadmen in both economic and non-economic terms. The system should be flexible

enough to fulfill the roadmen's aspirations as seen from their point of view, and not necessarily from management's point of view. This might agree or disagree with what the management thinks is important for them. The point needs to be remembered that what motivates people is what they feel is right for them, and not necessarily what others feel is right for them.

7. Establish the procedure for measuring the performance of the roadmen and keep records of their performance in order to control and follow the efficiency of roadmen, supervisors and managers (254).
8. Establish the managerial structure (the one which is recommended by the researcher in Part I of this thesis) in order to ensure that the information on performance and knowledge of the scheme travels quickly to those who have the responsibility to act. In addition, there should be feedback in the system in order to eliminate any circumstances which could affect worker performance or satisfaction.

9.3. Improving Productivity Through Training

9.3.1. Training Objectives

The benefits which can be expected to be gained from investing in training can be summarised as the following (237):

1. Training aids employees to learn their jobs quickly and effectively which, in turn, improves their performance.
2. Improved productivity can be expected from trained employees who work faster and more efficiently.
3. Training helps to achieve, maintain and improve work standards and thereby increases the employees' contribution to the achievement of operation objectives.

4. Retraining employees maintains efficiency in specialist fields as new methods replace more traditional ones.

5. Training increases employees' versatility by widening their range of expertise to include related jobs. This will meet the organisations' needs for a flexible and efficient work force. This is especially true with the shortage of skilled labour within the highways maintenance departments. The answers of the counties surveyed showed that one of the reasons for contractual work resulted from the shortage of skilled labour.

6. Any organisation with a reputation for providing good training tends to attract better applicants. In addition, training can reduce labour turnover, absenteeism and maintenance costs.

7. Training in safe working practices reduces accidents, so resulting in social and financial benefits to both the employee and the organisation.

Apart from these benefits, training can be used to influence improvements in employees' morale (255). No-one can ignore the private benefits enjoyed by those who have been trained. Training increases the value of an employee in the labour market, which helps to provide him with a higher standard of living. Training can increase job satisfaction as a result of non-financial benefit including higher status, a greater degree of job security, better promotion prospects and a degree of control over their work. The gaining of these benefits achieved by training will lead to further benefits as productivity improves due to better utilisation of human resources within the organisation.

To test the acceptance and recognition of the importance of training within the highways authorities, the counties surveyed were asked to rank the first three benefits expected to be gained by training. They regarded increasing productivity as the most desired benefit, followed by the two other objectives (see Table 9.20).

Table 9.20.

Training Benefits

Training benefits	Priorities		
	1	2	3
Increased productivity	✓		
Reduced maintenance costs		✓	
Improved morale			✓

It is noticeable from their replies that highways authorities' managements are fully aware of the importance of organising training programmes for their labour forces. In the meantime, the Marshall Committee on highways maintenance pointed out that more training is needed, and considered that training would contribute more to the efficiency of highways maintenance (1). The researcher believes that the above recommendation is useful because highways maintenance departments are organised in many different ways, the maintenance work is varied and has to be carried out under varied conditions, whilst also involving a large labour force with differing abilities and a large range of skills. Through training it will be possible to provide the skills needed to meet the requirements of the highways departments for new entrants with the basic skills, and for the development of specific skills to suit the interests and abilities of the individual, according to the needs of the authorities (237).

The researcher believes that training is a part of management, i.e. that management should conceive of training not as something abstract and separate, but as an integral part of planning, control, evaluating and decision-making (86).

No organisation can choose whether or not to train employees. The training programme has to be planned on a continuous basis. The training programme gets under way as the employee joins the organisation and specific training plans should be drawn up for each identified need (255). New employees, regardless of their previous training, education and experience, need to be introduced to the work environment of the new organisation, and to be taught how to perform specific tasks. Moreover, specific occasions for retraining arise when an employee is transferred or promoted, and when a job changes because of change introduced by advancing automation. These circumstances involve change in traditional working methods and the introduction of new skills.

In addition training is needed where there is a special problem interfering with production, such as excessive turnover among new employees, considerable absenteeism, a high accident rate, excessive spoilage of work, or a serious shortage of adequate replacements for a given job. Sometimes, specific training requirements are identified as a result of inadequate productivity.

9.3.2. Training Programme within Highways Departments

The researcher believes that a common starting step for any training programme is to assess the need for training. This is not required for training's sake, but should always be for a specific purpose (256). The more specific and clear the training objectives, the more successful the training is likely to be. Any organisation should have clear objectives for its training policy (257). The following table shows the answers of the counties surveyed about the objectives of organising training programmes.

The majority of the counties surveyed considered the main objective of their training programmes should be to provide training appropriate to the requirements of the highways departments.

Table 9.21.

Objectives of Training Programmes

Objectives of Training programme	Reply%
To provide training appropriate to the requirements of the department	80
To identify and develop potential supervisors	70
To provide training appropriate to the needs of the individual	60
To shorten the time required to produce an effective worker	40

When the roadmen were asked to state the objectives of training, they said that joining training programmes would give them the opportunity to increase their earning capacity, and at the same time, give them a new task. Table 9.22 illustrates what the trainee believes should be the objectives of training.

Table 9.22.

The Trainees' Objectives of Training

Aspect	Reply%
Increase earning capacity	70
Given new task	70
Increase job satisfaction	60

Of the counties surveyed, those which provided training programmes were asked to provide an example of such training programmes, the number of roadmen involved, the type of worker which had been trained and the evaluation of the results gained by such schemes (see Table 9.23).

Table 9.23.

Categories of Workers Being Trained

Categories of workers		Counties' replies									
		A	B	C	D	E	F	G	H	I	J
Roadmen		✓		✓	✓	✓	✓	✓	✓	✓	✓
Foremen		✓		✓		✓		✓	✓	✓	✓
Others :	Superintendents	✓		✓	✓				✓		
	Electricians	✓							✓	✓	✓
	Asst. Works Managers								✓		
	Inspectors										
	HGV Drivers	✓								✓	✓
	Totals	69*	-	-	361	-	-	-	276	291	140

* Indicates county council direct labour employed for trunk roads only. No quantitative data available for districts.

From their replies, the researcher ascertained the following :

a) There were no detailed figures available of the number of roadmen trained in county training schemes.

b) The training programmes mainly provided for roadmen and did not cover all groups of workers within the counties.

c) One of the Metropolitan counties covered by the survey had no information about training programmes within the district council and provided only information regarding their roadmen employed for motorways and trunk roads.

d) There was no evaluation of the results of the training programmes which would provide information to the management regarding the skills of the labour or the effect of training on improving the productivity and worker satisfaction.

The management of highways departments argued that training is organised in a separate training centre where the trainer carried out the task of evaluating the roadmen, but the researcher found that the only evaluation done in the training centre concerned the absenteeism of the trainees, and their progress to ensure the satisfactory completion of the training programme. However, it is not only the progress of the training programme which is in need of assessment, but also consideration of the relationship between the worker and the work environment which ultimately affects performance (258). There is a need for evaluation of training programmes to detect faults that will pave the way for future improvements.

Where management considered that the first objective of training is determined by the requirements of the department, it was expected that assessment of the numbers of roadmen and availability of jobs and skills would determine training needs. However, it was found that training programmes were developed by a central body, a list of courses circulated, and the choice of courses followed by local workers remained dependent upon the divisional offices being allocated a limited number of places on courses which they considered relevant. It was argued that training courses did not always match their requirements and therefore were of little relevance. The criteria upon which these decisions are made can be affected by a number of factors :

a) The work load within divisions and availability of roadmen, ensuring the minimum disturbance to the work programme.

b) The management attitude towards the importance of training. The support of top management was considered essential to the success of a training programme.

c) The workers' attitudes towards training programmes. Difficulties were encountered in persuading workers to join the training programmes. It is believed that the men are either content with their present positions, or that they are frightened of highlighting their illiteracy, or that they have a lack of confidence regarding responsibilities which may affect their ambitious desire to improve their present skills.

However, in some counties, the workers argued that suitable training programmes were not available to satisfy the requirements of both the county and themselves. Workers felt that the counties believed contract labour to be more skilled than DLO's, although they themselves disputed this. Some of the roadmen interviewed said that they had worked for contractors before joining the local authority, and that their main reasons for joining the local authority were either to find more permanent work with security of employment, or because of family responsibilities which prevented them from travelling great distances to work.

When discussing the reasons for the roadmen's refusal to join training programmes in some counties, they said that sometimes, they found no benefits to be gained from attending these courses. They gave the following examples to illustrate their answers :

a) New workers attend induction courses within a few months of joining the council.

b) The majority of the roadmen said that they had been trained in specific methods of working and had either to use different methods on returning to their gangs or they were never to use their training because of changes in the type of work they were to undertake.

c) Some workers argued that attending such programmes would affect their earning capacity by reducing their money as a result of losing bonus pay during the duration of the course.

d) Objections to returning to a school-like atmosphere.

It is obvious from replies by management and workers that a well-organised training programme would answer their queries and ensure the gaining of benefits expected by the training.

The following is an example of assessing the training needs of roadmen within one of the counties surveyed.

- The top management believed in the importance of training programmes to provide the department with skilled labour. The practice in this county is to ask the Divisional Surveyor and Section head to assess training needs by the completion of a training needs survey questionnaire. The first aim of this questionnaire is to provide information which will give an indication of the training required to qualify the roadman for his grade. The second aim is to collect information on the training necessary to satisfy the needs of the authority in manpower and skilled labour. The Divisional Surveyor is able to recommend training from his assessment of skills lacking within his work force, and personal knowledge of his roadmen. He depends, in the preparation of such required training, on the information which sets out the requirements for each grade of roadman, etc. (NM194(b)), and information about the courses which will be available at, or through the training centre.

In compiling the list of training requirements, the Divisional Surveyor or Section Head will indicate the priority needs. This is done by listing roadmen's names and the courses for which they are recommended in priority sequence (see Figure 9.7).

The researcher believes that the information needed to assess the requirement of training can be improved to achieve the aim desired.

1. It is not enough to list the roadmen according to specific grade. Information should be collected regarding the actual skills, as this will indicate the shortage of skilled labour within the present work force.
2. Information is needed about previous training, together with comments on their performance.
3. More personnel information is needed about the length of service within the highways authority in order to determine the commitment of the workers to the training programme.

Figure 9.8. illustrates a modified list for assessing the training needs suggested by the researcher. The completion of this form is inexpensive and easy to administer. The analysis of this information resulting from this new assessment will enable future programmes of training to be determined. In addition, further detailed information

County Surveyor's Department

TRAINING NEEDS

Division....................

Roadmen etc.

Works no.	Initials and name	Date of Birth	Present Grade	Courses for which recommended (in order of need priority)

Figure 9.7.

Training Needs in X County Council

		NAME
		WAGE GROUP
		JOB TITLE
		GRADE
		LEVEL OF EDUCATION
		DATE OF BIRTH
		LENGTH OF SERVICE
		MARITAL STATUS
	GENERAL LABOURING	ROAD
	BASIC ROADWORKING : OPERATIONS	
	LAYING OF BITUMINOUS AND TAR MATERIALS	
	PAVING BRICK AND SETTS	
	KERB LAYING	
	FENCING	
	STEEL FIXING	
	EXCAVATION OPEN-CUT	
	FIXING OF ROAD STUDS	
	WALLING (DRY STONE ETC.)	
	REINFORCED	

PRESENT TASK											PREVIOUS AND PRESENT							
DMEN										REMARKS								
REINFORCED CONCRETING	PATCHING	SURFACE DRESSING	WHITE LINING	BRICKLAYING AND JOINTING	GENERAL LABOURING	GULLY CLEANSING INSPECTION	PIPE-LAYING AND JOINTING	REPAIR WORK IN SEWERS	ETC.		INTRODUCTION TO ROADWORKS	TERMINOLOGY AND SAFE PRACTICE	SAFETY - ROADWORKS	ROAD MATERIALS : CONCRETE	SURFACE DRESSING F/W BY HAND	FOOTWAY CONSTRUCTION	PATCHING AND REINSTATEMENT	SETTING OUT ROADWORKS

Figur 9.8.

Planned Training

NT TRAINING COURSES										COMMENT	FUTURE TRAINING RECOMMEN		
TIMBERING TO TRENCH WORKS	FLEXIBLE ROADS MAINTENANCE	HIGHWAYS MAINTENANCE	KERB LAYING (1,2)	SNOW AND FROST TREATMENT	BASIC SETTING OUT	WHITE LINING	LIGHT MECHANICAL PLANT	CITY & GUILDS ROADWORK CERTIFICATES	ETC.		N.J.C. 194B ROADMAN COURSES	QUALIFICATION COURSES	REFRESHER TRAINING

8.

ng Needs

MENT	FUTURE TRAINING RECOMMENDED				
	N.J.C. 194B ROADMAN COURSES	QUALIFICATION COURSES	REFRESHER TRAINING	OTHER ROADMAN COURSES	SUPERVISORY COURSES

about present skills and training to be prepared will ensure that those skills which are most necessary for the efficient working of the division are the first to be provided through training (259). In the meantime, detailed information will aid the evaluation of training programmes, and the feedback of information on its impact on improving the morale of the workers, reducing turnover, and increasing earning capacity following the acquisition of new skills.

The efficiency of the training programme depends on the continuous assessment of the trainee's progress and potential in order to develop roadmen to meet their own and management's requirements in an effective way. Therefore, it is important to re-examine the requirements of the haighways authority in relation to the workers involved, their changing situation, their geographic location, the unit best equipped to train them and the best techniques, taking into account the time available, previous training and the limited budget. The next section is devoted to an explanation of the requirements of a successful training programme.

9.3.3. The Requirements of a Successful Training Programme

While the determination of the training objective is a prominent step in the training programme, it is only the first step. Unless training programmes are well organised, they will be likely to fail to satisfy the objective. The management should include the following activities to ensure that the requirement of successful training programmes is fulfilled (255).

a) The formulation of training policy in the light of continuous assessment of the organisation's training need.

A successful approach to any training programme will require a constant appraisal of short- and long-term needs for all workers, supervisors, and management where required. Generally, the more specific and concrete the training goals, the more successful the training is likely to be.

b) The analysis of jobs and skills in order to determine that the training needed can be formalised.

The appraisal of training need can be formalised and carried out at regular intervals in progress reviews based on careful job description. This will help to raise the worker performance and use the training in its widest sense as an aid to self-development (259). Figure 9.9 illustrates this approach.

c) The preparation of planned schemes of training based on carefully constructed programmes (including the selection of the trainees and the trainer).

Training programmes are effective to the extent that the step cited above can be carried out in practice. The best practice is dependent on the programme content, the trainee and the skill of the trainer.

1. Programme content

Carefully planned subject matter that stresses the methods designed to counter specific troubles. There is no one answer to the method of training that ought to be used. Many types have been developed and all have their advantages. The most reliable rule is to select the method that is most likely to alleviate the problem for which the training

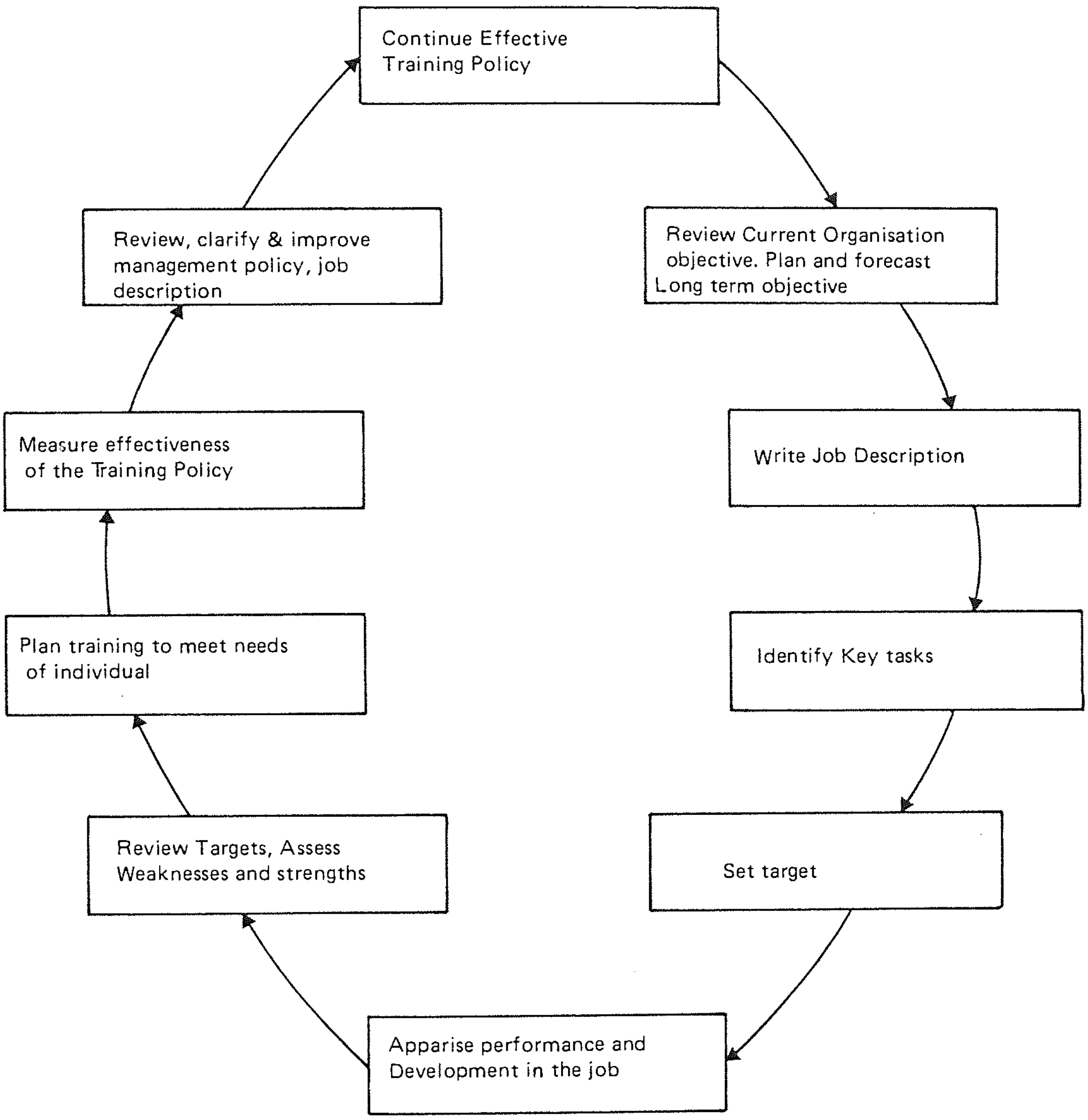


Fig. 9.9: Training policy as an aid to management development

programme is initiated. All workers can learn, but some are more proficient at it than others. As an example, a programme to develop specific job skills should be based on the study of errors - missing skills or inefficient application of existing skills. If all workers share the same shortcoming, an inclusive demonstration and practice programme is appropriate. When just a few workers make errors, a supervisor can work with them individually while they are on the job.

The researcher believes that it is important for the management to choose the right method and technique which best suits the training objective and the workers themselves, in order to attract them to join the training programme.

2. The trainees

It is important to remember that it is not only the technical aspect of a training programme that will guarantee its success, but also the human aspect. The trainer faces not only the problem of how to teach the new worker the specifics of a complex job for today, but also how to create a learning situation in which that worker can develop his other capacities by preparing for the future. It is important when designing a training programme to take into account the kinds of learning principles which have been developed from research on the human aspect. These principles may be summed up briefly as :

(i) The trainee must be motivated and eager to learn. His motivation to improve his job performance, or to learn a new skill, must be high. Motivation is increased by the prospect of some reward at the conclusion of the learning process.

(ii) The aim of the training programme should be explained to the trainee to make sure that he knows what is expected of him.

(iii) There should be an atmosphere that allows the trainee to make mistakes and learn from correction. This is best accomplished through practice rather than theory.

(iv) The skill to be learned should be developed in stages with feedback correction at each stage, if necessary. The feedback process can help to test if the trainee makes the correct response to the learning process.

3. The trainer

The best planned learning programmes are likely to be ineffective if the trainers are poorly qualified. A well-qualified trainer is one who not only has the mastery of the technical details of the particulare job, but knows how to train (i.e. has a positive teaching capability). Each trainer undertakes his role when he endeavours to guide and facilitate the efforts of his trainees to develop themselves. The trainer can follow these guidelines that help the trainee to rise successfully within the training programme.

(i) Make the trainee feel relaxed and part of the group.

(ii) Make it clear to the trainee what is expected of him.

(iii) Be sure that he has contact with his immediate boss.

(iv) Keep him occupied with meaningful activities.

(v) See that he has all the necessary tools and materials.

(vi) Instruct him properly and have confidence in his ability.

(vii) Give credit when it is due or criticise constructively.

d. The Administration and Control of Training Schemes, including the Supervision of Instructors

Unless training programmes are well-organised, they will be likely to fail to satisfy the objectives. The facilities and training centres should be fully prepared. Nearly everyone has suffered through boring incompetent presentation held in inferior classrooms with inadequate teaching aids. Therefore, the following points should be taken into consideration, in addition to that mentioned above, and in order to ensure the success of any training programme.

(i) Adequate physical facilities (classrooms, mock-ups, materials etc.) that allow instruction without disturbing interruptions.

(ii) A detailed timetable of instruction.

(iii) A schedule which allows time for practice and repetition.

(iv) A summary that relates all parts of training to the overall objective.

(v) A follow-up routine to reinforce learning and confidence.

(vi) The evaluation of the effectiveness of training including a system of progress measurements and the revision of schemes as necessary.

A system of recording the progress of roadmen through a training programme is needed for planning and control purposes. Therefore, it is important to measure individual performance with pre-training figures, Another kind of assessment required is calculating the total cost of the training given and comparing it with the financial benefits gained by the improved performance of the roadmen.

There will be shortcomings in training unless consideration is given to continuous assessment of the training programme and evaluation of results (260). The evaluation of the training programmes should be carried out with a clear understanding that an effective member of an organisation requires not only to be taught job skills but also an understanding of the organisation's objectives, its practices, its climate or culture and the various career paths available within it. The data provided by continuous assessment would discover at what points the training programme might be improved. This information should then be fed back to the management to encourage constant improvement in updating the training system as a whole.

CONCLUSION

The questionnaire proved that there is a gap between what the roadmen feel is the right incentive to motivate them, and what the management believes. It is necessary for the management to realise that it is not only the money which is considered important to the roadmen in order for them to extend their effort to work hader and improve their productivity. No direct relationship exists, many different factors contributed together to affect the satisfaction of the roadmen with their work. Although nobody can deny the role of financial incentive to satisfy basic needs, there exist needs which cannot be satisfied with money. It is important for the management to try to understand the needs of their roadmen in order to choose the right system of motivation which will be able to motivate them to improve their productivity.

However, individuals are very complex systems which require more understanding in any attempt to discover how they can be motivated to improve productivity. This depends, among other things, on the way they satisfy their expected needs through the work that they do within the organisation. Consequently, the right working environment and management style and philosophy are among the factors which contribute to providing the individual with the right climate to improve his productivity.

It can be concluded that to improve the productivity of the roadmen, the management need to :

1. Motivate the roadmen through applying the incentive scheme to motivate them to achieve the desired objectives. The questionnaire proved that both the management and the roadmen rely heavily on the incentive bonus scheme to improve their productivity. Although the roadmen were satisfied with their work, and the incentive bonus scheme to improve their level of payment, they were dissatisfied with the application and the way it works. Their dissatisfaction mainly resulted from the lack of knowledge about such schemes regarding the calculation of their bonus, and because of the inadequacy of the basis of distributing this bonus. Therefore, by eliminating the reasons for dissatisfaction, the management can gain the advantages expected from such schemes. In the meantime, the management needs to look more carefully to the non-economic side of their roadmen's needs. They should try to improve labour relations, and try to fulfill the roadmen's needs in aspects of self-actualisation and self-esteem. Giving the roadmen more say in their work, more freedom, more initiative and more participation in the decisions affecting their work is expected to contribute towards improving their satisfaction. Although there is no direct, simple relationship between satisfaction and productivity, the researcher believes it is the right step towards improving productivity, as long as the labour factor continues to be considered the primary factor affecting productivity.

2. The researcher believes that the supervisors have an important part to play in their effect upon the roadmen within the highways departments. They represent the first line of management. They are the people who translate higher management policy and decisions into practice, they encourage day-to-day work and try to ensure workers' involvement achieving the desired results. The foreman can play his role as a linking pin between the work group and the management. In order to ensure an effective working philosophy, he should :

a) talk in the language of both workers and management

b) encourage the participation of the roadmen in decisions affecting their work

c) give them greater freedom and intiative to carry out their work as long as they achieve the desired result.

3. In order to ensure the satisfaction of the individual and improve his productivity, there is a need to give him the feeling of control over his work. One way that it is possible to achieve this is by providing the right training experience. The need for training starts from the moment the roadman joins the highways department, It should continue during his employment and develop according to the requirements of the department and the individual himself. Having a well-trained roadman with a wide range of different skills will help to solve one of the important issues of the work by DLO versus contractors, and provide the management with the advantage of the flexible work force able to be transferred to different jobs at different times and places in order to fulfill the objectives of working in the most economic way by ensuring the full utilisation of the human resources available within the organisation.

Chapter 10

Conculsions and Recommendations

10.1. Summary and Conclusions

The principal objective of this thesis is to investigate, through an empirical study, the different functions of the highways maintenance departments, and to suggest methods by means of which road maintenance work could be carried out in a more efficient way, by utilising its resources of men, material and plant to the utmost advantage. This is particularly important under the present circumstances of national financial difficulties which have resulted in continuous cuts in public expenditure.

In order to achieve this objective, the researcher carried out a survey among DLO's of several Highways Authorities by means of questionnaire and interview. The information so collected was analysed in order to understand the actual, practical situation within highways maintenance departments, and highlight any existing problems and try to answer the question of how they could become more efficient.

It is essential, as a first step, to understand the whole system of the organisation of the highways maintenance departments before suggesting any improvement. Therefore, it is important to point out the following circumstances :

1. One of the functions of local authorities that comes most to the attention of the members of the public is the maintenance and construction of roads. This is not only true today, but it is also a historical fact, for this is one of the oldest local government services. Highways maintenance has now become very much the problem of the national government as well as the local authority, and there is very close interlocking of responsibilities of both.

2. Theoretically, local authorities can take a synoptic view of local conditions, trends and prospects based on deep analysis of environmental, economic, financial, demographic, social and any other factors. However, the actual situation is different. Local authorities have limited powers, are subject to external restraints, have duties placed upon them by functionally concerned legislation and are themselves organised on a functional basis. The central government, not the local authorities, determines the nature, scope, quality and direction of the principal local services. It settles for each year the amount which it considers each local authority should spend in the aggregate, and has ways of influencing its action to keep it within the limit imposed.

3. Highways maintenance is complex, not only in its variety of activities included under the term maintenance , but also in the manner of its administration. Trunk roads and motorways are the responsibility of the Department of Transport (DTp). However, this department has not got a direct labour organisation and the actual maintenance work of trunk roads and motorways is, therefore, carried out by the appropriate local highways authority designated, in this

case as the agent authority. County councils are generally the agent authority for trunk roads. The responsibility for maintaining principal and other roads lies with the county councils ; however, the district councils are agent authorities for the county councils for carrying out maintenance works.

4. The sources of money for road maintenance come mainly from the rate support grant and the rates. The Department of Transport pays a support grant to the local authorities to serve as its agent for administering certain stretches of its trunk roads, and the work is done for it in exchange for the cost of this administration. The road mileage is one of the main factors taken into account in calculating the grant due to each local authority. The counties have to submit a "Transportation Policy Programme" (TPP), and from this plan the government will allocate the rate support grants. Specific grants are given for the improvement of principal roads. Anything that cannot be paid for out of government grants is a burden on the rate fund. Local authorities can ascertain what should be spent on maintenance work in order to bring their roads up to the required standard to ensure that highways are maintained in a condition such that vehicles carrying passengers, goods, livestock etc., can travel safely and economically. As a result of the analysis of their objective, the benefits derived from the highways maintenance departments are found to be intangible and indirect. The factors making up the final output are hard to identify in quantitative terms.

In the light of these circumstances, the management of the highways maintenance departments have to plan, organise and control the work, and fully utilise their resources in order to achieve their objective as efficiently as possible.

The analysis of the results obtained through the questionnaire and the extensive interviews with management and roadmen revealed the following problems :

I The objectives of the local authorities are not defined as clearly as they should be. There is a lack of effective identification of the community's needs and problems, and there is a slow response to the changing environment which influences its existing processes and decisions. Local authorities suffer from certain shortcomings resulting from too much central government control. They are actuated by functional pressures rather than by a sense of unity ; councils are too large and committees are too numerous. Although many changes have been made in the administration of local affairs, central administration has altered little. Local authorities have difficulty in deciding priorities rationally and planning effectively.

These problems reflect on the highways maintenance department as one of the local authorities' departments. It was found that the objectives of the departments were neither precise nor measurable. There were no quantitative indicators which could be used to measure their achievements. Moreover, the organisational structure of the department appeared to suffer from problems resulting from lack of communication between different hierarchical levels, and between the different divisions. Thus, overlapping and duplication occur throughout the organisation. One of the main reasons which might have contributed to this complexity resulted from the fact that their organisational charts which outlined the functional relationships and responsibilities were neither precise nor maintained up to date. In most of the cases where there was an organisation chart available, it was kept in the head office without any practical use of the information it contained. The different hierarchical levels within the organisation are too extensive and affect communication down to the lowest levels of the organisation. In addition, the actual authority of decision-making within the department was held up as a result of boundaries between committees' terms of reference and the departmental duties. The management have limited powers and are subject to external constraints which prevent them from exercising their planning and control duties as they think fit.

II The planning for achieving the objective, from the scientific point of view, is not executed as it should be - such is the case within most counties. Planning, in practice, is an attempt to ensure that the local authority decides its aims only after examining the local environment and the public's requirements, and decisions taken are, as far as possible, not affected by existing boundaries between the committees' terms of reference and by departmental duties. Theoretically, it assumes that having settled the objectives, the management must then decide how, to what extent and in what order they can be accomplished. This plan has to be classified in terms of the work required to achieve the management's aims, and annually modified. For this purpose, activities have to be reviewed in the light of the long-term objectives and of the resources likely to be available over the period.
However, the majority of the counties surveyed argued that they could not adopt long-term planning to forecast a future need

in the present economic climate where everything changes suddenly and with the continuous cuts in public expenditure. They said that the present state of the road network is largely a result of its treatment in earlier years. However, they have to adopt a short-term policy - possibly more costly in the long run - due to shortage of available funds. The majority of the counties surveyed claimed that money is the critical factor affecting their work. It seems that restraints on expenditure, in many cases, have prevented maintenance policy from being sufficiently forward-looking to prepare for modern traffic. They argued that it is the budget which determines the work load, and they have to plan their work programme according to the available funds, not the actual needs of the road network.

Notwithstanding the fact that there are two assessment systems - MARCH and CHART - available to help the authorities in determining the priority of roads to be maintained, not all the authorities have adopted them. They argued that adopting such systems needs them to have standards, and fully computerise their system, which needs a lot of money not available to them. Only 30 per cent of the counties surveyed had adopted one of these systems, the remainder having either developed their own assessment system, or depending on the personal experience of the Divisional Surveyor, his assistant and a technician.

It seems from the above facts that the management of highways maintenance departments consider the lack of funds as an excuse for not planning maintenance work. However, the researcher believes that on the contrary, it should be the reason for urgent planning. It is believed that if the financial resources of maintenance work - translated into material, equipment and labour are limited , they must accordingly be allocated as effectively as possible.

III For the highways maintenance departments to carry out their responsibility to maintain the roads within their individual boundaries, they have to choose between their own work force and outside contractors. The questionnaire showed that there was a belief among the local authorities that it would be convenient and practicable for each highways authority to establish a Direct Labour Organisation to carry out the day-to-day routine work, and they considered its existence to be very essential in dealing with the various emergencies. For dealing with emergencies the majority of counties surveyed were of the opinion that private contractors would not be able to cope. They believed that besides the facility to deal promptly with emergencies, DLO's are also capable of providing an efficient work force for the maintenance of roads. In addition, there is the possibility for DLO's to compete for specialised work such as resurfacing and surface-dressing. However, the suggestion that DLO's can efficiently cope with this highly specialised type of maintenance work is the subject of much controversy. At one extreme there are some counties who said they used their DLO's for specialised work through competitive tenders, and that they are more economic and efficient. At the other extreme, there are some counties who argued that they could not use their DLO in specialised work because of the shortage of suitably skilled operatives, and that the necessary specialised would not be fully utilised.

It seems that the criteria which affected their decision to carry out the work by either DLO or contractors are :

1. The nature of the maintenance work required.
2. The availability of maintenance facilities and the work load of these facilties.
3. The availability of skilled labour required to carry out the work.
4. The costs associated with each alternative.

According to the results of the questionnaire, the majority of counties considered the availability of skilled labour to be the main criterion affecting their decision. They said that they had not got enough skilled labour to carry out the specialised work and that they had difficulty in recruiting the required labour because of the restrictions on expenditure. In addition, the rate of pay within the counties is less than that of the private contractor, and is not sufficient to attract skilled labour in the required numbers.
Some counties said that the reasons why some types of work were given to contractors was the shortage of skilled labour within the DLO, needed to carry out the work programme. However, other counties said that acquisition of skilled labour would solve only part of the problem, because they would not be able to fully utilise them throughout the year.
Another important criterion affecting the choice between DLO and contractor is the cost associated with each alternative. Some counties take it for granted that carrying out the work by contractor is more economic because of the necessity of employing specialised types of plant, and because material costs were higher for them than for the contractor. However, in other counties they had their own plant and obtained their materials at a reasonable

price, and provided data to prove that they had legitimately won contracts when tendering against contractors. As such, the costing data is considered an essential factor in enabling management to take the right decision between carrying out the work by DLO or by contractor. Therefore the costing system, as applied within the highways maintenance departments, has been examined in order to decise its suitability as a tool for decision-making. This examination revealed that the costing system which was adopted was an absorption costing system. The main feature of this system is that all costs are eventually charged to services. This involves charging the cost unit not only with their direct costs but in addition, with a share of all overheads. The management's dependency on this costing technique not only prevents it from taking the right decisions, but also misleads it due mainly to not providing the management with the relevant information needed to cope with effective decision-making. Besides adopting the appropriate costing system, the management needs to judge the efficiency of its DLO in carrying out the maintenance work. This is important, because this thesis supports the continuance of DLO's provided they are economic and efficient in carrying out maintenance work. In order to achieve this aim, the management has to measure the productivity of its DLO when carrying out all aspects of maintenance work, in order to improve the efficiency of its different activities, and attempt to obtain the maximum benefit from the limited funds available.

IV Only if the management can test the efficiency with which its maintenance work is carried out will it be persuaded that it can be improved. The measurement technique which is adopted by the highways department, the Effective Performance (EP), is only concerned with measuring the labour output and using it as a measure of the overall productivity which is, in fact, strongly influenced by factors (materials, plant and management). This technique pays less attention to other factors that reflect the current condition of the internal state of the organisation : labour skills, motivation, capacity for effective interaction, communication and decision-making. In the meantime, this technique suffers from another disadvantage which results from its concern with only the end results, without giving management enough information to explain the reasons which affect achieving these results.

In the highways maintenance department, the technique used to measure productivity depends on the technique of work study. They considered that the standard time for carrying out a specific task was suitable for the measurement of the productivity of their work. However, the questionnaire indicated that there are certain problems associated with applying such a scheme. These problems resulted from the single fact that in most, if not all the counties surveyed, it was found that only one technique of work study (time study) was used without adequate use of the other technique (method study).

Despite the fact that the Marshall Report has recommended the use of national standard times, and has invited the different local authorities to adopt them, after modifying them to suit their different circumstances, very little has been done up to the time of this thesis, to adopt such standards. The questionnaire revealed that the main purpose for introducing such a scheme was the installation of an incentive bonus scheme. Only 40 per cent of the counties surveyed adopted standard time to control their work. This scheme, in most of the cases, had been borrowed from other neighbouring counties without modifying it to cope with the different local circumstances. However, many of the managements of the counties surveyed were fully aware of the fact that method study should be carried out, in order to estimate accurate standard times, but they argued that due to financial difficulties and shortage of staff, they could not adopt such a scheme. Some other counties said that it would take a lot of time to apply method study, but the researcher maintains that they cannot make such a statement without experimenation, and suggests that a start should be made somewhere. The calculation of standard time to be used as a measure of the productivity without carrying out a method study (which should ensure that the method is effective and not wasteful) create more problems within the highways departments.

The questionnaire revealed that there is no acceptance of these standards by the roadmen, who consider them unfair and unreliable. This has resulted in creating an atmosphere of dissatisfaction among the roadmen with the way they have been rewarded. They believe that their efforts have been underestimated and their bonus scheme is too complex to be understood, as well as not working satisfactorily, although they were concerned that they should receive some form of bonus in order to compensate for their low wages. The majority of the roadmen consider their wages low in comparison with the private sector or other types of work requiring the same skills. They said that although the bonus, when added to their basic wage, made their earnings more respectable, yet the main shortcoming of the bonus scheme was that it tied the amount of bonus to their pay grade, regardless of the efforts they expended to achieve a particular output. In addition, the roadmen claimed that they operate in difficult working conditions and the rewards are not enough to persuade them to increase their efforts. They argued that they cannot relate the rewards to their effort and there are different reasons beyond their control which affect their earning capacity.

Despite the importance of financial rewards, the questionnaire proved that the roadmen are seeking to satisfy different needs from their work. They considered having good human relations, a feeling of control over their work, good relationships with their supervisors and workmates, the full appreciation of management and the climate created by the style of management to be very important with regard to job satisfaction. Although there is no direct relationship between satisfaction and improving productivity, it seems logical that having a satisfied work force is a psoitive step towards achieving improved productivity.

This is especially true as the maintenance work is considered to be labour-intensive where labour costs represent 50 per cent of the total cost. In addition, the study carried out by the researcher to measure the productivity of DLO's took into consideration the effects of other factors which contributed to the output (i.e. material, equipment, management and work environment and found that the labour factor was the major cause affecting overall productivity.

According to the results obtained by the questionnaire and interviews, and the analysis of the results, the researcher concludes that it is in the management system where least has been done, and where problems exist and are most complex. The management of the highways departments argued that the reasons for their problems included both financial and organisational difficulties, apart from political pressures and the nature of the activities undertaken. The researcher believes that this ought to necessitate improving the management's analytical tools and techniques, or even replacing them, if necessary, in order to achieve the most effective way of performing every activity. They should recognise that for good management in all its spheres, satisfactory working conditions, good employee relationships and high quality of work are the aims which they should work harder to achieve. Nevertheless, if the management hopes to improve the productivity of its DLO it should try to answer the question of "How" it could become more efficient.

The main aim of this thesis is to help the management to answer this question and utilise its resources efficiently. To this end, the researcher recommends the following procedures to be adopted by the management of the highways maintenance departments.

10.2. Recommendations

I. Good management should not be impeded by unnecessary bureaucracy, centralisation and slow decision-making processes. An effective organisation structure needs to be appropriate for the work to be done, and must have simple lines of authority and responsibility, accountability, and clear channels of communication. The researcher suggests an alternative type of organisation based on viewing the highways maintenance department as a part of the whole system of local authority. This alternative organisation has an interactive influence network and through the interference action of the whole group and their participation in decision-making, better communication should be achieved. This flexible type of organisation will facilitate direct linking between the different levels where the hierarchical boundaries dissolve through better information flow through the vertical and lateral levels of the organisation. This will help in improving the planning capacity, encourage better resource utilisation, in such a manner that favourable and co-operative attitudes are created, and all members of the organisation endeavour to pull concertedly towards common, accepted goals which they have helped to establish (81). Consequently, this will help to improve the efficiency and productivity of the whole organisation.

However, although the right organisation structure forms an essential foundation to sound administration, it does not in itself guarantee efficiency. Therefore the management has to consider the achievement of efficiency to be one of its major tasks, which should be achieved through better planning and controlling of its work.

II The planning of the work of highways maintenance departments requires the identification of the main objective of the department in as measured terms as possible, and using criteria to guarantee the achievement of such objectives. This can be accomplished by adopting quality and quantity standards in order to determine the level of service it is desired to achieve. Until it is possible to design a national standard which can be adhered to by all the different authorities, the adoption of the standard suggested by the Marshall Report is recommended after modifying it to suit the particular local circumstances within the different authorities. Unless a common language is used among the different authorities, the task of comparing and controlling the work will be very difficult.

After determing the objectives of the department, an assessment of the work load needs to be based on the actual condition of the present road network. This will depend on preparing a priority list of the work which needs to be done in order to ensure the rational allocation of the limited funds available, as effectively as possible. The researcher recommends the adoption of either MARCH or CHART assessment systems. There seems to be no point in every authority attempting to develop its own assessment system ; rather, it is better to modify either of the suggested systems in order to cope with the different situations in the different authorities. This is considered a key factor in solving the problem of standardisation of the level of services provided by the different highways departments.

According to these procedures, the management should be able to plan the scheduling and execution of the work in such a way as to ensure the full utilisation of its available resources of men, material and plant.

The researcher recommends the use of simple bar charts for the day-to-day maintenance work. For large improvement projects, network analysis techniques can be used in order to ensure better utilisation. Consequently, it will help to draw up a well-planned programme of work which gives a satisfactory forecast of labour, plant and material requirements.

The researcher recommends the following procedures to be adopted by the Divisional Surveyor or the responsible manager of highways in executing the work.

1. Identify the different types of maintenance work needed to be carried out in terms of time and physical resources, material, equipment and men.
2. Plan for the work which is to be done by DLO's on bar charts, using a weekly, detailed, and monthly programme, and a less detailed annual programme.
3. Identify the different skilled labour needed, the skilled labour available and the required skilled labour which should be provided through training programmes.
4. For specialised types of work about which there is the problem of either using DLO's or contractors to carry it out, the researcher recommends the establishment of special gangs with the skills required for performing such work. In order to ensure the full utilisation of such special gangs, they should be moved throughout the different districts of divisions of the counties. The man-made boundaries between divisions should be removed and the suggested organisation should help to ease communication among the different parts of the same counties. The management of the highways departments have to balance between the expenses of transporting road gangs, plant and materials etc., and the benefit gained from moving them freely through the counties. This will guarantee the full utilisation of the specialised plant which may be required for such types of work.

In addition, gain is to be expected in reducing the cost of material if ordered in bulk by the counties. In the meantime, the following points should be considered :

a) Effective stock control procedure should be implemented. Materials with a limited storage life (e.g. cold laid bituminous materials) should be carefully controlled, suitably stored, and adequately protected from the weather.

b) Transport of materials, labour and plant from depot to site should be studied in order to minimise unnecessary transportation time.

c) The design of plant (including equipment for temporary works) should be studied in order that the plant actually used should be suitable for the purpose to which it is put. In some cases, minor modification of existing plant may substantially improve its productive capabilities.

d) Hand tools should be maintained in good condition. Any possible modification should be carried out to provide tools more suitable and perhaps less fatiguing than the existing ones.

5. The management needs to have a flexible costing system in order to help in rationalising its decision of choosing between DLO's and contractors. The researcher recommends the marginal costing technique as a better alternative to the absorption costing technique. The marginal costing technique is considered by the research to be a powerful tool for planning, controlling and decision-making. It provides a flexible accounting system able to cope with different decisions taken by management, by identifying the relevant cost data. According to the different decisions to be taken, one can arrange the costing data in different ways to provide the most accurate basis suitable to the problem that needs to be solved.

III Controlling the work

The management of the highways departments needs accurate, reliable, simple measurement of its productivity in order to control the work. It is important that the data provided by such measurement be suitable, updated, and correspond to the needs of management. The measurement process, consequently, must be able to show clearly the reasons for achieving, or not achieving, the desired results (81). It should be used as a guide rather than a policy.

The measurement technique which is most appropriate must be able to show what is happening at all times, because any inadequacy of the measurement process used by the highways authorities leaves a large gap in the amount and kind of information available to the management for controlling the work.

Therefore, the researcher recommends the application of a technique of measuring productivity, called the "Method Productivity Delay Model" (MPDM). The researcher carried out field studies of three different examples of maintenance operations (patching, kerb laying and gully emptying) in three different authorities in order to indicate the expected benefits gained through its application. The information provided by the model makes it possible for management to measure productivity and be made aware of delaying factors as a result of the contribution to production of labour, materials, equipment, plant, management and the work environment.

The technique is quite simple and depends on using the time study technique, but in a rather different way than normal. It demands studying and observing the work flow for the whole gang as one entity, and following these main steps :

1. Studying the main method of doing the work and identifying

the production unit, the production cycle (the time needed to finish a production unit which is repeated every time) and the leading resource.

2. Observing and recording on a simple sheet, the time of each production cycle and any kinds of delay that may occur during this cycle. The different categories of delay are environment, equipment, labour, material and management, symbolised repectively by Een, Eeq, Ela, Ema, Emn.

3. Determining the productivity equation by means of the simple, mathematical calculation :

$$\text{Overall productivity} = (\text{Ideal productivity})(1-\text{Een}-\text{Eeq}-\text{Ela}-\text{Ema}-\text{Emn})$$

4. Modifying the equation to take the new circumstances into consideration should the leading resource, which affects the method of doing the work, change.

By adopting such a technique, the management will be able to measure accurately and reliably, the productivity of doing the work. It supplies an explanation for the reasons which might affect overall productivity so that management can take appropriate action.

IV Improving the Productivity of DLO

If the management uses the information obtained by such measurement techniques, for helping the workers to improve their productivity - in a constructive and non-authoritarian way - it is much more likely that this would be welcomed and accepted by them, rather than feared and resisted.

Improving productivity, however, should not be the sole responsibility of the top management in any organisation. Rather, it is a part of the everyday function of every line manager, supervisor, foreman and operative (235). It might be true that it is at the level of the first line management and supervisors that so many problems exist in British industry today ; if so, then this is where improvement in the effective use of all human and physical resources must be obtained (252). So management and employee should participate together in order to achieve the desired productivity (235). In addition, it is considered an important factor towards solving the problem of managing people at work and improving their productivity (240). The lack of understanding of the human resources of any organisation results in the following problems (86) :

1. Workers' alienation and job dissatisfaction, as the decision-making processes of organisations fails to provide the involvement which the employee expects.
2. Rising unemployment and falling productivity. While the productivity of industry and workers is declining, the counter-productive behaviour (e.g. turnover, absenteeism, sabotage, theft, union militancy, etc.) is increasing.
3. Public confidence in large institutions and big business is being eroded.

The major cause of all these symptoms is a result of meaningless jobs, authoritarian management and the deteriorating quality of life at work. These affect the individual's feelings towards himself, his job, and towards the organisation. Therefore, better understanding of the importance of the human element in the production process will contribute to improve productivity (81). This agrees with the results obtained through measuring the productivity of the different maintenance work by applying MPDM, which demonstartes that the major cause affecting overall productivity is the labour factor. Labour delay represents the highest percentage of all delays and the management has to understand the different needs of their roadmen in order to be able to discover what motivates them to extend their effort. In addition, the management must choose the right system for motivating them to improve their productivity. However, individuals are very complex systems, and different factors affect their desires and contribute to motivating them to improve their productivity. This depends, among other things, on the way they satisfy their expected needs through the work that they do within the organisation. Good working conditions, a suitable working environment and good management style and philosophy are among the factors which contribute to providing the individual with the right climate in which to improve his productivity.

Therefore, the researcher recommends that to improve the productivity of DLO's, the management needs to :

1. Motivate the roadmen through applying a well-designed incentive scheme. In order to motivate them to achieve the desired objective, the management has to eliminate the reasons for dissatisfaction. The researcher recommends the following procedure :

    a) Enough information has to be available to the roadmen about the objectives of the proposed incentive scheme, and explaining the way their bonus is calculated.

    b) Ensuring that the amount of bonus paid is based on how much effort the individual has exerted and not on the basic wage rate.

c) Using the standard hours as a basis of the incentive scheme only after applying the right procedure of method study in order to ensure that the method of work is efficient.

2. In the meantime, the management needs to look more carefully into the non-economic side of their roadmen's needs. Giving the roadmen more say in their work, more freedom, more initiative and more participation in the decisions affecting their work is expected to contribute to improving their satisfaction, which is believed to be the primary factor affecting productivity.

3. Improve labour relations with the supervisors, since they have an important part to play as a linking-pin between the work group and management. In order to ensure this role and create a good working climate, the supervisor should :

   a) Talk in the language of both worker and management.

   b) Encourage the participation of the roadmen in decisions affecting their work.

   c) Give them greater freedom and initiative in carrying out their work as long as they achieve the desired results.

4. In order to ensure the satisfaction of the individual and improve his productivity, there is a need to give him the feeling of control over his work. A way by which it is possible to achieve this is by providing the right training experience. The researcher recommends the following points :

   a) Providing the training according to the actual needs of the department and the skills available and required. This necessitates a well-planned training policy with enough information about the previous training provided, the current training required, and the expected training needed.

b) Encouraging the roadmen to join the training programmes by providing training at the right time, in the right place with the right equipment and, most important of all, providing training which is suitable to the real needs of the roadmen and their abilities.

c) Regarding the training policy as an integral part of management policy. The need for training starts from the moment the roadman joins the highways department. It should continue during his employment and be developed according to the needs of both the department and the roadman.

Having well-trained roadmen with a wide range of different skills will help to answer the one crucial question : whether it is more efficient to carry out the work by DLO or contractor. It will also provide the management with the advantage of a flexible work force able to be transferred to different jobs at different times and places, in order to fulfill the objective of working in the most economic way, by ensuring better utilisation of the human resources available within the highways maintenance departments.

Thus, the objective of this study has been to identify, highlight and analyse the problems confronting highways maintenance departments' management in utilising their DLO's as a valuable resource. The recommendations arising from the study, from the technical, practical, and human aspects, are essential factors of which management should be aware - and certainly should not neglect - in order to achieve its objectives of improved productivity in the highways maintenance departments. Adopting such recommendations should help the management of a highways maintenance department to develop their organisation into a highly co-operative social system where every member of the organisation has coalesced into a strong force aimed at accomplishing the mutually established objective of the organisation.

APPENDICES

Appendix 1.1.

Counties in Order of Population in England

No.	County	Population
	Metropolitan Counties	
1.1	West Midlands	2,779,700
1.2	Greater Manchester	2,779,700
1.3	West Yorkshire	2,082,200
1.4	Merseyside	1,602,700
1.5	South Yorkshire	1,317,200
1.6	Tyne and Wear	1,819,500
	Non-Metropolitan Counties	
2.1	Kent	1,440,800
2.2	Hampshire	1,434,700
2.3	Essex	1,408,100
2.4	Lancashire	1,370,100
2.5	Surrey	1,005,900
2.6	Staffordshire	991,100
2.7	Nottinghamshire	981,000
2.8	Hertfordshire	941,700
2.9	Devon	928,800
2.10	Avon	915,300
2.11	Cheshire	902,300
2.12	Derbyshire	892,300
2.13	Humberside	848,800
2.14	Leicestershire	829,800
2.15	East Sussex	658,900
2.16	Berkshire	653,400
2.17	Norfolk	650,300
2.18	North Yorkshire	648,600
2.19	West Sussex	615,400
2.20	Durham	610,900
2.21	Hereford and Worcester	585,900
2.22	Dorset	570,500
2.23	Suffolk	567,300
2.24	Cleveland	565,600
2.25	Cambridgeshire	540,700
2.26	Oxfordshire	535,300
2.27	Lincolnshire	519,500
2.28	Wiltshire	506,700
2.29	Buckinghamshire	497,800
2.30	Northamptonshire	496,400
2.31	Gloucestershire	485,400
2.32	Bedfordshire	484,300
2.33	Cumbria	475,700
2.34	Warwickshire	469,500
2.35	Somerset	400,400
2.36	Cornwall	398,600
2.37	Shropshire	354,400
2.38	Northumberland	258,700
2.39	Isle of Wight	110,900

Appendix 1.2.

Initial Invitation to Co-operate on

Research Programme

Interdisciplinary Higher Degrees Scheme Office
The University of Aston in Birmingham B4 7ET.

The County Surveyor,

Dear Sir,

I have pleasure to introduce myself. My name is Sonia M. El-Bakry. I do research work to obtain my PhD. under the supervision of Mr. L. Ford of the Civil Engineering Department at Aston University in Birmingham. My project title is "Measurement of Productivity and Cost of the Direct Labour Orhanisation within Highways Maintenance Departments."

I have designed a quesionnaire to investigate the necessaity and utilization of direct labour organisations. I hope you will co-operate with me in completing my questionnaire. I would like to gather my questionnaire by personal interviews. If you are willing to help me, please send me a letter telling me when it would be convenient to pay a visit to your county.

I'll be grateful if you are kind enough to send me also the number of your direct labour with the county.

I look for ward to your letter as soon as possible. If you need any more information, please don't hesitate to contact me.

Thank you in advance for your co-operation.

Yours faithfully,

Sonia M. El-Bakry

Appendix 1.3.

I Questionnaire Designed for the Management of Highways Maintenance Departments

I GENERAL

1.1. What are the objectives of the Highway Maintenance Department?

____

____

____

____

1.2. Has adequate time been allotted by those concerned in respect to forward planning and ways of meeting objectives?

Yes .... No ....

1.3. Is there a clear understanding of objectives from the points of view of the different groups. (Please tick where appropriate)

1.3.1.	Members	Yes	No ....
1.3.2.	Management team	Yes	No ....
1.3.3.	Surveyor	Yes	No ....
1.3.4.	Department management	Yes	No ....
1.3.5.	Supervision	Yes	No ....
1.3.6.	Operators	Yes	No ....

1.4. Are forecasts established to reflect future needs?

Yes .... No ....

1.5. What points might be considered to bring about improvements in the plans to meet objectives of the Highways Department?

____

____

II ORGANISATION STRUCTURE

2.1. Is there an organisation chart outlining the functional relationships and levels of responsibility among the different departments of your authority?

Yes .... No ....

(If yes, please attach a copy of the chart)

2.2. Is an organisation chart maintained up to date?

Yes .... No ....

2.3. Does the organisation reflect the objectives and the programme to meet those objectives?

Yes .... No ....

2.4. Are the various duties and responsibilities delegated properly and defined clearly?

Yes .... No ....

2.5. a. Is there any overlapping or duplication of functions?

Yes .... No ....

If yes, please give reasons

____

____

____

____

2.6. Are the lines of authority effective from the stand-point of control?

Yes .... No ....

2.7. Do the people concerned have sufficient understanding of responsibilities and authorities assigned?

Yes .... No ....

2.8. What are the strengths and weaknesses of your present organisation? (Please write in)

2.9. What steps could be taken to increase the effectiveness of the organisational structure? (Please write in)

III FINANCE

3.1. Who is responsible for the annual Highway allocation? (i.e. for determining the amount of funds)

____

3.2. Who is responsible for the allocation of funds for the Highway Maintenance Department?

____

3.3. What are the different sources for providing the funds of the Highway Maintenance Department:

3.3.1. within the County Council?

____

2. within the District Councils?

____

____

3.4. What are the procedures for allocating funds for Highway Maintenance work?

____

____

3.5. Are there certain resources devoted to each type of maintenance work?

Yes .... No ....

If yes, please explain

____

____

____

____

3.6. Is there budgetary control over all expenditure?

Yes .... No ....

3.7. Which of the following factors most affect Maintenance Expenditure? (Please tick where appropriate)

3.7.1. Increased traffic ....
3.7.2. Weight of vehicles ....
3.7.3. Increased road mileage ....

3.7.4. Higher standards and new requirements ....
3.7.5. Something else (Please write in)

____

(If there is any other quantitative data relevant to this section please include).

3.8. Have there been, in your experience, jobs which require more than one financial year for completion?

Yes .... No ....

3.9. a. Is it allowable to carry over the current years appropriation to complete any unfinished job in the next year?

Yes .... No ....

b. If NO, what is the source of finance for this job during the next year?

____

3.10. What are the other problems requiring appraisal when considering finance for maintenance work?

____

____

IV MAINTENANCE

4.1. Please state briefly the jobs undertaken by the Highway Maintenance Department.

____

____

____

4.2. Is there a reliable estimate of the capacity of your direct labour maintenance organisation? (e.g. Physical value or value of work which can be undertaken)

Yes .... No ....

(If yes, please state the procedure)

____

____

4.3. Do you classify maintenance work into different categories?

Yes .... No ....

4.4. If yes, What are the bases of these classifications: (Please tick where appropriate)

4.4.1. Emergency ....
4.4.2. Nature of the maintenance function ....
4.4.2.1. Structural Maintenance ....
4.4.2.2. Cyclic (including aids to movement, safety and amenity) ....
4.4.2.3. Winter maintenance ....
4.4.2.4. Contract maintenance ....
4.4.2.5. Miscellaneous maintenance ....
4.4.3. Kind of labour ....
4.4.4. Kind of plant ....
4.4.5. Others (please write in) ....

____

____

4.5. Please state briefly the categories of maintenance undertaken by:-

4.5.1. Direct Labour

____

____

4.5.2. Contractor

____

____

4.6. What categories of maintenance work do you consider can only be undertaken, efficiently or otherwise, by Direct Labour? Please give reasons.

____

____

____

4.7. Does the Authority own any specialised items of equipment (e.g. finishers).

Yes .... No ....

a. If, yes, please list the items

____

____

____

____

b. If no, do you consider that the Authority could compete with contractors in so-called specialist work, such as resurfacing given the given the equipment? (Please comment)

____

____

____

____

4.8. What decision criteria do you use in choosing between direct labour and contractors for maintenance work? (Please comment).

____

____

____

____

4.9. Are you adopting one of these rating systems: (please tick one)

	Yes	No
4.9.1. MARCH	....	....
4.9.2. CHART	....	....

4.9.3. Something else. (please write in)

____

(If NO, what are the reasons for your answer)

____

4.10. What is the most important cost factor in maintenance? (Please tick)

4.11.1. Labour costs ....
4.11.2. Plant Costs ....
4.11.3. Material Costs ....
4.11.4. Others (Please write in)

____

4.11. If you would like to express any other opinion about anything concerning maintenance work in your department feel free to do so in the space below.

____

____

____

____

V LABOUR

5.1. Please give the numbers of workers employed in your department according to the following classification (if appropriate)

5.1.1. Technicians ....
5.1.2. Divisional area foremen ....
5.1.3. Inspectors ....
5.1.4. Gangs ....
5.1.4.1. Gangers/Working Foremen/Chargehands
5.1.4.2. Plant Operatives ....
5.1.4.3. Craftsmen ....
5.1.4.4. Fitters ....
5.1.4.5. Roadmen ....
5.1.4.6. Others (please write in)

____

5.2. a. What are the numbers of employees in each of the following groups?

5.2.1. Technical Staff ( )
5.2.2. Clerical Staff ( )
5.2.3. Others (please write in)

____

b. How do you estimate the correct number of workers required for each group?

____

____

5.3. Is the number of workers in your Department sufficient for carrying out the maintenance work during the whole year?

Yes .... No .... Don't know ....

What are the reasons for your answer?

____

____

____

5.4. What is the level of each of the following factors:
(Please tick where appropriate)

		Low	Normal	High
5.4.1.	Absenteeism	....	....	....
5.4.2.	Turnover	....	....	....
5.4.3.	Sick Leave	....	....	....
5.4.4.	Request for transfer	....	....	....

5.5. If the level is High, for any or some of the above factors

a. What are the reasons, from your point of view?

____

____

b. Is there any analysis done for these reasons?

Yes .... No .... Don't Know ...

5.6. Is there operating within the Highway Maintenance Department a scheme of job description and job classification?

Yes .... No ....

If yes, please attach a copy.

5. 6.1. If No, are you thinking of adopting one?

Yes ... No ... Don't Know ...

What are the reasons for your answer

____

5. 7. Is the maximum use made of direct labour?

Yes .... No ....

5. 7.1. If Yes, what are the reasons for your answer?

____

5. 7.2. If No, how can they be used more effectively?

____

5. 8. Does the department provide any kind of fringe benefits to workers?

Yes .... No ....

(If yes, please state it briefly)

____

____

IV INCENTIVE SCHEMES

6.1. Have you adopted an incentive bonus scheme within the Highways Departments?

Yes .... No ....

If Yes,

6.1.1. Do the workers understand the bonus scheme?

Yes .... No .... Don't know ....

6.1.2. Who is entitled to work on such a scheme?

6.1.3. Do the workers know how much time they have in hand?

Yes .... No .... Don't know ....

6.1.4. Do the workers know the formula for translating time saved into percentage bonus and from percentage to cash?

Yes .... No .... Don't know ....

6.1.5. How are rates set in the first place?

____

6.2. In your opinion, do the workers need to have an incentive bonus scheme.

Yes .... No ....

What are the reasons for your answers?

____

____

____

6.3. Do you think that the incentive bonus scheme works satisfactorily among the workers?

Yes .... No .... Don't know ....

6.4 What are the reasons for your answers?

____

____

____

6.5. What are the main factors affecting the capacity to earn (please tick where appropriate)

6.5.1. Waiting time ....
6.5.2. Waiting for equipment ....
6.5.3. Faulty material ....
6.5.4. Allocation of work. ....
6.5.5. Something else (please write in)

____

6.6. What are the steps taken to offset their effects?

____

____

6.7. Which is more important to workers (rank if possible - 1, 2, 3 etc.)

6.7.1. economic incentives ....
6.7.2. Human relations ....
6.7.3. Others (please write in)

____

6. 8. How can a system of economic incentives be made to pay off in higher productivity?

____

____

____

VII PRODUCTIVITY

7.1. Is there within the Highway Maintenance Department a scheme of method and time study?

Yes .... No ....

If Yes:

7.1.1. Are there problems in operating such a scheme?

Yes .... No ....

(If yes, please state briefly)

7.1.2. What can management do to meet these problems?

7.1.3. Has productivity per man-hour increased?

Yes .... No .... Don't know ....

7.1.4. Has cost been reduced?

Yes .... No .... Don't know ....

7.2. What method has been established to measure productivity?

7.3. a. Do you think that there is a need for Maintenance standards?

Yes .... No .... Don't know ....

b. What are the reasons for your answer?

7.4. Are work units identified and standards set?

Yes .... No ....

If Yes,

7.4.1. What are these standards? (Please give details)

7.4.2. Who is responsible for fixing these standards?

7.4.3. Are these standards obtainable?

Yes .... No ....

If No, what are the reasons?

7.4.4. What are the factors to be considered in setting these standards?

7.5. Which type of saving or increase in productivity may be expected from method and time study? (Please tick where appropriate)

7.5.1. Through reduction in the work content of the process ....
7.5.2. Through better machine efficiency ....
7.5.3. Through better use of labour ....
7.5.4. Something else (please write in)

7.6. What else is needed to increase the Maintenance Department's efficiency?

VIII TRAINING

8.1. Are there organised training programmes within the Highways Departments?

Yes .... No .... Don't know ....

8.1.1. If No, what are the reasons? (Please tick where appropriate)

8.1.1.1. No need for training programme ....
8.1.1.2. No facility ....
8.1.1.3. Others (please write in)

8.1.2. If Yes, who is to be trained? (please tick where appropriate)

8.1.2.1. Roadmen ....
8.1.2.2. Foremen ....
8.1.2.3. Others (please write in)

8.1.3. How many persons have been trained?

8.1.4. Who is to do the training?

8.1.5. What is the content of the training programme? (Please attach a copy)

8.2. What are the phases of training new maintenance men? (Please tick where appropriate)

8.2.1. Formal school ....
8.2.2. On the job training ....
8.2.3. Others (Please write in)

8.3. What are the objectives of the training? (Please tick where appropriate)

8.3.1. For the trainee

8.3.1.1. Increase job satisfaction ....
8.3.1.2. Increase earning capacity ....
8.3.1.3. Given new task ....
8.3.1.4. Others (Please write in)

8.3.2. For local authorities :

8.3.2.1. To provide training appropriate to the requirement of the department. ....
8.3.2.2. To provide training appropriate to the needs of the individual. ....
8.3.2.3. To shorten the time required to produce an effective worker ....
8.3.2.4. To identify and develop potential supervisors ....
8.3.2.5. Others (please write in)

____

8.4. Will the achievement of these objectives lead to further benefits such as the following? (Please tick where appropriate and mark them up to 3 in order of importance).

8.4.1. Increased productivity ....
8.4.2. Reduced repair and maintenance costs ....
8.4.3. Improved morale ....
8.4.4. Less absenteeism ....
8.4.6. Others (Please write in)

____

8.5. Are new workers given sufficient orientation and training?

Yes .... No ....

8.6. Are there any evaluations of these training programmes?

Yes .... No ....

8.6.1. If no, what are the reasons?

____

____

8.6.2. If yes, please answer the following questions.

8.6.2.1. Has production increased?

Yes .... No ....

8.6.2.2. Were former training periods reduced for certain jobs?

Yes .... No ....

8.6.2.3. Are new workers able to reach expected earnings more quickly?

Yes .... No ....

8.6.2.4. Are there fewer accidents?

Yes .... No ....

8.6.2.5. Is there less spoilage and less damage to machines and equipment?

Yes ....   No ....

8.6.2.6. Have turnover rates reduced?

Yes ....   No ....

8.6.2.7. Have better industrial relations been achieved?

Yes ....   No ....

8.7. What other problems are you likely to encounter with training?

____

____

____

____

IX BUDGETARY CONTROL SYSTEM

9.1. Do you have a budgetary control system?

Yes .... No ....

(If yes, please attach a copy)

9.2. Are there limiting factors which affect the budget and which play an important part in its construction?

Yes .... No ....

9.2.1. If yes, what are these factors?

9.3. In designing the budget do you use

9.3.1. Standards? ....
9.3.2. Estimates? ....

9.4. Do you prepare a budget for every job?

Yes .... No ....

9.4.1. If yes, do you prepare a budget for every operation within the job?

Yes .... No ....

9.5. Do you compare the acutal cost and the budgets for every element of cost in every operation within the job?

Yes .... No ....

9.5.1. If Yes, do you do this comparison:

9.5.1.1. weekly? ....
9.5.1.2. monthly? ....
9.5.1.3. Others? (please write in)

9.6. Do you analyse this deviation to discover the reasons in order to take corrective action?

Yes .... No ....

9.7. Is your maintenance department divided into cost centres for the purpose of cost accounting?

Yes .... No ....

9.8. Does your cost analysis divide the cost elements into: (Please tick where appropriate)

9.8.1. Direct and indirect costs? ....
9.8.2. Variable and fixed costs? ....
9.8.3. Others? (Please write in)

9.9. How do you allocate the cost of the following items to each cost unit?

9.9.1. Transport cost of raw material

____

9.9.2. Workshops repair and maintenance

____

9.9.3. Storage costs

____

9.9.4. Administration costs

9.10. State the basis of calculating the cost of the cost unit

____

____

____

9.11. Can you get the actual cost information from the record ?

Yes .... No ....

If Yes, what are the cost accounting records used in your department? (Please attach a copy of each record)

____

____

9.12. How do you estimate the total cost of the job in order to take a decision whether to do the job by direct labour or by contractors?

____

____

____

____

Thank you for your co-operation.

Appendix 1.4.

Sample letter enclosed with draft Questionnaire

Interdisciplinary Higher Degrees Scheme Office
The University of Aston in Birmingham B4 7ET.

The County Surveyor

Dear Sir,

Thank you for your letter dated

I have pleasure to send you a copy of the questionnaires which I designed to investigate the necessity and utilization of direct labour organization. I think it would be better if you know the nature of the questions before the interview* to minimize the time required.

I have chosen the counties purely at random from the counties which agreed to co-operate in completing the questionnaire. In order to complete the study it is necessary for me to find out the views of the management about direct labour organisation at the Highways Maintenance Departments. For this purpose I have designed the first questionnaire.

Since, for scientific requirements, it is important to get the views of particular cross sections of the work force in the Highways Maintenance Departments I designed the second questionnaire. Also, I hope that you will be able to arrange for me to interview a sample number of workers who will be willing to offer their help.

Your individual replies are entirely confidential and will be seen by no-one but myself.

Thank you for your co-operation.

Yours faithfully,

Sonia M. El-Bakry

Enc :

* I'll arrive on about o'clock at the train station.

Appendix 1.5.

II Questionnaire Designed for the Roadmen of Highways Maintenance Departments

I PERSONAL

1.1. Are you? Single .... Married .... Others ....

1.2. How old are you?

Under 21	40-49
20-29	50-59
30-39	Over 60

1.3. How long have you been employed here? (Please tick where appropriate)

1.3.1. Less than one year
1.3.2. Between one year and five years
1.3.3. Between five and ten years
1.3.4. Between ten and twenty years
1.3.5. Over twenty years

1.4. Where do you live?

1.4.1. Less than one mile from work
1.4.2. One to three miles
1.4.3. Three to six miles
1.4.4. Over six miles

1.5. What is more important to you? (Please tick one)

1.6.1. Economic incentives
1.6.2. Good human relations
1.6.3. Others (Please write in)

II ATTITUDE TO WORK

2.1. What do you aim at from your work?

2.2. a. What particular thing do you like about your job?

b. What particular thing do you dislike about your job?

2.3. Whenever you talk about your job, would you say that your comments are mostly?

favourable? unfavourable?

2.4. Which one of the two statements is more true to your needs:

2.4.1. A great deal of satisfaction in people's lives comes from the job they do. No matter how much money they get, if the job itself is not a satisfying experience they remain discontented.

2.4.2. People work so that they can lead a satisfying life away from work. No matter what this is if the money is right they won't worry.

2.5. To what extent does your job offer you the following rewards and opportunities? Please put a tick for each statement in the space nearest the answer you believe best describes your rewards and opportunities as they are now:

	Very little					Very much
2.5.1. Security of employment	.	.	.	.	.	.
2.5.2. Good working conditions	.	.	.	.	.	.
2.5.3. Good pay	.	.	.	.	.	.
2.5.4. Warm friendly relationships at work	.	.	.	.	.	.

	Very little						Very much
2.5.5. Recognition of personal services to the department	.	.	.	.	.	.	.
2.5.6. Opportunities for upgrading or promotion	.	.	.	.	.	.	.
2.5.7. Recognition of my training or qualifications	.	.	.	.	.	.	.
2.5.8. Opportunities to learn new thing in the trade by using my training	.	.	.	.	.	.	.
2.5.9. A feeling of control over my work	.	.	.	.	.	.	.
2.5.10. Convenient hours so that I can follow my out of work interest	.	.	.	.	.	.	.
2.5.11. Opportunities to develop my abilities	.	.	.	.	.	.	.
2.5.12. A chance to call someone else anytime things go wrong	.	.	.	.	.	.	.
2.5.13. Something else (Please write in)							

2.6. Are the following things provided. (Please tick where appropriate)

2.6.1. Showers and washing facilities	Yes	No ....
2.6.2. Breaks	Yes	No ....
2.6.3. Lunch facilities	Yes	No ....
2.6.4. Special clothing	Yes	No ....
2.6.5. Others (Please write in)		

2.7. Below are a number of aspects which may attract you to consider another job. Could you choose three which would be the most attractive to you and place them in order of importance, numbering them 1,2,3.

2.7.1. Higher pay
2.7.2. Better hours or nearer to home
2.7.3. Promotion chance
2.7.4. Chances to get right kind of experience in a job or to use my qualifications
2.7.5. More interesting or a different sort of work
2.7.6. To be nearer my friends
2.7.7. Something else (please write in)

2.8. Do you frequently work under these conditions: (Please tick where appropriate)

2.8.1.	hot	Yes	No ....
2.8.2.	cold	Yes	No ....
2.8.3.	wet	Yes	No ....
2.8.4.	dusty	Yes	No ....
2.8.5.	noisey	Yes	No ....
2.8.6.	gaseous	Yes	No ....
2.8.7.	something else (please write in)		

III PAYMENT SYSTEM

3.1. How is payment made? (Please tick where appropriate)

3.1.1. Team work
3.1.2. Piece work
3.1.3. Premium bonus
3.1.4. Time rate
3.1.5. Others (please write in)

3.2. a. What do you think about your present pay? (Please tick one)

Bad
Good
Unsure

b. What are the reasons for your answer?

3.3. a. If you had to choose a system of payment for yourself, which of the following do you think might be the best? (Please tick one)

3.3.1. Individual piece work
3.3.2. Time rates
3.3.3. Measured day work
3.3.4. A share of production plan
3.3.5. Others (Please write in)

3.4. What do you think is the best about your choice of payment system above compared with others? (Please tick one)

3.4.1. Increases efficiency
3.4.2. Increases earning
3.4.3. Increases satisfaction among employees
3.4.4. More just and fair
3.4.5. Other (please write in)

3.5. Is the incentive bonus scheme important to you?

Yes .... No ....

If yes:

3.5.1. Do you know how to calculate your earning?

Yes .... No ....

3.5.2. Will the extra reward be worth the extra efforts?

Yes .... No .... Don't know ....

III PAYMENT SYSTEM

3.1 How is payment made? (please tick where appropriate).

3.1.1. Team work ....

3.1.2. Piece work ....

3.1.3. Premium Bonds ....

3.1.4. Time rate ....

3.1.5. Others (please write in)

____

3.2 a. What do you think about your present pay? (Please tick one)

Bad ....

Average ....

Good ....

b. What are the reasons for your answer?

____

____

____

3.3 What do you think the aim of a good payment system is? (Please tick where appropriate)

3.3.1. Increases efficiency ....

3.3.2. Increases earning ....

3.3.3. Increases satisfaction ....

3.3.4. More just and fair ....

Others (Please write in) ____________________

3.4 a. Is the incentive bonus scheme important to you? Yes .... No ....

b. What are the reasons for your answer?

____

c. Do you know how to calculate your earnings? Yes .... No ....

d. Will the extra reward be worth the extra efforts?

Yes .... No .... Don't know ....

3.5 Do you think the bonus scheme works satisfactory?

Yes .... No .... Don't know ....

What are the reasons for your answer?

____

____

____

3.6. Do you feel yourself to be part of a particular group within the Highway Maintenance Department?

Yes .... No ....

3.6.1. If yes, what are the most important things you have in common with others in the group.
(Please choose three and mark them 1, 2, 3, in order of importance)

3.6.1.1. Same job together
3.6.1.2. Work close together
3.6.1.3. Same pay grade
3.6.1.4. Similar outside interests
3.6.1.5. Talk during breaks
3.6.1.6. Trade union interests
3.6.1.7. Something else (please write in)

IV SUPERVISION

4.1. Do you normally work as a part of a team on a specific operation?

Yes .... No ....

4.2. a. Does your foreman tend to watch over you when you are doing a job?

Yes .... No ....

b. How much do you think he should watch over you?

4.3. Does your foremen put pressure on you to work harder?

Yes .... No ....

4.4. a. Does your foreman tell you in detail how to do a particular job?

Yes .... No ....

b. Are you in favour of this way?

Yes .... No ....

c. What are the reasons for your answer?

4.5. Does your foreman ask you to stick to the rules in all cases?

Yes .... No ....

4.6. How often does your foreman talk to you about things not related to the work?
(Please tick one)

Never	Sometimes	Always
( )	( )	( )

4.7. Does your foreman involve you in decisions which affect your work?

Yes .... No ....

4.7.1. Do you think he should involve you?

Yes .... No ....

What are the reasons for your answer?

4.8. What are the duties of your foreman from your point of view? (Please tick where appropriate)

4.8.1.	Maintaining discipline	....
4.8.2.	Maintaining flow of work	....
4.8.3.	Communicating with management	....
4.8.4.	Dealing with worker's queries	....
4.8.5.	Keeping records	....
4.8.6.	Something else (Please write in)	

____

4.9. Would you say that relationships between you and your foreman were normally

good ( ) satisfactory ( ) poor ( )

(please tick one)

4.10. Does your foreman consult you aobut any new plans which might affect your job?

Yes .... No ....

4.11. Do you speak with your foreman if you wanted to:

4.11.1.	Make suggestion to improve productivity	Yes	No ....
4.11.2.	Complain about being given a particular job	Yes	No ....
4.11.3.	Complain about work condition	Yes	No ....
4.11.4.	Make a point about overtime levels	Yes	No ....
4.11.5.	Something else (please write in)		

____

____

Appendix 2.1.

The Work of Local Authorities - I England & Wales

Sources : Bains Report, Appendix L, Circular 121/27 Department of the Environment.

Key: NMC = Non-metropolitan county NMD = Non-metropolitan district
MC = Metropolitan county MD = Metropolitan district
T = Trading activity

Social Services and Personal Health Services

Social services	NMC			MD

Education and Related Services

Education	NMC			MD
Libraries	NMC			MD
Museums and Art Galleries	NMC	NMD	MC	MD
Arts and Crafts	NMC	NMD	MC	MD

Housing and Town Development

Certain Reserve Powers, e.g. Overspill	NMC		MC	
Town Development	NMC	NMD	MC	MD
Housing - including building and management, slum clearance, house and area improvement		NMD		MD

Town and Country Planning and Related Matters

Structure Plans	NMC		MC(in special cases)	
Local Plans			MC	MD
	NMC (in special cases)			NMD (most)
Development Control			MC	MD
	NMC			MND (most)
Acquisition and disposal of land for planning purposes, development or redevelopment	NMC	NMD	MC	MD
Clearance of derelict land	NMC	NMD	MC	MD
National Parks (subject to the existence of Boards)	NMC		MC	
Country Parks	NMC	NMD	MC	MD
Footpaths and Bridleways	NMC	NMD	MC	MD
Commons - Management		NMD		MD
- Registration	NMC		MC	
Gipsy Sites - Management		NMD		MD
- Provision	NMC		MC	
Smallholdings and Cottage Holdings	NMC		MC	
Allotments		NMD		MD
Designation of Conservation Areas and Service of Preservation Notices	NMC	NMD	MC	MD
Caravan Sites - licensing and management		NMD		MD
- Provision	NMC	NMD	MC	MD

Highways and Related Subjects

Transport Planning	NMC		MC	
Highways - all(subject to the rights of districts to claim powers	NMC		MC	
- Right to claim maintenance powers in relation to un-classified roads in urban areas		NMD		MD
Traffic	NMC		MC	
Parking	NMC		MC	
Public Transport Undertakings				
- operation (T)		NMD		
- co-ordination (T)	NMC			
Passenger Transport Authorities (T)			MC	
Road Safety	NMC		MC	
Street Lighting	NMC			

Environmental Health

Food Safety and Hygiene		NMD		MD
Control of communicable Disease		NMD		MD
Offices, Shops and Railway Premises Act		NMD		MD
Factories Act		NMD		MD
Shops Act		NMD		MD
Port Health		NMD		MD

Other Environmental Services

Local Sewers		NMD		MD
Land Drainage	NMC	NMD	MC	MD
Refuse Collection		NMD		MD
Litter		NMD		MD
Refuse Disposal (including abandoned vehicles)	NMC		MC	
Coast Protection		NMD		MD
Clean Air		NMD		MD
Building Regulations		NMD		MD
Street Cleansing		NMD		MD
Nuisances		NMD		MD
Cemeteries and Crematoria		NMD		MD
Markets (T)		NMD		MD
Offensive Trades		NMD		MD
Health Education	NMC	NMD	MC	MD

Consumer Protection

Weights and Measures	NMC		MC	
Food and Drugs	NMC		MC	
Trade Descriptions	NMC		MC	
Consumer Protection Act 1961	NMC		MC	

Police and Fire

Police (subject to amalgamation)	NMC		MC	
Fire (subject to amalgamation)	NMC		MC	

Recreation and Tourism

Playing Fields and Swimming Baths	NMC	NMD	MC	MD
Parks and Open Spaces	NMC	NMD	MC	MD
Physical Training and Recreation	NMC	NMD	MC	MD
Publicity for Tourist Attractions	NMC	NMD	MC	MD

Licensing and Registration Functions

Most		NMD		MD
Births, Deaths and Marriages	NMC			
Adoption Societies	NMC			

Other Services

Entertainments (T)	NMC	NMD	MC	MD
Aerodromes (T)	NMC	NMD	MC	MD
Natural Emergencies	NMC	NMD	MC	MD
Restaurants (T)		NMD		MD

Appendix 3.1.

Example of Agency Agreement, County "B"

County Council of---------(B)

Agency Agreement Code of Practice CT2 1975

(Transport Engineering Division (TED)

Highway Revenue Budget and Programme Control

1. Introduction

This code of practice describes the procedures adopted to enable the County Council as Highways Authority to exercise control of highway revenue, budgets and programmes.

It is to be read in conjunction with the financial Code.

It is based on the requirement to relate progress and expenditure to a programme and plan.

In outline the code required detailed returns, quarterly, of both expenditure and physical progress against plan with less detailed expenditure returns monthly and exception reports as required.

The code covers the following Divisions of Services, within the revenue budgets.

(i) Roads and Footpaths Maintenance
(ii) Traffic Management Maintenance
(iii) Street Lighting Maintenance
(iv) Roads and Footpaths Improvements
(v) Traffic Management Improvements
(vi) Street Lighting Improvements.

2. Coding and Documentation

- A standard system of documentation will apply to all procedures involving County and District Councils. All forms utilised will be produced and supplied by the County Council following appropriate consultation where necessary, with the District Councils.

- A standard coding and budgeting system of documentation will apply to agency services based on the formal rules of agreement.
- A standard definition of expenditure to be treated as administration expenditure as opposed to direct expenditure will be produced by the County Council and agreed with the District Councils and adopted for coding and budgeting purposes.

3. Estimates

3.01 Schedules of proposals will be submitted with, and in support of The District's budget submissions. These will cover the following detail heads :

a) Roads and footpaths maintenance
   Special surface treatment
   Bridges and subways
   Fences
   Guard rails
   Drawings
b) All traffic management maintenance
c) Street lighting maintenance
d) All minor improvements.

3.02 Schedules are not required for the detail heads by the MARCH assessment.

01	Resurfacing	Surface dressing
02	Reconstruction	Footpaths and cycle tracks
		Kerbing

3.03 Estimates for other detail heads not mentioned above should be supported with relevant documentation.

4. Budget-Notification and Variation

4.01 The County Council will notify to the Districts full information on the approved budget by 1st March each year. The notified budget will be based on the previous November price levels.

4.02 Variations to the approved budget are covered by the Financial Code and the procedures for real term variations will remain in accordance with that code. Any request for a supplementary estimate will be submitted to the County Council for approval.

4.03 Variance between approved headings is provided for in the Financial Code subject to agreed limits.

The following limits will apply :

Division of services :	No amount shall be transferred without prior approval of the County Council.
Detail heads within Division of services :	District Council may authorise variance on certain Detail Heads to be defined if the amount involved in any one year is no greater than 10% of both transferee and transferer Detail Heads.

4.04 Inflation.

The County Council will agree with the District Councils the variations required in their budget allocations on a quarterly basis. The assessment of such variations will take into account pay and price variations up to the last day of the month preceding the following April, July, October and January.
The agreed variation shall be notified to those diistricts during those months subject to County Council policy or underwriting inflations.

4.05 Carry-over of Unspent Allocations in relation to Agreed Programme

The County Council will consider proposals for carrying over to a succeeding financial year unspent balances relating to an agreed programme of work, which the District can reasonably complete in the new financial year without detriment to the new year's programme. Notification not later than the 28th February in each year will be required for such proposals.

5. Programme and Expenditure Plan

5.01 Within 8 weeks of being notified of the approved budget each District will submit programmes and expenditure plans in respect of each Detail Head of Account except for those for which expenditure plans only are required.

5.02 Expenditure plans only will be required for the following detail heads : Patching ; Embankment and cuttings ; Gully Emptying.

5.03 Summary Expenditure plans only will be required for Divisions of Services.

5.04 Expenditure plans will be updated by County and District as inflation allowances are allocated.

5.05 If budgets are varied a new programme and expenditure plan will be notified by the District within two weeks of the variation being agreed.

6. Progress Reporting and Control

Quarterly Returns will be made by each District on or before 21 July, 21 October, 21 January, 21 April, to the County Council.

6.02 The Returns will report both progress against programme and Expenditure to the end of the quarter.

6.03 Summary Expenditure returns for each Division of Service will be made monthly on or before 21 February, 21 March.

6.04 Any deviation in progress or expenditure on any Head of Account in excess of 10% shall be reported to the County immediately.

6.05 Any deviation in expenditure on any Division of Service in excess of 5% or which would lead to an overall under- or over-expenditure on that Division of Service shall be reported to the County Council immediately.

Appendix 4.1

County Working Party on Organisation of Highways Maintenance

Draft List of Maintenance Functions

A. Structural Maintenance Functions

1. Resurfacing and corrections to camber.

   (i) Set up new levels
   (ii) Scarify to reshape existing surface
   (iii) Tack coat
   (iv) Lay coated materials by hand or machine
   (v) Roll.

2. Reconstruction and strengthening of foundations.

   (i) Excavate and cart away
   (ii) Trim formation and consilidate
   (iii) Place and consolidate new foundation material.

3. Surface Dressing.

   (i) Sweep surface
   (ii) Protect ironwork
   (iii) Spray binder - by hand
   - by pressure sprayer
   (iv) Spread chippings - by hand
   - by gritter
   (v) Roll
   (vi) Clear Ironwork
   (vii) Back sweep surplus chippings.

4. Patching.

   (i) Remove unsound material from bottom and sides of hole
   (ii) Brush clean
   (iii) Apply tack coat
   (iv) Spread new material and consolidate.

5. Drainage Repairs.

   (i) Pipe lines
   (a) Excavate to depth of existing drain
   (b) Remove old pipes
   (c) Lay new pipes, check line and level and joint
   (d) Backfill and consolidate.

   (ii) Gullies
   (a) 1. Break out existing gully and complete excavation
   2. Provide for additional gullies
   (b) Place concrete in base
   (c) Lower and position gully
   (d) Place concrete surround
   (e) Connect
   (f) Build base for frame and fit.

   (iii) Catchpits
   Excavate for and build catchpits complete either in brickwork or precast concrete sections including fitting cover frame.

(iv)	Manholes	As for catchpits
(v)	French Drains	(a) Where replacement of pipe is required as for Pipe Lines ; otherwise (b) Excavate filter media and replace with clean filter media.
(vi)	Covers and Grates	(a) Take up settled or broken frames (b) Re-bed existing or bed new frames (c) Make good surrounding carriageway.

6. Kerbs and Edgings

(a) Take up existing kerbs, channels, back edging and break out concrete backing and foundation.
(b) Lay new concrete in kerb foundations and backing to kerb
(c) Lay kerbs to line and level.
(d) Lay back edging to line and level including concrete foundations.

7. Footways (i) Flexible.

(a) Dig out old foundation and replace with new, consolidate.
(b) Patch potholed surfaces as for carriageway patching.
(c) Apply tack coat and cold asphalt skim coat.
(d) Surface dress footway.

(ii) Flagged.

(a) Rake out and open joints and brush in sand/cement mix or mortar mix.
(b) Take up single flags and re-bed and flush joints - replace with new flags where appropriate.
(c) Take up a number of flags, replace with new as appropriate re-bed and flush joints.

8. Bridges (i) Brick or Masonry Structures

(a) Rake out and point joints.
(b) Take down existing parapet walls and rebuild providing new brick or stone as necessary.

(ii) Steel Structures.

(a) Clean down steelwork and paint.

(iii) Concrete Structures.

(a) Remove defective and spalled concrete by bush hammer and/or brushing.
(b) Build up new concrete by "Gunnite" or similar process.

(iv) Joints.

(a) Remove existing cover plates in road joints between spans.
(b) Replace holding down bolts and re-fix cover plates.
(c) Rake out structural joint filler and repack with new filler.

9. Embankments.

(a) Excavate slipped material.
(b) Place granular fill material.
(c) Excavate and lay porous pipe drains.
(d) Soil and seed reinstated areas.

10. Siding and Verge Maintenance.

(a) Trim back verge from edge of carriageway - by hand or by plough.
(b) Place soil fill in depressed verges.
(c) Lay and peg turf edging to verges.
(d) Open out grips across verges.
(e) Soil and seed verges to renew.

11. Concrete Carriageways.

(a) Rake out joint filler and reseal.
(b) Cut out defective concrete surfacing and patch by gunniting.
(c) Cut out defective areas of concrete slab to full depth. Renew and consolidate formation. Place new concrete in slab including reinforcement and forming joints.

12. Walls, Fences, Guardrails.

(i) Walls (a) Erection of brick and masonry fence and retaining was including excavation, concrete in foundation and backing and drainage provision.
(b) Erection of concrete walls.
(ii) Fences (a) Erection of timber post and rail fences of various patterns.
(b) Erection of concrete post and rail fences of various patterns
(iii) Guardrails (a) Erection of Pedestrian guardrails
(b) Erection of vehicular guardrails
(iv) Planting hedges and trees
(a) Prepare ground and provide topsoil as appropriate
(b) Plant quicks or other hedge plants
(c) Plant standard trees including stake and band.

B. Cyclic Maintenance Functions

1. Aids to Movement and Safety

(i) Signs (a) Cleaning signs including bollards etc.
(b) Paint signs and supporting posts.
(c) Erect new signs including removing existing, excavate for and concrete to post foundation.
(d) Attach signs to existing lighting etc. columns (Tespa Band).
(e) Replace defective lighting bulbs and/or tubes.

(ii) Traffic Signals - specialist maintenance by contract.

(iii) Road Markings (a) Lay or renew Verynyl panels as pedestrian crossing markers.
(b) Lay or renew white and yellow lines on carriageways including arrows, letters etc.
(c) Replace defective pads in road studs.
(d) Take up road stud casting and adjust for level or position including excavation.
(e) Excavate for and fix new studs.
(f) Fix, by adhesive, plastic studs to carriageway surface.

(iv) Fences, guardrails etc. - Paint as appropriate, fences, vehicular guardbeams and pedestrian guardrails.

(v) Road Lighting (a) Routine replacement of lamps
(b) Lantern and reflector cleaning.
(c) Check on security of switchgear.

(vi) Gully Emptying

(a) By hand
(b) By machine

(vii) Clearing Drains

(a) Rodding drains and gully connections.
(b) Clearing catchpits
(c) Clearing culverts.

2. Amenity

(i) Grassed areas and plantings

(a) Mowing - by hand
  - by machine
(b) Weed control - by spraying.
(c) Tree maintenance
(d) Hedge trimming (not normally a Highways Authority responsibility).

(ii) Sweeping

(a) By hand with orderly cart
(b) By hand with tractor gang
(c) By mechanical sweeper
(d) Clearing litter bins at lay-bys.

C. Winter Maintenance

1. Gritting (using either grit or salt or mixture)

(i) Carriageways

(a) With towed gritter
(b) With built-in gritter
(c) With bulk gritter.

(ii) Footways

(a) By hand
(b) By machine

2. Snow Clearing

(i) Carriageways

(a) Ploughing
(b) Clearing channels by hand
(c) Loading by tractor and carting
(d) Snow blowing from drifts
(e) Snow cutting from drifts.

(ii) Footways

(a) Ploughing
(b) By hand

3. Snow Fences

(i) Erection and removal

D. Contract Maintenance

1. Electrical work on signs
2. Traffic signal maintenance
3. Road lighting
4. Resurfacing
5. Surface dressing
6. White lining and carriageway markings
7. Road studs.

E. Miscellaneous

1. Vehicle and plant maintenance
2. Emergency functions
   (a) Attending on vehicle accident sites
   (b) Clearing fallen trees from highway
   (c) Attendance at sites of collapsed buildings.
3. Reinstatement of highway surfaces subsequent to Statutory Undertakers Works and other road openers.

Appendix 4.2

Example of Programmed Work Maintenance, County "H"

Programmed Work Maintenance

As a first stage objective it was intended to use the highway inventory as a base for the Resource Planning and Budgeting, particularly of general maintenance activities. Resource budgeting with its direct link to quantities of work and therefore numbers of gangs, would be not only very sensitive to alterations in budgetary provisions, but would provide direct comparisons between estimate and expenditure for control purposes of each activity. This information could be rapidly assessed by all, and particularly by senior management as an aid to decision-making.

A. Measuring the Task - High Inventory

The system by which Highway inventory is compiled in this county is as follows :

1. Road Sections

A skeleton map of the county has been drawn over which is superimposed the Standard National Grid system. Every maintainable road in the county has been split into "sections". Each section begins and ends at a road junction and is allocated a unique reference number. If necessary, precise points within the section may be located by grid reference.

2. Road Section Numbering

Trunk, Class I and II roads have the DoE reference number followed by a suffix, e.g. A27/120. Class III roads have the county reference followed by a suffix, e.g. C123/25. For the purpose of numbering unclassified roads, the county has been divided into "blocks". Blocks are bounded on all sides by Class I and II roads. Each block is given a unique reference number. Each unclassified road within this block has the block number followed by a suffix, e.g. 98/47. This "unique" numbering system prevents duplication of section numbers and allows for the future expansion particularly necessary on unclassified roads.

3. Field Measurement

Measurement of all physical features of each road section is carried out on foot, with the aid of a measuring wheel, in 100 metre sub-sections

4. Data Recorded

When compiling this inventory, it was decided to include any information that would be useful in the planning of highways maintenance work in addition to general maintenance, and to embody such features as the maximum and minimum road widths, with provision for the data and type of road surface treatment. Dual carriageways are measured separately and the whole of the central reservation included in one section detail.

A page for each section records :

Works unit no.
Class of road - trunk, principal, non-principal or unclassified road.
Type - rural/urban
Parish name
Road name and number
Single or dual carriageway
Work measurement for each type of tractor-flail mower, pedestrian mower, gully emptier, sweeper and other sundry maintenance. The assessment for each class of work is made at the time of the field survey.

Maintenance standard frequencies.

Each page is dated to show the last occasion it was revised (for input sheet and Highway Inventory road section).

5. Updating

There is a set procedure for notifying production engineers of any alterations to the physical content of any road section due to improvement or reconstruction, or the addition of new road sections resulting from private street works or section development.

This information is filed on the computer. A search and retrieval program will recover the information with accuracy and rapidity in the way the user demands. Standard outputs are a complete highway inventory and a road and street gazetteer which are issued to each work unit and other sections of the department. These, together with the skeleton road maps with numbered road sections, are extensively used by other departments of the county.

B. Determining the Maintenance Work Load

In this county a determined attempt has been made to arrive at the correct establishment of labour and plant which is required to meet the accepted needs of general maintenance (in accordance with agreed county standards and frquencies) and having fixed these constants, to be able to readily translate them into financial terms. Though this decision was taken prior to the period of double figure inflation, the system has been an invaluable aid in forecasting the effect of price increases to senior management. It is a fundamental requirement of this highway management system to always provide first for general maintenance needs in budgetary provision before considering the allocation to structure maintenance.

In addition to the Highway Inventory there has been filed on the computer a range of current "mode" prices from the annual tenders for plant and materials, standard minute values, the hourly rates for labour and county council plant (including all on costs). These files, in conjunction with computer retrieval programs, produce work schedules, costed maintenance schedules and unit rates for structural maintenance works. New material prices or increases in plant and labour rates can be reflected within 24 hours into all rates and estimated costs for future works.

Programmed maintenance has as its objectives a systematic approach to cyclic maintenance activities carried out at pre-determined frequencies (the county standards) as recommended by the Marshall Report, for functional gangs or items of plant.

This task is accomplished by providing work schedules in route order : for each maintenance gang to carry out its work in a pre-determined area on a four-weekly cycle. Each cycle takes account of seasonal work requirements and includes a buffer period of one week to be available to provide for unpredictable interruptions during the four-week period (storm damage, floods, traffic accidents or load spillage). The work load of the schedules is in accordance with the past, effective performance of the gang and therefore within its capacity. The computer calculates the total cyclic maintenance requirements of work units, area and county.

By inserting the constraints into the search programme, it is possible to determine the area to be covered by one maintenance gang, but before this is finalised, consultation takes place with the Works Manager and his staff to establish that any local problems are taken into account, e.g. location of industrial estates, gravel pits, port or dock install-ations and centres. Due consideration is also given to the distribution of labour and the depot at which the gang will be based. In some areas there will be an increase in road mileage and therefore, the work load, mainly due to estate development. Normally, an increase of 3 miles can be absorbed before the gang has to be reinforced in numbers or the area changed in size.

Non-cyclic maintenance work carried out by functional gangs - patching gangs, bridgework gangs, public Rights of Way maintenance gangs - do not readily lend themselves to programmed maintenance as it is not possible to pre-determine precisely the quantity of work for these types of activities. But nevertheless, resources are provided on a planned basis, e.g. in the case of patching gangs, these have been resourced in accordance with a work specification for patching, to arrive at the hourly, and consequently the annual cost of plant and labour. Material is estimated from the cunsumption recorded during previous years.

The advantages of this system are quite clear. All concerned with carrying out the work have full knowledge of :

- the quantity of work
- the standards to which it is to be maintained
- the plant requirements
- the labour necessary
- the money allocated.

It is attractive to manual workers because it sets out clearly the work requirements by a series of four-weekly schedules of works with built-in factors for travelling/wet time. Paperwork for bonus claims is minimal. Bonus payments are stable and if the gang keeps to its time schedule and maintains quality of work it is unlikely that there will be any variation.

C. Control Maintenance Work

Control of work is achieved by comparing work completed on the ground with the routine schedule. Where slippage occurs it can be easily identified and action taken to remedy the cause. Cost control of all general maintenance activities is monitored by using a computerised works management control information system which issues fortnightly cost statements with a ten-day time lag, enabling progressive costs to be compared with the estimate (see Table 4.2.1). Exceptions can readily be seen and the reasons analysed for the benefit of management and supervisory staff.

Where increases in costs takes place, the effect can be confidently forecast. If money is cut, the sensitivity of the system demands to know where the reduction is to take place.

Site supervision is focussed on quality checks - program intervention is minimal and the system will cope with emergencies.

A complete budget maintenance schedule is issued to Area Engineers and Works Managers at least two months prior to the start of the financial year setting out, for all general maintenance activities, the composition of each type of functional gang in terms of labour, plant and materials, the number of gangs or specialised equipment (sweepers, gully emptiers and tractors). A further discussion takes place in September each year between the Production Engineer and the area engineers and works managers, to adjust, where required, the numbers of gangs for these non-cyclic activities.

The consideration that must go into arriving at the number and composition of functional gangs compels thought to be given to better methods of working, correct plant and equipment for the task, durability and effectiveness of materials used. Economies or improvements produced in one gang have impact on perhaps 20 or 30 similar gangs across the county. It is consdiered that work-planning in this way will produce the economies we are all looking for, and be more constructive than the arbitrary slashing of budget figures.

The researcher believes that preparing the budget in this form is not suitable for controlling all types of maintenance work. The information provided might help in some routine scheduled work, but it would not provide any useful information to the management for other types of work like winter maintenance, where it should be devoted to cover work in a certain period. Apart from which, it does not give any explanation as to why the actual expenditure exceeds the budget. This kind of information can mislead the management in its decision to control the work of the authority and needs to be modified to include detailed information of the different types of maintenance work and explanation of the reasons for the variance with the budget.

Table 4.2.1.

County Surveyor's Department
Works Management System

Date 19 December 1975
Week 36 Year 75/76
Percentage norm = 69%*

Maintenance Budget Control Information

Works Unit 5

(All rods, including trunk roads)

Gang/Unit		Budget Allocation	Expenditure to date	% of expenditure
001	Maintenance gang	120557.00	86065.11	71
002	Patching/repairs	89142.00	65877.04	74
003	Traffic signs unit	20480.00	13573.10	66
004	Tractor gang	10336.00	918558	89
005	Gully emptying gang	10810.00	5275.13	49
006	Suction sweeper unit	10810.00	8146.51	75
007	Bridge gang	6300.00	1141.83	18
008	Miscellaneous works	4000.00	1039.23	26
009	Winter maintenance	15000.00	2472.38	16
010	Carriageway markings	7500.00	2262.02	31
011	Electrical charges	5060.00	3577.98	71
012	Public Rights of Way	4210.00	5699.06	135
013	Chemical treatement	4000.00	1649.45	49
014	Trees unit	7001.00	9052.01	129
	Total	315206.00	215376.43	68
	Total County roads	310996.00	209677.37	67
	Total trunk roads		15482.01	
	Total P.R.O.W.	4210.00	5699.06	135

* Expected percentage of expenditure today.

Appendix 7.1.

Work Study

Introduction

The purpose of including the following sections on the principles, techniques and likely benefits from the application of work study is to give the reader some general background information. Highways maintenance has many differences in the work study context which clearly distinguish it from the more common applications to industrial processes, many of which take place in a controlled environment. However, a number of techniques which originated in industry, have been successfully adapted for use in the highways maintenance area. No doubt other industrial techniques will be successfully tailored to this area in the future. In any case, the overall objectives of work study, whatever the application, must be similar, i.e. the same quality at reduced cost.

1. The History of Work Study

Work study is as old as industry itself. The first man who succeeded in simplifying his job by the use of his reason can be considered to be its unconscious founder, for, behind the many techniques which constitiute the ever growing province of work study, lies a basic, scientific attitude (197).

It is generally agreed that work study had its beginning in the machine shop of the Midvale Steel Company in 1881, and that Frederick W. Taylor was its originator (261). He is generally known as"the father of scientific management"(262 p.4). Taylor's real contribution to industry was his scientific method, his questioning attitude and his constant search for the facts. This gave him the high place which he reached and still holds as a proponent of science in management (263). He recognised that management cannot be scientific without an adequate knowledge of how long it should take to do work. He approached problems which had been thought either not to exist, or to be easily solved by common sense in the spirit of scientific enquiry (264). He concentrated his attention on solving important industrial problems, such as determining the best way to do the job (265).

Taylor realised that an overall time did not give accurate enough information as to how time was used in order to indicate if the time was used inefficiently. Since then, his technique "Time Study" has become the principal feature of scientific management (263). To him must go the credit of having first evolved the principle of breaking a job down into detailed elements to determine, by time study, a time to be allowed for the job.

Taylor started by breaking down the cycle of the operation into small groups of motions, called elements. Each element was timed separately and the elapsed time of each element determined (197). By timing the individual elements, one can easily obtain a complete breakdown of the total operation into an easily analysable form. By simple arithmetic it becomes easy to calculate the overall time of any operation (223). He extended his studies further and endeavoured to establish basic principles of management which would apply to all fields of industrial activity. Taylor explained his objectives as having been the following (197) :

1. The development of a science for each element of man's work. This replaced the old rule-of-thumb method.
2. The selection of the best worker for each particular task and then training, teaching and developing him. This replaced the former practice of allowing the worker to select his own task and then training himself as best he could.
3. The development of a spirit of hearty co-operation between management and men in the carrying out of activities in accordance with the principles of a developed science.
4. The division of work into almost equal shares between the management and the workers, each department taking over the work for which it is best fitted. This replaced the former condition in which almost all of the work and the greater part of the responsibility were thrown on the workers.

These prinsiples formed the basis of what has been called "scientific management" (204).

Taylor presented time study as a tool to be used in increasing the overall efficiency of indutrial plant, making possible higher wages for labour and lower prices to the consumers (261). The main criticism of Taylor's work resulted because he was interested principally in the time factor. He approached the problem of method and motion study in a far less scientific manner since he considered it to be an ancillary task in the practice of his time studies (265).

Colleagues of Taylor like Frank and Lillian Gilbreth, criticised his reliance on time study alone. The Gilbreth's were mainly concerned with devising the most economical methods and the most effective layout of work space, followed by a motion study (266). They held that it was bad practice to make a time study to set times before one had ensured that the most economical method of performing the operation had been properly established. They developed what they called "Motion Study" to cover their fields of research (267). In 1917, the Gilbreths defined motion study as :

"It consists of dividing the work into fundamental elements, analysis of these elements separately and in relation to one another, and from these studied elements, when timed, building up a method of least waste." (197 p.6).

The Gilbreths made little use of the stop-watch in their studies. They concentrated on finding the very best way of doing work and in determining the shortest possible time in which the work could be performed (277). Their objective was to find the ideal method or the method nearest to the ideal that could be practically used (261). They refined Taylor's concept of work elements by further sub-division into elements of "Transport, Empty, Load, Grasp, Use, Assemble, etc." (266,p.4) Gilbreth gave the name "Therbligs" to the twenty elementary movements or groups of movements into which he divided all types of human activity, "Therblig" is his own name backwards (268,p.4).

The Gilbreth's activities covered a wide range of construction industry and in addition, they investigated the problem of fatigue (261). From their studies, they held that it was possible to eliminate "heedless fatigue". The three principal methods by which this could be done were :

"1. Lightening the load

2. Introducing rest periods

3. Spacing the work" (197, p.6).

The Gilbreths also contributed to "method improvement" by establishing the currently well-conceived and generally accepted principles of motion economy and micromotion techniques (267). The term micromotion study was originated by the Gilbreths and was first made public at the meeting of the American Society of Mechanical Engineers (ASME) in 1912 (261). Micromotion study is the study of the fundamental elements or subdivisions of an operation by means of a motion picture camera and a timing device which accurately indicates the time intervals on the motion picture film. This, in turn, makes possible the analysis of the elementary motions recorded on the film, and the assignment of time values to each (269).

The contemporary work of Frank and Lillian Gilbreth in the field of motion study, brough new and original ideas on the role of method in productivity. They contributed a deeper understanding of work methods and fatigue than had hitherto existed and, above all, a greater understanding of the importance of the human element in all work study (204). The social, ethical and moral rightness of work has become a controversial issue in present times in dealing with the human factors and understanding of its psychological aspects (270).

In British practice, the term method study is used in place of the term motion study (although the latter was intended by Gilbreth to cover almost exactly the same field), and the term work study is used in place of time and motion study (271).

Britain is largely responsible for the growing international adoption of the name "Work study" (263). The scope of work study extends far beyond the activities known as engineering and certainly well beyond industry proper,into the fields of agriculture, the armed services and public administration. The British contributions of recent years have been along three special lines (197) :

a. The systematic attempt to humanise and co-ordinate techniques and to emphasise that work study is an integral part of management's job and not an expert system superimposed upon them and those for whom they are responsible. This is coupled with more intensive theoretical and practical training for work study practitioners.

b. The successful extension of method study to far beyond the individual work place and covering the whole existing department of works and increasingly to the development and design of new processes and products and layout of factories.

c. The development of work measurement to cover non-repetitive work such as engineering maintenance and construction, much more effectively than heretofore and to establish data from which work values for this type of work can be synthesised.

2. Work Study Procedures

The International Labour Office Manual of Work Study quotes eight steps to be taken in any work study exercise. They are (271) :

1. Select the job or process to be studied.
2. Record from direct observation everything that happens using the most suitable of the recording techniques available, so that the data will be in the most convenient form to be analysed.
3. Examine the recorded facts critically and challenge everything that is done, considering in turn : the purpose of the activity ; the place where it is performed ; the sequence in which it is done ; the person who is doing it, and the means by which it is done.
4. Develop the most economic method, taking into account all the circumstances (method study).
5. Measure the quantity of work involved in the method selected and calculate a standard time for doing it (work measurement).
6. Define the new method and the related time so that it can be identified.
7. Install the new method as agreed standard practice with the time allowed.
8. Maintain the new standard practice by proper control procedures.

These steps imply that the technique of work study is primarily a means of recording, in convenient form, the use to which an organisations resources are being put in the provision of goods and services. These records are subsequently analysed along specific lines to ascertain where necessary effort should be made and where waste of all kinds occurs, in order that steps can be taken with a view to its elimination (262).

The term work study itself is used to associate two distinct, yet completely interdependent groups of techniques of method study and work measurement (197). (See Figure 7.1.1.) (261, p.3).

As such, the aim of method study is to subject each operation of a given piece of work to a close analysis, one result of which should be the elimination of every unnecessary operation. In addition, method study helps to determine the quickest and best method of performing each necessary operation and helps to standardise equipment, methods and working conditions. Then, and not until then, scientific measurement is used to determine the number of standard hours in which an average man can do the job (272). Therefore, the application will help to simplify and identify more economical means of getting the work done to achieve the desired goal of higher productivity (263).

The next section is devoted to an explanation of method study and work measurement as an integral part of work study.

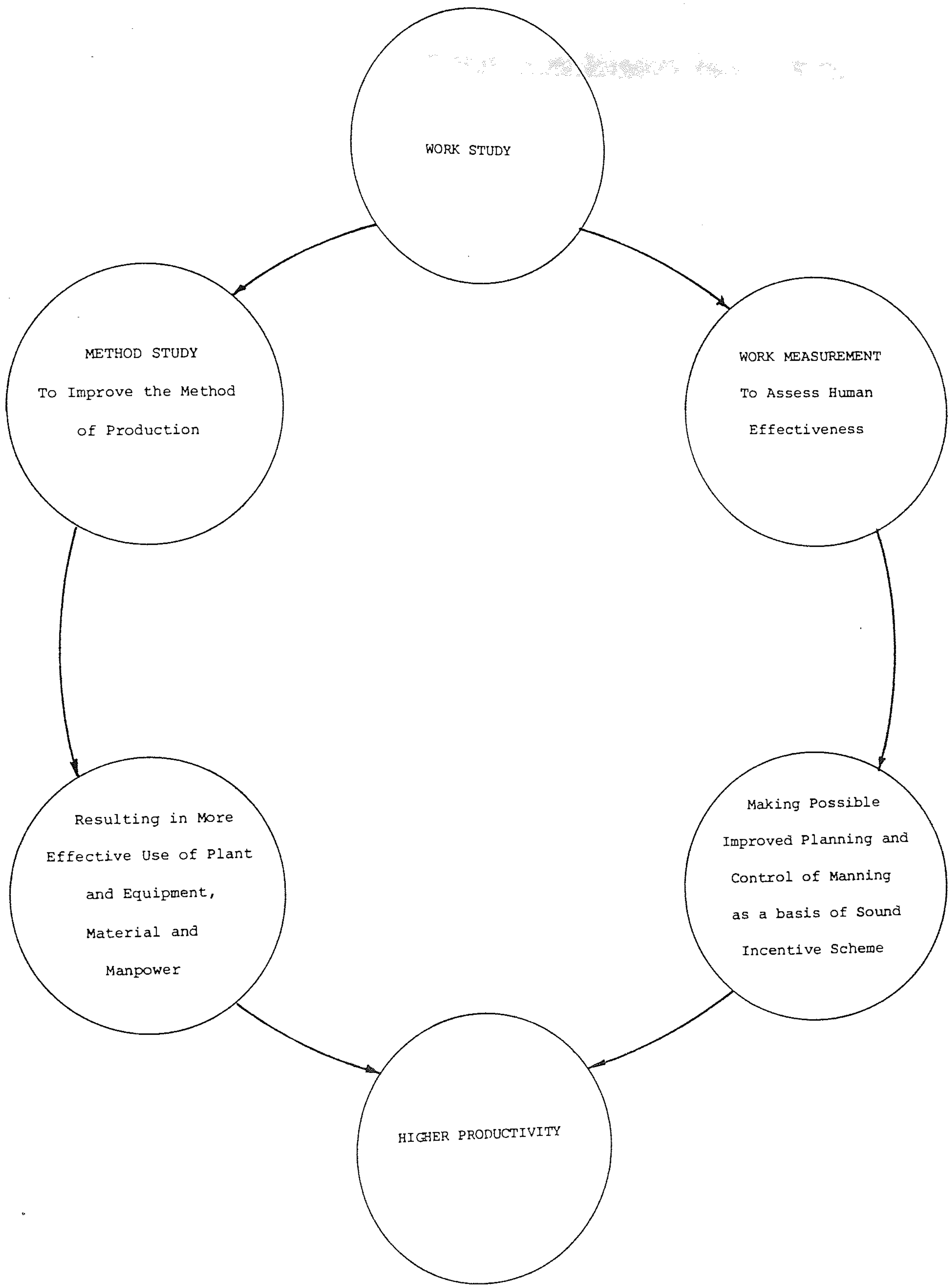


FIGURE 7.1.1 Work Study Technique and Achieving Higher Productivity

3. Method Study and Work Measurement as an Integral Part of Work Study

3.1. Definition of Method Study

The British Standard Glossary of Terms in Work Study gives this comprehensive and useful definition of method study :

"The systematic and critical examination of ways of doing things in order to make improvements" (273, p.7).

The definition of method study showed that fundamentally it involves the breakdown of an operation into its component elements and their subsequent systematic analysis. Then, those elements which cannot withstand the tests of interrogation are eliminated or improved (261).

Method study is applicable to work as a whole, not just to manual work or to work in industry, but to any work wherever it is done. It mentions both existing and proposed ways. Method study is often applied to existing work, sometimes to give new impetus to a well-proved process, sometimes in a belated attempt to make some process achieve its promised performance (236).

3.2. Method Study Procedures

The method study procedures can be described in the following six stages (271) :

1. Select the work to be studied.
2. Record all the relevant facts of the present (or proposed) method.
3. Examine those facts critically and in sequence.
4. Develop the most practical, economic and effective method, having due regard to all contingent circumstances

5. Install that method as standard practice.

6. Maintain that standard practice by regular routine check.

These stages are considered essential in the application of method study, and none can be excluded. It is important to strictly adhere to their sequence as well as to their content in order to ensure the success of an investigation (197). Figure 7.1.2 illustrates these procedures.

A full investigation into the problem is usually the most important part of the work of method study, and is the part that yields the most easily measured and profitable results (274). Since the object of any investigation is to achieve the best method in accordance with the available circumstances, it follows that these circumstances must be carefully examined. Figure 7.1.3 illustrates the factors to be assessed in the approach to an investigation (274, p.233).

It is important to set clearly defined limits to the scope of the investigation. Method study investigations so often reveal scope for even greater savings that there is a strong temptation to go beyond the immediate objective. This should be resisted, and any job shown up as offering scope for big improvements through method study should be noted and tackled separately (271).

It is essential, as well, when considering the desirability of the method study investigation of a particular job, to keep certain facts in mind (197) :

1. Economic considerations

2. Technical considerations

3. Human reactions.

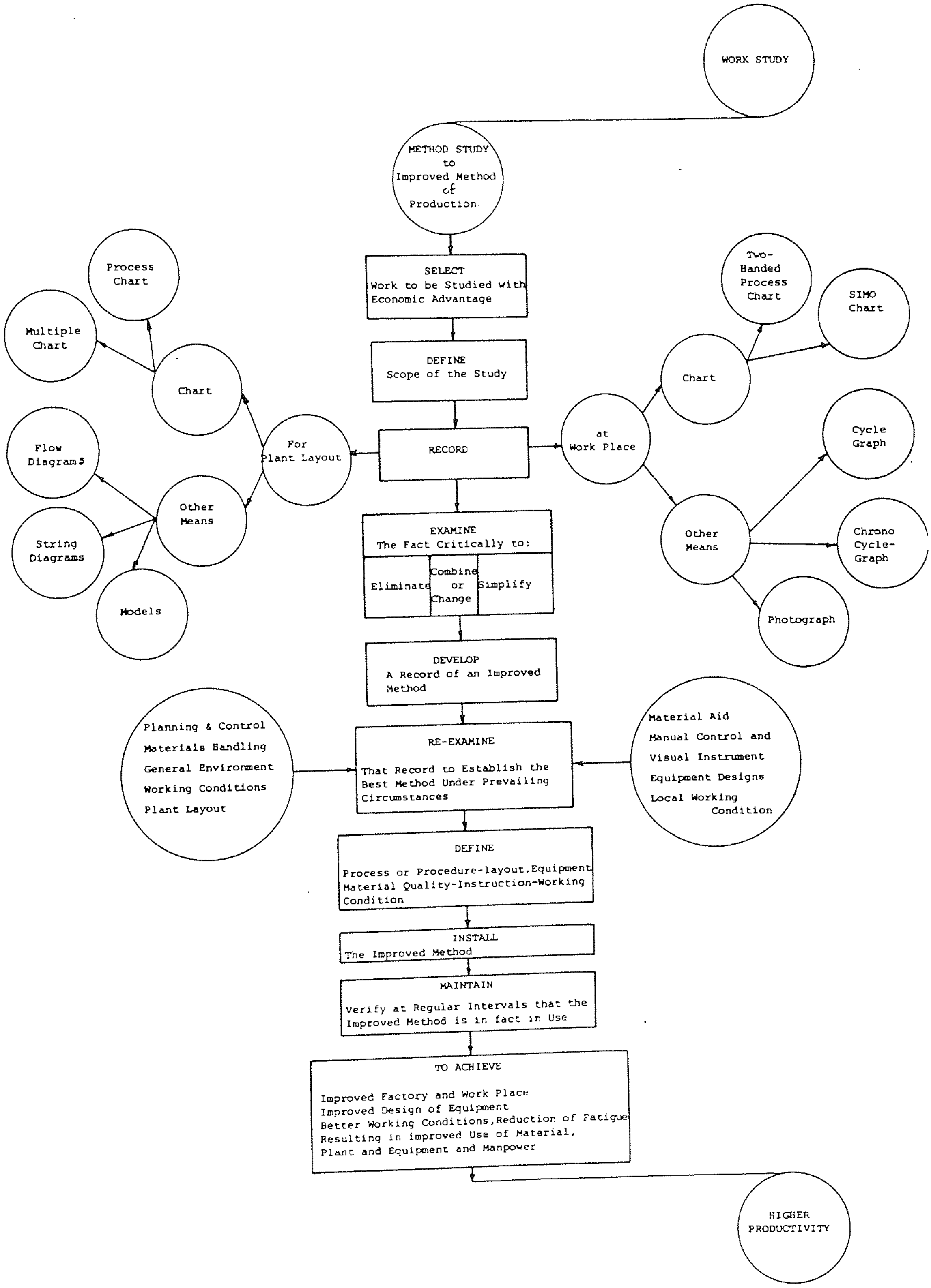


FIGURE 7.1.2.Method Study General Procedure

Note: During this Procedure, Work Measurement will Frequently have to be Used As a Means of Helping to get the Facts.

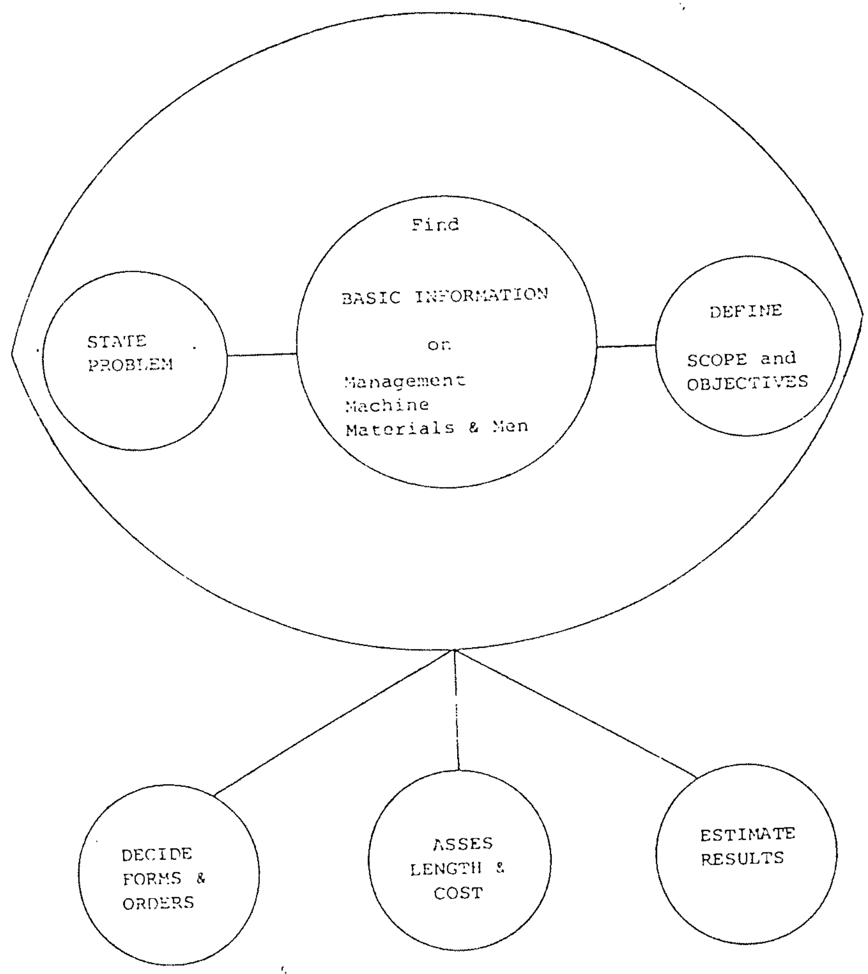


Figure 7.1.3.

Factors to be Assessed in the Approach to an Investigation

3.3. Method Study Objectives

The search for a better way to do things has progressed since the birth of mankind. Better methods were, thus, early on, allied with the benefits and welfare of human individuals. Indeed, man's self-interest demands more efficient, less fatiguing procedures by which to work. The installation of method study is aimed at :

A. Improving work efficiency by getting rid of unnecessary work, delay and other forms of waste (197). This aim can be achieved through :

1. Revealing and analysing the true facts concerning the situation.
2. Examining these facts critically.
3. Devloping, from the examination of the fact, the best answer possible under the circumstances.

B. Effective utilisation of available resources. This can be achieved by (197) :

1. Improved layout and design of factory, plant and work place. This may lead to less money being needed to invest in plant or work in progress or stock.
2. Improved use of material, plant and equipment, and manpower. This may lead to better utilisation of these resources so that output can be increased.
3. Improved working procedures by the design of a working method which takes less time or which is less demanding on skill.
4. Improved design or spcification of the end product. This may lead to a product which is less costly to produce or which is better in use.
5. Improved working environment.

These achievements will result in higher productivity. The improvements possible through method study are incalculable, limitless, and are considered the key to work study (236).

3.4. Definition of Work Measurement

Work measurement is defined by the British Standards Institute as :

"The application of techniques to establish the time for a qualified worker to carry out a task at a defined rate of working."

(273, p. 2).

This definition implies that work measurement techniques are used to measure work in terms of time. It is concerned, not only with the actual measurement but also with determining the frequency at which they need to be combined in order to make a reasonable prediction of the representative method (223). The basic problem of work measurement is to answer the question "How long will it take someone to do something ?" (223). It is obvious that a number of other questions must be answered in whole or part, before an answer can be given to the basic question ; the something must be specified, the someone must be specified and lastly, there will be a question of "How fast ?" and possibly "When ?" and "Where ?". This is all part of the technique of work measurement and these factors play a much more important part than the actual process of measuring itself. Attention should be paid to the consideration of measurement as a process by means of which information and facts about the activities can be obtained. The analysis of these facts can be used as a means of facilitating an improvement of these activities, and to evaluate the extent to which the maximum use of resources is achieved to fulfill the organisation's objectives.

3.5. Work Measurement Procedure

Work measurement procedure follows three distinct stages (223) :

A. Analysis. The work to be measured is broken down into its constituent parts.

B. Measurement. The time for an operator to carry out each part is determined.

C. Synthesis. The constituent parts are combined together to form a specific pattern.

A. The analysis stage

The analysis stage occurs when the work to be measured is broken down into its constituent parts. These constituent parts are called elements or basic elements when they are constant in the pattern of working which they represent.

B. Measurement

The measurement stage occurs when the basic time for each of the constituent parts is ascertained. There is no single technique, rather a group of techniques (see Figure 7.1.4) which includes (223,p.30) :

1. Time study and its subsidiary technique, production study ;
2. Simplified PMTS (predetermined Motion-Time Study) ;
3. Analytical estimating (although this technique is based on estimating time rather than measuring it).

Time study and PMTS are the basic techniques used for measuring work. PMTS is the technique in which times are established for basic human motions and subsequently used to build the time for a job at a defined level of performance (223).

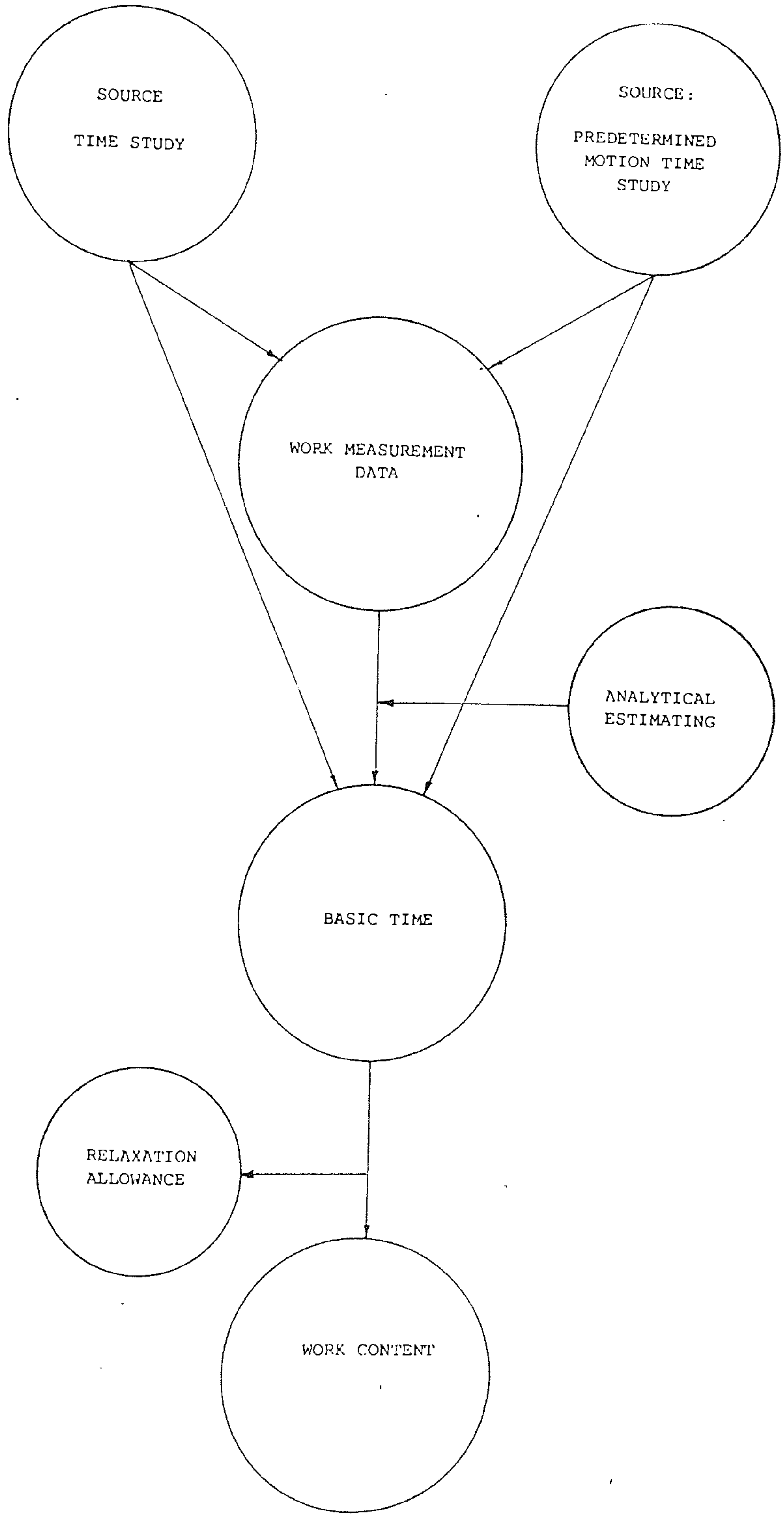


Figure 7.1.4.

New Approach to Work Measurement

PMTS might be likened to a micrometer in that it is a very fine measuring tool for work. However, time study is considered a basic technique of work measurement since it is concerned with the direct observation of work (275). It involves timing the basic elements with a stop-watch, and assessing variations in the speed of working (197). Time study has been defined as :

"A work measurement technique designed to establish the time for a qualified worker to carry out specified elements under specified conditions at a defined rate of working, recorded by direct observation of the times, using a time measuring device and the ratings for individual elements" (273, p.13).

The purpose of time study, as interpreted in the light of the British Standards recommendation, is to determine the standard time that a worker or group of workers should take to do a specified job at a defined level of performance (263). A specified job means a job for which there is a written specification concerned with such matters as the following (276) :

1. The standard of quality to be achieved.
2. The machines, equipment and materials to be used.
3. The working conditions under which the job should be performed.
4. The method (including, if appropriate, the motion pattern) to be followed by the worker.

Therfore the standard time should be developed from detailed analysis of actual studies of the work which is under consideration (277).

C. Synthesis

The synthesis stage is the final stage when the available information is gathered together into a suitable form for use according to the purpose for which the measurement is required. The basis of the synthesis is that the constituent parts of the work should be combined together in sequence in the way in which it is envisaged that a qualified operator may do the work on some occasion in the future (197). The pattern of working thus built up is the representative pattern.

It has been the practice in the past to measure a job by the appropriate techniques from start to finish. It has become increasingly apparent, however, that to use only one technique for a whole job may be wasteful because many of the elements in different jobs are identical, and in consequence, they are measured over and over again (223).

Nowadays, the practice of work measurement tends more and more towards the pattern of breaking the job into its elements, consulting the records of previous studies for the basic times of as many of these elements as possible, and only then measuring the remaining elements by an appropriate technique. The values so determined are added to the records of basic times. The proportion of rest required is assessed and added to the basic time, to arrive at the time for doing the work at the standard rate of working (i,e, work content) (197).

3.5.1. The Procedures for Setting Up Standard Times

Adopting a time study technique in order to set up standard time is carried out through the following stages which involves observation, timing and recording (263).

The observation of a method of doing an operation is accomplished by means of collecting data for the method while the operation is being performed, under known conditions. There is a danger that this might encourage the operator to slow down while he is being observed and timed. However, a number of representative observations of the time required for performing an operation using a specified method are taken and may help to overcome this disadvantage to a certain extent (276). An important feature of time study is the way in which the accuracy of the result is obtained. As the number of occasions on which the operation being observed is increased, the accuracy of the results improves. The following are essential requirements for the time study of any operation (197) :

1. An accurate specification of where the job begins and when it ends, and of the method by which it is to be carried out, including details of equipment, materials, conditions, etc.
2. A system of recording the observed (actual) times taken by workers to do the job while under observation.
3. A clear concept of what is meant by standard rating.
4. A means of assessing the amount of rest which should be associated with the job.

Consideration of these requirements will contribute, ensuring that accurate times established as targets for useful measurement purposes (275). This necessitates the importance of method study to be carried out before any time study in order to subject each operation of work to close analysis, to be able, as a result, to eliminate any innecessary operations.

The next step in determing the standard time for a method of doing an operation is to determine the method's observed time (261).

The observed time means the time that can be maintained by an average worker, during a typical day without undue fatigue.

Ideally, the timing should be of a qualified worker. A qualified worker is one who is physically and mentally suited to do the job he is given and who has acquired the necessary skill and knowledge to carry out the work involved to a satisfactory standard of quality, quantity and safety, in other words, the standard performance (263). Standards of performance may be assessed for the average worker, but individual abilities vary quite widely. For this reason, ratings are made which are "assessments of the individual worker's rate of working relative to the observer's concept of the rate in comparison with the standard rate of a qualified worker"(261, p.158).

A scale has been fixed giving this ideal effectiveness a value of 100 and this is designated as the standard rating (278). Observers are trained to be able to recognise the conditions of standard rating and to assess, to the nearest five points, the degree to which a worker's observed speed and effectiveness varies from the "100" concept.

It is found in practice that a worker's rating may vary, not only from cycle to cycle of a job, but frequently, also within each cycle itself. When breaking the job down into elements, it is essential that each element should be clearly distinguishable. Therefore, the researcher believes that the applications of the following principles will be of assistance (197) :

1. Distinguish and separate elements which are identical from those which are variable in the work they comprise.

2. Separate heavy work from light work (e.g. loading kerbs).
3. When convenient, use audible points in the work, such as the sound of closing gully lids or the starting and ending point of any operation, etc.

Having observed the time to carry out an element and rated the deviation from the standard, the observed time is extended to the time the operator would have taken if he had worked at standard performance, i.e. if the operator had worked to the representative motion pattern and maintained the natural speed of movement (278). After the rating is done, the observed time can be converted into the basic time. The time required to carry out the work at standard rating is called the basic time, and the calculation which extends the observed time to basic time is called "extension" (223).

As it is a principle that the worker should be able to achieve standard performance as an average over the day, or shift, without becoming more than reasonably tired, the period of rest allowed is calculated on this basis. Basic times per cycle, relaxation and contingency allowances are combined to give the units of work required (197). The time study involves the techniques of establishing an allowed time standard to perform a given task, based upon measurement of the work content of the prescribed method with due allowance for fatigue and for personal and unavoidable delays (275).

The standard time is the basic time plus allowances for interruptions (267). All work induces fatigue and in order that a worker may maintain the standard rate of working over a day, it is necessary to allow him some time for relaxation. This done by calculating the amount of relaxation time required and adding it as a percentage of the basic time (229). This relaxation allowance is added to the appropriate element of work in the time study. The relaxation allowance is given as a percentage of the total job time ; the proportion of relaxation to work varying with the nature of the job (275). An extra allowance is added to cater for various items which require the operators time and which are not a regular part of any job. The determining and making of the correct allowances is a very important step in the time study (280).

It is believed that the necessity for making allowances stemmed from the fact that it is not practicable to allow time on an individual job for human delays, minor breakdowns and other irregularities which cannot be foreseen. The common types of allowance are (272) :

1. Personal allowance.

   The items which come under this class are few in number and the amount of time used for this purpose varies with the person rather than the condition of work.

2. Fatigue allowance.

   The items which are classed as fatigue vary in number and amount, according to the working conditions, job conditions and the length of the operation. It is believed that a fair fatigue allowance should be determined and added to each job.

3. Unavoidable delays.

   These are delays which are out of the control of the operator and may be incurred by the good as well as the poor operator. The unavoidable delays which may occur on a given class of work depend on the nature of the work and the conditions surrounding it (275).

4. Special allowance.

   Within a given class of work there may be certain jobs on which delays or fatigue are much greater than is usually the case. The ordinary allowances for fatigue and delays will not be great enough to cover these jobs. However, it should be borne in mind that the kind and the amount of allowances to be made should not be estimated or described in an arbitrary manner, but should be the result of thorough analysis and careful study of the work under observation

By enabling a target time to be set, which incorporates a rest allowance appropriate to the type of work involved, a satisfactory basis is provided on which the management can rely for planning and controlling its operation.

3.6. Work Measurement Objectives

Industrial developments have been very rapid since 1945, especially in the field of managerial and engineering techniques applicable to various areas of enterprise activities.(204). Discoveries of new resources increased world production, enlarged consumer markets and rapidly growing requirements of customer services calls for revised enterprise objectives, including higher quality and capability of manpower, improved facilities and materials, more refined production techniques, more effective performance and higher business efficiency (227). Present day management, therefore, has no choice but to know or learn how to evaluate the extent to which maximum use is being made of available production means, management techniques and procedures, the capability and dependability of manufacturing, the market standing of a product and the overall competitive capacity of the enterprise.

Work measurement offers one of the most reliable avenues used by scientific management to achieve the benefits of increased production at lower cost for the advantage of everyone (204). The object of work measurement is to get accurate facts and report them objectively to management (197). The quantitative facts derived from measurement are used in one or more of the following principal ways (236) :

a) The development of a method of work.

Work measurement is an integral part of method study (271). It can be used as an aid in the development of method and in the comparison of one method with another. Other conditions being equal, the method which takes the least time will be the best method.

b) As a guide to labour requirement.

Work measurement provides data to assist in the organisation of labour by enabling a daily comparison to be made between actual times and target times. Information submitted for labour control tells management how the duties delegated are being carried out in comparison with established standards. By proper analysis of deviations from the standrad, the true causes and extents of losses are disclosed and management can see what action, if any, should be taken to improve labour utilisation and performance. The time derived in measurement will assist in allocating labour to jobs in proportion to the work involved so that labour on a job is properly balanced (223). It provides data to enable estimates to be prepared for future manning requirements.

c) As a basis for sound, realistic and fair incentive schemes.

This is the application which usually springs to mind when work measurement is mentioned because of the widespread use of payment schemes based on times derived by work measurement. Many persons consider such schemes to be the sole reason for work measurement(280). However, these schemes comprise only one area of usage to which time data may be put. The subject of work measurement is time, the duration of work and its frequency. It is mainly concerned with establishing a reasinable time for a given item of work to be performed in a specified way. It provides consistent information and provides an equitable incentive.

d) As a basis for work control by comparing expected performance with actual achievement.

Measurement is an essential component of the feedback process in that it enables the manager to steer the course which has been charted, or to chart a more sensible course than the one which has been initially chosen (282). Obviously, measurement is both necessary and important as a basis of corrective action or as a datum for planning. The measurement should be used as a means of informing the responsible manager concerning variances and problems which require his corrective action. Measurement of performance at all levels is necessary for management to achieve control.

e) To assist work scheduling and work loading (197).

Work measurement enables realistic schedules of work to be prepared by relating reasonably accurate assessments of human work to plant capacity. In assessing the economic manning of a job, two questions are posed, the answers to which can only be provided by using work measurement :

Are workers fully occupied, or are they limited in their operation time by layout, machines or equipment ?

Are all workers occupied to the same extent or does their operating time vary so that some are less occupied than others ?

If the work measurement reveals deficiencies in either of these two respects, the new method must be reconsidered.

f) Providing a quantitative assessment of the human work involved in some specified task (223).
Human factors have a great and dominant effect on the business world, especially in a rapidly advancing technology. They loom as large, or larger, in the fianl decisions of good management, as do the purely technical aspects of a given problem or situation. Guidance and measurement of human performance are thus necessary and important.

It is equally true that attention to a regard for the human factors in work measurement will become ever more essential to improvement in the productive efforts of industry, as well as to distinguishing industrial engineers as scientific artisans in the design of integrated systems of men, machines and material (204).

4. Work Study Objectives

A manager's job in an enterprise is concerned particularly with the deployment of its resources in order to achieve its objectives. Work study is of interest to a manager because it is concerned with all the resources with which the manager has to deal, and particularly with four prime resources : people, their equipment, the space in which they work, and the materials with which they work. Predominantly, it involves the systematic improvement in both effectiveness and efficiency of resource utilisation (204).

Sufficient experience has already been gained in many fields to show that work study can play a significant part in the continuous process of raising the general level of productivity, without which economic progress is impossible (271). To improve productive efficiency, there are a number of positive actions which can be summarised under six headings which have come to be known as the "Six Line Attack" (197,p6)They were first enunciated by I.C.I. and subsequently they have proved their value on the national scale as well as on the basis of individual firms.

"1. Improve the basic process by research and development	Long-term
2. Provide more and improved physical means of producing	Will require capital
3. Simplify and improve the product and reduce the variety	Intermediate - may require capital
4. Improve methods of operation	
5. Improve organisation, planning and control	Short-term. Will require little or no capital"
6. Increase manpower effectiveness at all levels	(197, p.14.)

The first two lines of attack entail investment in highly trained technical staff and in buildings, plant and equipment. They demand all those facilities which go with technical and engineering research and development, especially as applied to the creation of new peoducts and design of new plants ; work study is making a significant contribution here. A modern trend is for all technical staff to be made aware of the principles of work study and to have well-trained work study specialists in development and design teams.

In the third line of attack, there are great economic benefits to be gained from standardisation and the reduction of the range of products to a reasonable minimum. In all these ways, work study techniques have their part to play in simplifying the problem and in assessing the economics of various alternatives.

The remaining three lines of attack are concentrated in the operational field where work study can be widely and immediately applied. Work study can play an important role in the fourth line of attack. By an analytical and intensive study of the details of the operation of an existing plant, many firms have found unexpected and still growing fields for improvement. As such, the applications of the techniques of work study are essential to success, provided they are adequately integrated with technical considerations.

Work study plays an important role in improving organisation planning and control. The fundamental facts revealed by work study have been proved, beyond a doubt, to be a far better basis for executive judgement than inspiration or misguided experience (282).

The last line of attack increases manpower effectiveness at all levels and includes everybody from the most exalted executive to the most recently joined apprentice. Work study, as the name implies, is the study of work of any situation where human work is performed (197). For some years now, it has been widely recognised that work study can be of service to management in all spheres (280). Necessarily, the developments have not been as intense on some fronts as they have on others.

Despite the fact that it may be convenient to deal separately with the various areas of work study, in practice, they are usually well mixed. The main activities in which work study is of most use are (236) :

1. The analysis, design and improvement of work systems, work places and work methods.
2. The establishment of work standards for determining requirements in men and equipment, assessing performance, planning operations, costing operations and products and paying workers.
3. The development and application of job evaluation schemes based on job descriptions.
4. The specification of plant facilities, layout, space utilisation and material and traffic flows.
5. The economic evaluation and optimisation of alternative combinations of personnel, materials and equipment.
6. The improvement of organisational structure and patterns of communication.
7. The development of procedures for presenting to management information about work performance.
8. The development of procedures for the planning and control of work and material usage.

One can conclude from the above that the task of management involves planning and control for which the measurement and assessment of time is required (280). Work study is now regarded as an essential service within the management team. Work study is more than just a set of routine techniques to be used for improved methods of working out incentive schemes. It is a part of management which nothing else can replace (278). It is, in common with other management techniques, a functional rather than an executive aspect of management and is carried out by specialists in the time study field. The information which work study provides is, thus, of an advisory nature and forms a basis for decisions by executive management (263). The successful conduct of any business requires exact information covering every detail of its operation. This information must be of unqualified accuracy. It must be obtained simply and must be complete enough to give the management a thorough knowledge of its every detail.

The possession of such accurate information will enable the management to eliminate waste and utilise its resources to the maximum (279). The whole success of work study depends on management possessing not only sufficient knowledge for executive control but also sufficient understanding to stimulate the the application of the technique to decide "what" is to be studied (the work study staff will decide "how") and to appreciate work study possibilities as well as its limitations (284). As such, work study must be integrated into the normal process of management and must not be left to specialists alone. This is especially important since work study is not something which can be started and applied haphazardly ; it should be continuous. Managers should be given sufficient knowledge of work study to ensure that they have proper executive control over its application, and a full appreciation of its potentialities (197).

Appendix 7.2.

Work Study Results of Kerb Laying

Production Results in

Both Counties "C" and"D"

Example 1 : Kerb Laying at County "C"

This example has to do with placing edging kerbs at the back of a footway.

1. In this county, a form titled "Rated Activity Sample Sheet" was used in order to record the basic time and the observed rating (see Figure 7.2.1).
2. In order to convert the observed times into basic times, a "Work Measurement Analysis Sheet" was used (see Figure 7.2.2).
3. It is noticed that the result of this example on the "Summary Sheet" gives only the total basic time required for each element of the work (see Figure 7.2.3). To convert the basic time into standard time, the required rest, contingency and special allowances are added according to the nature and class of work (see Figure 7.2.4 for table of percentages of rest allowance used in this county).

As there was no information provided by the work study officer in this county, regarding the percentages of the different rest allowances, the researcher will assume those percentages in order to extend the basic time into the standard time (see Figure 7.2.5).

4. The final presentation of the result of this example did not include the calculation of Effective Performance (EP). The work

study officer said that they had to wait until the end of the week to calculate it from the returned weekly hours worked by the gang.

As it is necessary to compare results and information provided by the work study to the management, the researcher has calculated this ratio for the example studied. In this county the Effective Performance is :

$$EP = \frac{\text{Standard minutes value of the work}}{\text{Total credit hours}}$$

$$EP = \frac{\text{Total productive time+Total non-productive time+Lost time}}{\text{Total clocked hours - Traffic control}}$$

From the work measurement summary (Figure 7.2.6) for example, the Effective Performance may be calculated.

$$EP = \frac{587.64 \text{ min} + 85.87 \text{ min} + 33 \text{ min}}{7\text{h } 56 \text{ min} - 19 \text{ min}}$$

$$= \frac{706.51}{7.62}$$

$$= 92$$

This formula needs to be modified because not only should lost time due to traffic control be deducted from the labour total attendance time, but also any other time lost for reasons beyond the operator's control. In addition, lost time due to wet weather ought to be excluded from the calculation of EP. It should only be recorded for historical use as an indication of the working conditions. So the formula can be modified to read :

$$EP = \frac{\text{Productive time in mins + Non-productive time}}{\text{Clocked hours - (Traffic control + Lost time for reasons beyond the operator's control)}}$$

The EP for Example 1 can be recalculated to take into account the above factors regarding controllable lost time factors :

$$\text{EP} = \frac{587.64 \text{ min} - 85.87 \text{ min}}{7\text{h}56 \text{ min} - (19 \text{ min} + 33 \text{ min})}$$

$$= \frac{673.51}{7.06}$$

$$= 95$$

RATED ACTIVITY SAMPLE SHEET

Edging Kerbs to Back of Footway

Study Ref No

Sheet No 1 of 2

Time	Kerblayer Element	Rat'g	Labourer Element	Rat'g	Element	Kerblayer Element	Rat'g	Labourer Element	Rat'g
1	Set levels (1)	85	Set levels (1)	85	20	Wait for conc (11)	—	Wait for conc (11)	—
2	" (1)	90	" (1)	90	21	" (11)	—	" (11)	—
3	" (1)	90	" (1)	90	22	" (11)	—	" (11)	—
4	" (1)	90	" (1)	90	23	" (11)	—	" (11)	—
5	" (1)	90	" (1)	90	24	Set levels (1)	90	Set pins (1)	90
6	" (1)	90	" (1)	90	25	" (1)	90	" (1)	90
7	" (1)	90	" (1)	90	26	" (1)	90	" (1)	90
8	" (1)	90	" (1)	90	27	" (1)	90	" (1)	90
9	" (1)	90	" (1)	90	28	UWT (13)	85	" (1)	85
10	" (1)	90	" (1)	90	29	Check levels (1)	90	Check levels (1)	90
11	" (1)	90	" (1)	90	30	UWT (13)	85	Move lorry (4)	85
12	" (1)	95	" (1)	95	31	" (13)	85	Load kerbs (4)	85
13	UWT (13)	85	" (1)	85	32	" (13)	85	" (4)	85
14	Instruct digger (2)	90	" (1)	90	33	" (13)	85	" (4)	85
15	" (2)	90	Wait for concrete (11)	—	34	" (13)	85	Move lorry (4)	85
16	Traffic control (7)	—	(11)	—	35	" (13)	90	" (4)	90
17	Wait for concrete (11)	—	(11)	—	36	Unload kerbs (4)	90	Unload kerbs (4)	90
18	" (11)	—	(11)	—	37	" (4)	90	" (4)	90
19	" (11)	—	(11)	—	38	Set line (1)	90	Sort tools (5)	85
					TIME				

Figure 7.2.1

RATED ACTIVITY SAMPLE SHEET

Edging kerbs to Back of Footway.

Study Ref No

Sheet No 2 of 2

Time	Kerblayer Element	Rat'g	Labourer Element	Rat'g	Time	Kerblayer Element	Rat'g	Labourer Element	Rat'g
39	Set Line (1)	95	UWT (13)	95	58	Receive conc (3)	100	Traffic Control (7)	100
40	" (1)	90	Set Line (1)	90	59	" (3)	100	" (7)	100
41	Talk to Super (6)	100	" (1)	90	60	" (3)	100	" (7)	100
42	Set Line (1)	95	" (1)	95	1	" (3)	100	" (7)	100
43	" (1)	95	" (1)	95	2	" (3)	100	" (7)	100
44	" (1)	90	" (1)	90	3	" (3)	100	" (7)	100
45	" (1)	90	" (1)	90	4	" (3)	100	" (7)	100
46	" (1)	90	" (1)	90	5	Set Line (1)	90	" (7)	100
47	" (1)	90	" (1)	90	6	" (1)	90	" (7)	100
48	Receive Conc (3)	90	Talk to Super (6)	90	7	" (1)	90	" (7)	100
49	" (3)	90	" (6)	90	8	" (1)	90	Shovel base conc (9)	85
50	" (3)	90	Traffic control (7)	100	9	" (1)	90	IT (26)	—
51	" (3)	100	" (7)	100	10	" (1)	85	UWT (13)	85
52	" (3)	100	" (7)	100	11	" (1)	90	UWT (13)	90
53	" (3)	100	" (7)	100	12	" (1)	90	Shovel base Conc (9)	90
54	" (3)	100	" (7)	100	13	" (1)	90	UWT (13)	90
55	" (3)	100	" (7)	100	14	" (1)	90	Shovel base conc (9)	85
56	" (3)	100	" (7)	100	15	Set kerbs (8)	85	" (9)	90
57	" (3)	100	" (7)	100	16	" (8)	90	" (9)	90
					17	" (8)	90	" (9)	85
					18	" (8)	90	" (9)	85

Figure 7.2.1. Continued

WORK MEASUREMENT ANALYSIS SHEET

Edging Kerbs to Back of Footway.

Study Ref No.

Interval (R.A.S.) 1 minute

Element Description	RAS / TS	70	75	80	85	90	95	100	105	110	Total BM's
Set Levels & Line (1)					卌	卌	卌				
					////	卌	卌				
						卌	卌				
						卌	卌				
						卌	//				
						卌					
						卌					
						卌					
						卌					
						卌					
						卌					
						卌					
						卌					
						卌					
						//					93.35
Measure & Instruct Digger (2)						//	/				2.75
Take delivery of R.M. Conc (3)						///		卌			
								卌			
								////			16.70
Load & unload edging kerbs											
& move lorry on site (4)					卌	卌		/			
						///					12.45
Sort tools (5)				卌	卌	卌	/				
				//	卌	卌					
						卌					
						卌					
						/					33.95
Talk to Superintendent (6)						//		/			2.80
Traffic Control (7)	19	Actual Minutes									

Figure 7.2.2.

Example 1 : Kerb Laying at County "C"

Work Measurement Analysis Sheet

WORK MEASUREMENT SUMMARY SHEET		Study Ref No
		Date 1.11.77
		Taken by Bn
Dept Engineers	Section a	Time Finished 3.56
Sketch	Time study/Prod Study	Time Started 8.00
83 kerbs laid in total	Act Sampling/Synthesis	Elapsed Time
	Operators	Total Recorded Time (B+C)
		Timing Error %
	Gang F/Man	Average Rating (100 D/B)

Operation Description	Placing edging kerbs in position on back side of footpath. Concreting base front and backing. Set up levels. Concrete = ReadyMix. Trench already excavated by JCB Back Actor.
Materials (Type/Qty)	Concrete edging kerbs 6' x 2' x 3"
Plant/Equipment	
Working conditions	Very cold. Dull. Heavy shower of rain.

ELEMENT DESCRIPTION	Total Basic Min	Occ. Qty	BM's per Unit
1. Set levels. Periodic checks	93.35	83	1.12
2. Measure, and instruct digger	2.75		
3. Take delivery of ReadyMix concrete and off-load in heaps on footpath	16.70	83	0.20
4. Load & unload edging kerbs & move lorry on site	12.45		
5. Sort out tools at start of day and misc. collection during day and out away tools at finish of job	33.95		
6. Talk to superintendent	2.80		
7. Traffic control	19.00	actual	minutes
8. Set kerbs in concrete and adjust to correct level	166.75	83	2.01
9. Shovel in base concrete from footpath heaps to trench	6.10	83	0.07
10. Shovel in front and backing concrete to kerbs. Trowel off and sweep footpath	131.10	83	1.58
11. Wait delivery of ReadyMix concrete	16	actual	minutes
12. Digger more surplus concrete from footpath to further along trench (1 man assist)	3.80		
13. U.W.T.	14.20		
14. Lorry off site collecting kerbs from dump site	8.00		
15. Rollup level line	8.55	83	0.10

Figure 7.2.3.: Example 1: Kerb Laying at County "C" : Work Study Summary

Dept. / Operation / Class of work / Classification no. / Date / Sex	Constant		Standing		Abnormal Position		Arduousness, Weight lifting or Use of Force		Light conditions	Air conditions		Visual strain	Aural strain	Mental strain	Monotony	Tediousness		TOTAL
	F	M	F	M	F	M	F	M	F M	F	M	F M	F M	F M	F M	F	M	
					7%	7%	20%	20%	5%	%	%	5%	4%	8%	4%	2%	5%	High
El. no. / Element	11%	9%	4%	2%	3%	2%	10%	10%	2%	%	%	2%	1%	4%	1%	1%	2%	Med.
					1%	0%	5%	5%	0%	%	%	0%	0%	1%	0%	0%	0%	Low

Personnel Administration

Figure 7.2.4.

Example 1 : Kerb Laying at County "C"

SELECTION OF REST ALLOWANCES

Operation (full description) 83 Kerbs laid in total		Date 1.11.77 Information calculated by Work Study Officer					Study No Information calculated by the Researcher				
No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. %	R.A. %	Sub Total	U.T. %	SM per
1	Set levels & periodic checks	93.35	83	1.12			1.25	19	1.49	0.18	1.67
2	Measure & instruct digger	2.75					3.08	19	3.67	0.44	4.11
3.	Take delivery of Ready Mix concrete and off-load in heaps on footpath	16.70	83	0.20			0.22	16	0.26	-	0.26
4.	Load and unload edging kerbs and move lorry off site	12.45					13.94	24	17.29		17.29
5.	Set out tools at start of day & misc. collection during day & put away tools at finish of job	33.95					38.02	12	42.58	5.11	47.69
6.	Talk to Superintendent	2.80									
7.	Traffic control	19.00									
8.	Set kerbs in concrete & adjust to correct level	166.75	83	2.01			2.25	24	2.79		2.79
9.	Shovel in base in concrete from footpath heaps to trench	6.10	83	0.07			0.08	19	0.09		0.09
10.	Shovel in front and backing concrete to kerbs. Trowel off and sweep footpath	131.10	83	1.58			1.77	20	2.12		2.12
11.	Wait delivery of Ready Mix concrete	16									
12.	Digger more surplus concrete from footpath to further along trench	3.80					4.26	19	5.06	0.61	5.67
13.	U.W.T.	14.20									
14.	Lorry off site collecting kerbs from dump site	8.00					8.96	24	11.11		11.11
15.	Roll up level line	8.55	83	0.10			0.11	16	0.13	0.02	0.15

Figure 7.2.5.

Example 1 : Kerb Laying at County "C" : Work Measurement Summary Sheet after Calculation of Standard Minutes Value

Element Description	Information calculated by Researcher						
	Total prod. m's	Total non-prod m's	Lost Time				Traffic control
			Talk with sup.	Un-work-ing	Wait for mat. deliv	Total lost time	
1. Set levels & periodic check	138.61						
2. Measure & instruct digger		4.11					
3. Take delivery of Ready Mix concrete off-load in heaps on footpath	21.58						
4. Load & unload edging kerbs and move lorry on site		17.29					
5. Set out tools at start. Collect during day. Finish job		47.69					
6. Talk to Superintendent			2.80				
7. Traffic control							19.00
8. Set kerbs & adjust level	231.57						
9. Shovel in base in concrete	7.47						
10. Shovel in front & backing	175.96						
11. Wait delivery of Ready Mix concrete					16.00		
12. Digger more surplus concrete from footpath		5.67					
13. U.W.T.				14.20			
14. Lorry off site collect - ing kerbs for dump site		11.11					
15. Roll up level line	12.45						
Total	587.64	85.87	2.80	14.20	16.00	33.00	19.00

Figure 7.2.6.

Example 1 : Kerb Laying at County "C"

Detailed Work Measurement Summary

Example 2 : Kerb Laying at County "D"

This example is concerned with kerb laying on a carriageway.

1. In this county, the work study officer used a "Work Analysis Sheet" in order to observe the time required for carrying out the work, and the observed rating. (See Figure 7.2.7.) It may be noticed that the form used by County "D" is more explicit and well-organised than that used in County "C". Hence, it is expected that less effort would be required to complete it and it should more easily be checked for errors.

2. This county used more detailed "Study Summary Sheets" than County "C" to present the results of the work (see Figure 7.2.8).

   The time study in this county involves the techniques of establishing an allowable time for relaxation and contingency allowance. The contingency is obtained by calculating the amount of contingency required and adding it as a percentage of basic time. The relaxation allowance is given as a percentage of the total job time. An extra allowance is added to the appropriate element of work in the example to cater for various items which require the operator's time but are not regular parts of any job.

3. In this county, the operator performance can be calculated from the study summary sheet.

$$\text{Operator performance} = \frac{\text{Total BM's}}{\text{AM's}} = \frac{\text{Total credit minutes}}{\text{Effective attendance mins on work sheet}}$$

$$= \frac{\text{Total control credit minutes}}{(\text{Attendance mins on work sheet} - \text{uncontrolled credit} + \text{Total lost time}}$$

$$= \frac{905.8 \times 100}{1002}$$

$$= 90\%$$

It is noticed in this example that the work study officer did not allow for the time lost during the study.

Study Analysis Sheet

	Page	Wait, Rain	Offload kerbs to roadside	Load old kerbs to JCB front bucket	Wait	Level soil from accesses by hand	Tractors to tip soil	Level soil from accesses by tractor	Set up level-string for kerbing	Dig out lay-by by JCB EB. Load to trailer	Tip RMC to previously dug trench	Vehicles wait whilst loading soil	Roller/Vibrator was in lay-by	Lay kerbs
OBSERVATIONS	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	4	9	2	5	-	-	-	-	-	-	-	-	-
	3	-	-	-	2	6	2	2	21	18	21	-	-	-
	4	-	-	-	18	-	4	-	22	39	-	35	4	52
	5	-	-	-	13	-	-	-	13	35	-	28	-	24
	6													
	7													
	8													
	9													
	10													
	11													
	12													
	13													
	14													
	15													
	16													
	17													
	18													
	19													
	20													
	21													
	22													
Total Obs. (B)		4	9	2	38	6	6	2	56	92	21	63	4	76
RATINGS	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	775	200	500	-	-	-	-	-	-	-	-	-
	3	-	-	-	150	510	150	200	2010	1745	2100	-	-	-
	4	-	-	-	1770	-	365	-	2035	3845	-	3500	380	5060
	5	-	-	-	1300	-	-	-	1190	3340	-	2790	-	2255
	6													
	7													
	8													
	9													
	10													
	11													
	12													
	13													
	14													
	15													
	16													
	17													
	18													
	19													
	20													
	21													
	22													
Total ratings (C)		-	775	200	3720	510	515	200	5235	8930	2100	6290	380	7315
Average Rating (D) = $\frac{C}{B}$			86	100	98	85	86	100	93	97	100	100	95	96
(E) = B x A			18	4	76	12	12	4	112	184	42	126	8	152
= $\frac{D \times E}{100}$			15.5	4	74	10.2	10.3	8	104.2	178.4	42.0	1260	7.6	145.9

Figure 7.2.7. Study Analysis Sheet
Example 2 - Kerb Laying at County D

Operation (full description) Date 17.11.77 Study No

Lay kerbs, quantity 29 kerbs, 8 drop kerbs

Excavate Lay-by by JCB and cart away soil

No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. % 12	R.A. %	Sub Total	U.T. %	SMV per
1	Prepare, put out traffic lights	40.5	1	40.50			45.36	19	53.98	5.44	59.42
2	Load kerbs to JCB FB	7.0	14	0.50	per kerb		0.56	24	0.69	–	.69
3	Load kerbs to tractor FB	4.0	12	0.33	" "		0.37	24	0.46	–	.46
4	Off-load kerbs to roadside	15.5	26	0.60	" "		0.67	24	0.83	–	.83
5	Load old kerbs	4.0	10	0.40	" "		0.45	24	0.56	–	.56
6	Level soil from access (hard)	10.2	3	3.40			3.81	19	4.53	0.46	4.99
7	Level soil from access (tractor)	8.0	2	4.00			4.48	10	4.93	0.54	5.47
8	Tractor to tip,dispose of soil,move	10.3	5	2.06			2.31	12	2.59	0.28	2.87
9	Set up level string for kerb laying 37m	104.2	37	2.82	per kerb		3.16	16	3.67	–	3.67
10	Tip R.M.C. into trench (quantity 37 L.m.)	42.0	37	1.14	" "		1.28	16	1.48	–	1.48
11	Lay kerbs (quantity 37)	145.9	37	3.94	" "		4.41	24	5.47	–	5.47
12	Backing and fronting to entrance kerbs (qty13)	45.1	13	3.46	" "		3.88	19	4.62	–	4.62
13	Dig out lay-by by JCB BB (94m^3)	178.4	94	1.90	" m^3		2.13	10	2.34	0.26	2.60
14	Vehicles wait whilst loading m^3	126.0	94	1.34	" m^3		1.34	–	1.34	–	1.34
	CONT.....							–		–	

Figure 7.2.8.

Example 2 : Kerb Laying at County "D"

Study Summary

Operation (full description) Date Study No

No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. %	R.A. %	Sub Total	U.T. %	SMV per
15	Roller/vibrate Lay-by ($15m^2$)	7.6	15	0.51	per m^2		0.57	16	0.66	0.07	0.73
16	Dig by hand, find and connect drain	61.4	1	61.40	" occ		68.77	19	81.84	8.25	90.09
	Element Nos. 2 and 3 (.69x14) +	(.46 x	12) +	(.56x	10) =	.577					
			36								
	Load kerbs = .58 SMs per kerb										
	Element No 4										
	Off-load kerbs to roadside = .83 SMs per	kerb									
	Element Nos 9, 10, 11										
	Lay kerbs on ReadyMix concrete = 10.62	SMs	per	kerb							
	Element No 12										
	Back and front kerbs with ReadyMix concrete =		4.67 SMs		per	kerb					

a	Repetitive BM's	808.7	d	Total BM's	905.8	Enforced Wait AM's	122
b	Contingency BM's	97.7	e	Effective AM's	1002	Enforced Wait BM's (gxf/100)	109.8
c	Contingency % (b/a x 100)	12	f	Op. Perf. (d/e x 100)		Enforced Wait % (h/d x 100)	12
	Temporary SMV's per						

Figure 7.2.8 Continued

Appendix 7.3.

Results of Work Study at Counties

"C" and "D"

(as presented by work study officers)

WORK MEASUREMENT SUMMARY SHEET		Study Ref No
		Date 15.12.77
		Taken by Bn
Dept Engineers	Section b	Time Finished 1.30
Sketch	Time study/Prod Study	Time Started 8.36
1st patch 61.21m^2	Act Sampling/Synthesis	Elapsed Time
2nd patch 4.44m^2	Operators A B	Total Recorded Time (B+C)
Total area of 2 patches		Timing Error %
= 61.21m^2+4.44m^2 = 65.65m^2	Gang F/Man X	Average Rating (100 D/B)
	Operation Description Cut key on tarmac road and patch with 3/8 bit tarmac, using emulsion, Leoseal for edges and brushing in grit.	
	Materials (Type/Qty) 2 tons ⅜ Bit Emulsion, Leoseal, Brushing in grit.	
	Plant/Equipment Vibroll, Cobra drill, Emulsion can.	
	Working conditions Good	

ELEMENT DESCRIPTION	Total Basic Min	Occ. Qty	BM's per Unit
1. Order, load and unload materials at start of shift	48.65		
2. Lorry moves in depot and on site	20.95		
3. Drive lorry to site at K, 2 man (44min/man) (Travel) sub-depot	88 actual minutes		
4. Lorry off site collecting materials back at main depot (1 man)	81 actual minutes		
5. Waiting time while lorry collects material at depot	27 actual minutes		
6. Prepare site for work icluding place out signs	11.05	315.47	0.04
7. Morning tea break (10 min/man) x 2 men	20 actual minutes		
8. Mark out patch with line of chalk	11.00	L/metres 459.43	0.02
9. Pick out key with cobra drill and shovel and sweep up scarifyings	85.75	469.98 L/metres	0.18
10. Fill emulsion can from drum and apply to road surface	6.05	315.47	0.02
11. Fill can with Leoseal and apply to key	14.95	L/metres 469.98	0.03
12. Spread tarmac from rear of lorry to patch	48.80	315.47	0.15
13. Vibroll patches	31.95	315.47	0.10
14. Ineffective time	7 actual minutes		
15. Talk to study people ∴ (ineffective time)	8 actual minutes		
16. U.W.T.	16 actual minutes		
17. Collect up tools at lunchtime	3.00	315.47	0.01

Figure 7.3.1.

Results of Patching at County "C"

WORK MEASUREMENT SUMMARY SHEET

Study Ref No	
Date	27.10.77
Taken by	Bn
Dept	Engineers
Section	a
Time Finished	16.22
Time Started	8.01
Time study/Prod Study	
Act. Sampling/Synthesis	
Elapsed Time	
Operators	M N
Total Recorded Time (B+C)	
Timing Error	%
Gang Foreman	
Average Rating (100 D/B)	
Sketch	
Operation Description	Gully-emptying in County "C" on Trunk Road. 2 man crew
Materials (Type/Qty)	
Plant/Equipment	Yorkshire Gully Emptier
Working conditions	

ELEMENT DESCRIPTION	Total Basic Min	Occ. Qty	BM's per Unit
1 Travel to building site to use hydrant for filling water tank	2.00	1	2.000
2. Fill clean water tank of vehicle at start of shift & one top-up during day at lunchtime	7.00	-	-
3. Empty gullies, starts with open gully top and ends with suction pipe reclipped to vehicle, gully top closed	214.00	224	0.955
4. Travel between gullies only	109.85	222	0.495
5. Travel from R for lunch from building site, and return to site	13.00	1	-
6. Travel to site to start at beginning of shift to 2nd site	9.00	2	
7. Drain off waste water after squeezing load	32.00	4	8.00
8. Travel to R at finish of gully emptying	9.00	1	
9. Travel to tip in R yard and wash bay	4.00	1	
10. Digging soil from top of gully	4.15	4	1.038
11. Wash hands and tea break	16.00	-	
12. Dinner	37.00	-	
13. One man stop and go for short period	4.00	1	
14. Roadside breakdown, refit change over valve handle to splined shaft (temporary repair)	7.00	-	
15. Empty vehicle in R tip	4.00	1	
16. Wash out vehicle	15.00	1	
17. Lock up tool boxes after replacing hydarnts etc.	3.00	1	
18. Ineffective	2.00	-	
19. Personal. Time study	5.00	-	

Figure 7.3.2.
Results of Gully Emptying at County "C"

Work Study Summary

Operation (full description) Apply fine cold asphalt wearing course to reinstatement trenches, rollwith pedestrian controlled tandem vibratory roll

Date 9.11.77   Study No /13/43

No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. % 9	R.A. %	Sub Total	U.T. %	SMV per
	Repetitive Elements										
1	Apply bituminous emulsion	40.50	68.72	.589	1:1	.589	.642	16	.745	.051	.796
2	Load in material from lorry (using barrow as required)	89.00	68.72	1.295	1:1	1.295	1.412	16	1.638	.113	1.751
3	Level with squeegee	73.00	68.72	1.062	1:1	1.062	1.158	16	1.34	.093	1.436
4	Shovel or sweep spilled material	37.75	68.72	.549	1:1	.549	.599	16	.695	.048	.743
5	Roll using tandem vibratory	88.00	68.72	1.281	1:1	1.281	1.396	16	1.619	.112	1.731
6	Measure and record	26.20	68.72	.381	1:1	.381	.416	14	.474	.033	.507
7	Move up lorry	24.00	68.72	.349	1:1	.349	.381	12	.427	.030	.457
8	Move up equipment	51.85	68.72	.755	1:1	.755	.822	16	.954	.066	1.020
9	Move up roll	33.55	68.72	.488	1:1	.488	.532	16	.617	.043	.660
10	Put out/take in/move up signs and cones	45.40	68.72	.661	1:1	.661	.720	16	.835	.058	.893
11	Load/unload roll from trailer	19.45	2.5occ	7.780	1:1	7.780	8.480	16	9.837	.678	10.515
12	Travel between sites in lorry	18.00	3.6min	5.00	1:1	5.00	5.45	12	6.104	.436	6.540
*13	Shovel material to side of lorry										
	See over for General occasional										
	/contingency elements										

a	Repetitive BM's	587.65	d	Total BM's	642.35	e	Enforced Wait AM's	53
b	Contingency BM's	54.70	e	Effective AM's	662	g	Enforced Wait BM's (gxf/100)	51.41
c	Contingency % (b/a x 100)	9	f	Op. Perf. (d/e x 100)	97	h	Enforced Wait % (h/d x 100)	8
Els 1-11	Temporary SMV's 9.994 per m^2						Ineffective AM's	192
							Traffic control AM's	45

* This element was necessary due to use of old material

Addendum to Figure 7.3.3.

General Occasional/Contingency Elements

	Total BM's
Start roll	1.80
Fill roll with water	14.55
Discuss with foreman	14.00
Oil tools/boots	2.70
Refuel roll	2.70
Remove clothing	.90
Level material with shovel	1.85
Sweep leaves from work area	4.75
Clean tools	.95
Discuss job	2.00
Ram edge	1.90
Move up on foot	3.60
Paperwork	3.00
	54.70
Other work	222

Work Study Summary

Operation (full description) Operate Yorkshire Emptier on British Leyland chassis, emptying and inspecting catchpits and emptying gully pots   Date 8.11.77   Study No

No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. %	R.A. %	Sub Total	U.T. %	SMV per
1,2,3,	Locate, open catch pit lid,										
4,5,7,8	empty and replace lid	= 2.634	x	2 men	=	5.3 SMs	per catchpit				
1,2,	Locate, open catch pit lid,										
3,6,8	inspect and replace lid	= 1.321	x	2 men	=	2.6 SMs	per catch pit				
9,10,	Locate, open gully grate, empty and										
11,12,13,14	replace lid and flush with clean water	= 2.044	x	2 men	=	4.1 SMs	per gully pot				
18,19,	Fill tank with 900 gallons of										
20,21	water from hydrant	= 11.448	x 2 men		=	22.90 SMs	per occ.				
22,23,	Empty and wash out										
24,25,26,27	sludge tank	= 19.062	x 2 men		=	38.1 SMs	per occ.				
15	Move up between gullies and catchpits	9.394	x 2	= 18.8	SMs per mile						
	Or	1.262	x 2	= 2.5	SMs per gully						
16	Travel to site	1.918	x 2	= 3.8	SMs per mile						
17	Travel to tip	4.312	x 2	= 8.6	SMs per mile						

a	Repetitive BM's		d	Total BM's		Enforced Wait AM's	
b	Contingency BM's		e	Effective AM's		Enforced Wait BM's (gxf/100)	
c	Contingency % (b/a x 100)		f	Op. Perf. (d/e x 100)		Enforced Wait % (h/d x 100)	
	Temporary SMV's per						

Figure 7.3.4 : Results of Gully Emptying at County "D" ... Work Study S[illegible]

Operation (full description) Date 8.11.77 Study No

Operate Yorkshire gully emptier

No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. % 3.2	R.A. %	Sub Total	U.T. % Nil	SMV per
1	Search for catch pit	1.55	1	1.55	1/70	.022	.023	12	.026		.026
2	Expose catchpit lids by shovel	1.44	5	.29	5/70	.021	.022	16	.026		.026
3	Remove catchpit lids	22.85	70	.33	1/1	.326	.336	19	.400		.400
4	Empty catchpit	85.24	58	1.47	1/1	1.470	1.517	19	1.805		1.805
5	Remove debris from catchpit by hand	2.91	3	.97	3/58	.050	.052	16	.060		.060
6	Inspect catchpits including flushing	5.86	12	.488	1/1	.488	.504	12	.564		.564
7	Flush catchpits after emptying	.64	3	.313	3/58	.011	.011	12	.012		.012
8	Replace catchpit lids	17.36	70	.248	1/1	.248	.256	19	.305		.305
9	Search for gully grate	2.09	2	1.05	2/47	.044	.045	12	.050		.050
10	Expose gully grate by spade	.36	2	.18	2/47	.001	.001	16	.001		.001
11	Open gully grate	11.50	47	.245	1/1	.245	.253	19	.301		.301
12	Empty gully pot	50.95	47	1.084	1/1	1.084	1.119	19	1.332		1.332
13	Replace gully grate	3.86	47	.082	1/1	.082	.085	19	.101		.101
14	Flush water around grate	10.51	27	.389	27/47	.224	.231	12	.259		.259
	CONTINUED....										

a	Repetitive BM's		d	Total BM's		Enforced Wait AM's	
b	Contingency BM's		e	Effective AM's		Enforced Wait BM's (gxf/100)	
c	Contingency % (b/a x 100)		f	Op. Perf. (d/e x 100)		Enforced Wait % (h/d x 100)	
	Temporary SMV's per						

Figure 7.3.4. Continued

Sheet 2

Operation (full description)				Date				Study No			
No	Element Description	Total BM's	Occ's	BM's per Occ.	Freq per Unit	BM's per Unit	C.A. %	R.A. %	Sub Total	U.T. %	SMV per
15	Move up between gullies or catchpits	127.82	15.4miles	8.3	1/1	8.30	8.566	12	9.394		9.394
	OR Move up between gullies and catchpits	127.82	117	1.092	1/1	1.092	1.127	12	1.262		1.262
16	Travel to site	10.14	6miles	1.690	1/1	1.690	1.744	10	1.918		1.918
17	Travel to tip	5.70	1.5mi.	3.80	1/1	3.80	3.92	10	4.312		4.312
18	Connect hose to hydrant	1.62	1occ	1.62	1/1	1.620	1.672	14	1.906		1.906
19	Flush out water tank	.12	1 occ	.12	1/1	.120	.124	-	.124		.124
20	Fill water tank (900 galls)	7.69	1 occ	7.69	1/1	7.690	7.936	-	7.936		7.936
21	Disconnect hose	1.26	1 occ	1.26	1/1	1.260	1.300	14	1.482		1.482
22	Squeeze water from tank	3.75	1 occ	3.75	1/1	3.750	3.870	-	3.870		3.870
23	Move up site	.70	1 occ	.70	1/1	.700	.722	12	.809		.809
24	Open rear door and push out debris	2.44	1 occ	2.44	1/1	2.440	2.518	14	2.871		2.871
25	Close rear door	2.64	1 occ	2.64	1/1	2.640	2.724	14	3.105		3.105
26	Wash out tank	2.82	1 occ	2.82	1/1	2.820	2.910	12	3.259		3.259
27	Level debris	4.30	1 occ	4.30	1/1	4.300	4.438	16	5.148		5.148
	See Addendum										

a	Repetitive BM's	388.12	d	Total BM's	400.40	Enforced Wait AM's	NIL
b	Contingency BM's	12.28	e	Effective AM's	427.30	Enforced Wait BM's (gxf/100)	NIL
c	Contingency % (b/a x 100)	3.2%	f	Op. Perf. (d/e x 100)	94	Enforced Wait % (h/d x 100)	NIL
	Temporary SMV's per						

Figure 7.3.4. Continued

Figure 7.3.4. Addendum

Occasional and Contingency Elements

	Total BM's
Level verge	1.62
Check pump	2.10
Adjust handles or cleansing pipe	.22
Clean hands	4.34
Put on gloves	.18
Traffic	1.24
Remove stone from boot	.47
Remove blockage from pipe	2.11

Appendix 8.1.

Guide to the User of Method Productivity Delay Model (MPDM)

The main aim of this method is to provide the management of highways maintenance departments with a means of measuring productivity. The researcher recommends the following steps to be applied by the users of MPDM.

1. Study the method in question and identify the resources (i.e. labour, material and equipment) used to perform the work.

2. Identify the production unit of the method studied, the "leading resources", the production cycle and the types of production delays to be cited. Generally, the five types of delay are :

   a) Environment delay (Een)
   b) Equipment delay (Eeq)
   c) Material delay (Ema)
   d) Labour delay (Ela)
   e) Management delay (Emn).

3. Collect MPDM data for the method using Production Cycle Delay Sampling (PCDS) (see Figure 8.1.1).

   a) Document time required for the completion of the Production cycle by using a stop-watch to clock the time between consecutive occurrences of the production unit. If the method is very complex, or the production cycle times very short, a filming procedure such as time-lapse photography may be used. The production cycle times are listed in Column 2 of the PCDS.

   b) Document the occurrence of any of the productivity delay types and note them in the appropriate column.

      (i) Only document actual delay times when it is convenient otherwise merely document the existence of delay.

      (ii) If more than a single delay type occurs in a given cycle, distribute delay times according to type as a function of their time occurrence.

4. Process the collected MPDM data for method by using the processing form (see Figure 8.1.2). It consists of seven rows labelled A to E. Rows A and B are merely the results of summing cycle times and averaging them. Rows C, D, E, F and G represent the delay information. The calculation of this information involves only simple mathematics as follows :

   a) Row A relates to the occurrence of non-delayed production cycles. The total production times for non-delayed cycles, the number of occurrences and the mean time for the non-delayed cycle are entered in the first three columns of this row. The calculation of the average delayed cycle depends on documentation of the occurrence of the different delays.

      (i) If actual delay times are documented, average delay cycle time is found by subtracting delay time from each cycle and averaging the remainder.

      (ii) If only the occurrences of the delay are documented, average non-delay cycle time is found by averaging non-delay cycle times.

      The last column of this row relates to the variability of the production cycle. It is calculated as the average of the sum of the absolute difference between the non-delayed production cycle time and the mean non-delay production cycle time.

   b) The entries in Row B of the processing form are made in the same manner as that of Row A. The difference is that all of the production cycles are considered in determining the four columns' entries. The entries in the first three columns of this row are the result of summing all of the production cycle times and averaging them without special consideration being given to non-delay or delay cycles. The last column entry is the calculated mean non-delay cycle time which is subtracted from every cycle time before the absolute values are summed and averaged.

   c) Row C is merely the sum of the number of occurrences of each delay type that was documented on the collection sheet.

d) Row D is for the sum of the added delay times for each type of delay. If the delay times were not cited before, they can be calculated by subtracting the calculated mean non-delay time from the delay cycle in question.

e) Row E represents the probability of occurrence of delay. The entries in this row are found by dividing the delay times for each type of delay by the total number of production cycles observed.

f) Row F is entitled "relative severity". The entires in this row are found by two mathematical operations. First, the entries of Row D are divided by the corresponding column entries of Row C. These divisions result in a determination of the mean added time per occurrence for each of the delay types. These values are then divided by the mean overall production cycle time that was calculated in Row B. The result is referred to as the severity rate. In other words, the severity rate is calculated as follows :

$$\text{Severity rate per delay type} = \frac{\text{Mean added cycle time per delay type}}{\text{Mean overall production cycle time}}$$

$$= \frac{\dfrac{\text{Total added time}}{\text{Delay occurrences}}}{\text{Mean overall production cycle time}}$$

g) Row G is entitled the "expected percentage delay" time per production cycle. The entries in this row are calculated as the product of Rows E and F entries in the respective columns, times 100.

5. Structure the MPDM of the method by using the form illustrated in Figure 8.1.3. The structure of MPDM consists of two somewhat distinct parts :

a) The first part of the model is the method productivity equation that relates overall or actual method productivity to ideal method productivity as a function of the five identified productivity delay types. As such, the productivity equation is :

$$\text{Overall Productivity} = (\text{Ideal productivity})(1\text{-Een-Eeq-Ela-Ema-Emn})$$

(i) Ideal productivity is that productivity which occurs when all kinds of delays are absent. The collected cycle times are to be used for the determination of the ideal productivity. The cycle time must be transformed to a productivity :

- if actual delay times are not documented, the mean non-delay production cycle time is used as a basis of calculating ideal productivity.
- if actual delay times are documented, all of the overall cycle times are used in determining the basis of ideal productivity. However, before using these overall cycle times, first subtract the added time due to delay from the cycle time.

The non-delay production cycle time is transformed into the time period-interval for which the productivity is to be measured and predicted and for which work improvement is to be performed. This time period interval will normally be in units per hour or day.

For example, if the mean non-delay production cycle time is 400 sec. the ideal productivity is calculated as follows :

$$\text{Ideal productivity} = \frac{60\text{min/h x } 60\text{sec/min}}{400 \text{ sec/unit}}$$

$$= 9 \text{ units/h.}$$

(ii) The delay factors in the right-hand side of the productivity equation (Een, Eeq, Ela, Emt and Emn) relate the method's ideal productivity to the method's overall productivity. The factors are merely percentages of the total production time caused by the delay types (as calculated in Row G of the processing form), divided by 100. These factors can have a value ranging from 0 to 1. When the sum of Een, Eeq, Ela, Emt and Emn are subtracted from 1, the result is a factor which relates to the probability of productive work being performed.

(iii) The overall method productivity on the left-hand side of the equation can be calculated by means of determining the product of the two terms on the right-hand side of the equation.

(iv) This overall method productivity can be verified by merely transforming the mean overall production cycle time into a productivity rate. (This can be done only if the ideal productivity is calculated from the non-delay production cycle time).

b) The second part of the structure model is entitled "method indicators". Four types of information are set out in this part.

(i) The first type of information is referred to as the "variability of method productivity". This gives a measure of the non-delay productivity cycles. These are calculated by dividing the entries in the last column of Rows A and B in the processing form by the mean, non-delay cycle time and the mean overall cycle time respectively. The mathematical formula for these two measures of variability are as follows :

$$\text{Overall cycle variability} = \frac{\dfrac{\sum((\text{Overall cycle time})-(\text{Mean non-delay cycle time}))}{\text{No. of total cycles}}}{\text{Mean overall cycle time}}$$

$$\text{Ideal cycle variability} = \frac{\dfrac{\sum((\text{Non-delay cycle time})-(\text{Mean non-delay cycle time}))}{\text{No. of non-delay cycles}}}{\text{Mean non-delay cycle time}}$$

Ideally, these ratios should be small. The higher the overall cycle variability and the ideal cycle variability, the less dependable is the productivity prediction.

(ii) The other three types of indicators in this part of the model relate to the five types of productivity delay which previously determined "probability of occurrence", "relative severity" and the "expected percentage delay time per production cycle".

The MPDM which was structured can be used to aid in the objective of measuring,predicting and improving productivity.

Page of

Method:

PRODUCTION CYCLE DELAY SAMPLING

Production Unit:

Prod. Cycle	Prod Cycle Time (sec/min)	Environ-ment Delay	Equip-ment Delay	Labour Delay	Mat-erial Delay	Manage-ment Delay	Notes	Minus Mean Non-Delay Time

Figure 8.1.1.

Collection Element of MPDM

M P D M PROCESSING

Method

Production Unit

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time})-(\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles				
B	Overall Production Cycles				

		Environ-ment	Equip-ment	Labour	Material	Manage-ment
C	Occurrences					
D	Total Added Time					
	Mean Added Cycle Time (Total Added Time/Delay Cycles)					
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)					
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)					
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)					

Figure 8.1.2.

Processing Element of MPDM

M P D M STRUCTURE

Method | Production Unit

Production Equation

Overall Productivity = (Ideal Productivity) x (1 - Een - Eeq - Ela - Ema - Emn)

=

=

Method Indicator

A Variability of Method Productivity

Ideal Cycle Variability =

=

Overall Cycle Variability =

=

B Delay Information

	Environment	Equipment	Labour	Material	Management
Probability of Occurrence					
Relative Severity					
Expected %age Delay Time per Production Cycle					

Figure 8.1.3.

Appendix 8.2.

MPDM Results of Kerb Laying, Patching and Gully Emptying at Counties "C", "D" and "B"

Example 1 : Kerb Laying at County "C"

This example is concerned with placing kerbs in position at the back of the footway. The kerb laying operation comprises the following elements :

1. Setting up the string line.

Transfer of the line and level indication provided into the form of a string line to which the kerbs to be laid are referenced. The procedures are as follows :

a) Line

- Locate offset primary line reference pegs, and locate pins in accordance with the dimensions given by the engineer.
- Locate additional pins on the lines of circles and transition curves.
- Locate further line pins at the discretion of the operative, to horizontal straights only.

b) Level

- From offset level reference peg, mark levels on additional temporary pins located in kerb line established above.
- Transfer levels to adjacent line pins.
- Remove temporary level pins.
- Add further level pins at the discretion of the operative to straight grade lengths only.
- Fix string line to each line pin at the marked level.

c) Check

- Check string line visually for apparent discrepancies in line or level.
- Check levels of apparently out-of-level pins and correct if appropriate.

- Check locations of apparently out-of-line pins and correct if appropriate.
- Obtain approval of supervisor to line and level of the string line erected, prior to continuation of work, unless this aspect of the work has been delegated to the kerb layer.

2. Prepare concrete foundation.

(a) Adjust level and compact concrete foundation using hand tools, to required level.

(b) Adjust width of concrete foundation to width specified, allowing for side support to the concrete and the weight and adjustment of kerbs.

3. Locate kerbs on concrete bed, using kerb lifter with rear top edge of kerb close to, and approximately parallel to string line.

4. Adjust front face of kerb, using maul until back of kerb touches string line along whole length.

5. Adjust top of kerb using maul until top surface of kerb is level with string line along whole length.

6. Check top of kerb is horizontal at right-angles to string line using spirit level.

7. Re-check line and level of kerbs and re-adjust as necessary.

8. Lay subsequent kerb with one end close to open end of intial kerb, and back of kerb close to, and approximately parallel to string line.

9. Form gap between end of subsequent kerb and end of initial kerb, using kerb lifters to obtain required gap (not exceeding 2mm). No further treatment applied to the dry joint.

10. Re-check line and level of kerb and joint gap, and re-adjust as necessary.

11. Remove string line after approval of kerb line by engineer, unless delegated to kerb layer.

12. Kerb backing

Back up kerbs at the end of working day, using shovel and trowel to configuration and dimensions specified. Where kerbs are not backed up the same day as laid, it becomes the first operation of the next day's work. The method assumes that concrete is placed to form a rectangular base of thickness not less than 150mm.

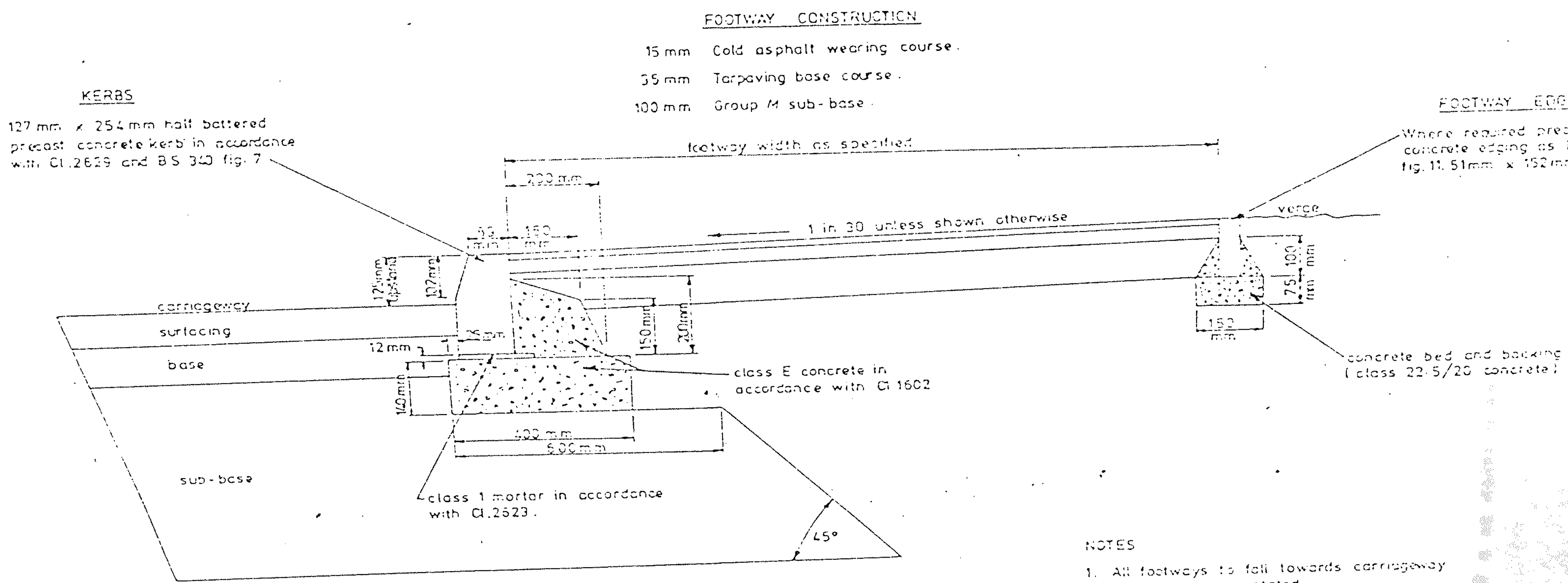
The materials used are ready mixed concrete which is delivered to the kerb laying site by truck mixer. The kerbs used are pre-cast concrete edging kerbs 150 x 50mm (see Figure 8.2.1).

The tools considered essential to the operation, or for jointing when specified, include :

- lump hammer
- cutting and dressing hand tools such as bolsters and chisels
- kerb lifter
- maul
- carpenter's square
- pointing trowel.

In addition, the following measuring and setting-out tools are included:

- tape
- rule
- straight edge
- string line
- spirit level.



NOTES

1. All footways to fall towards carriageway unless otherwise stated.

2. Footway edging to be provided in all cases where the footway is not supported by a kerb or wall etc.

3. Where the footway is overlaying on an existing c'way or footway, the difference is to be made up with the basecourse and wearing course material specified above — the existing kerb first being removed.

Scale 1 : 10

Figure 8.2.1.

Kerb, Footways and Cycle Tracks

Detail of Flexible Carriageway Edge Treatment

The gang consists of two men : a kerb layer as a ganger and a roadman working as a lorry driver.

The collection element of this example is shown in Figure 8.2.2. and the processing element in Figure 8.2.3.

Page 1 of 1
Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	270						✓	202
2	580	30			70			271
3	760			255	255			251
4	70			30				239
5	55	35						259
6	130			50	50			179
7	195			60				114
8	180			80				129
9	240			115				69
10	520			390	60			211
11	1085	180		120				776
12	150			90				159
13	400			220				191
14	110			60				199
15	200						✓	109
16	130					100		179
17	265				45			44
18	290				30			19
19	70						✓	239
20	450	135		185				141
21	275						✓	34
22	205						✓	104
23	420						✓	111
24	140						✓	169
25	60						✓	249
26	590			80				281
27	300						✓	9
28	180						✓	129
29	310						✓	1
30	460						✓	151
31	300						✓	9
32	365			60				56

Figure 8.2.2.

Production Cycle Delay Sampling, Example 1, County "C"

Page 2 of 1
Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING
Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	180						✓	129
34	240						✓	69
35	505	60		60				196
36	300			60				9
37	220						✓	89
38	650			65				341
39	380	30						71
40	315						✓	6
41	425						✓	116
42	435	135						126
43	710	140		270				401
44	600	80						291
45	460			40				151
46	600	60						291
47	515			200				206
48	375			50				66
49	585						✓	276
50	435						✓	126
51	330						✓	21
52	1035			120	405			726
53	330						✓	21
54	495			215				186
55	110						✓	199
56	400			120				91
57	520			240				211
58	270	60						39
59	620						✓	311
60	310	300						1
61	510						✓	201
62	500			60				191
63	645			355				336
64	560			195				251

Figure 8.2.2. Continued

Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
65	650						✓	341
66	480			315				171
67	555			165	315			246
68	885	60						576
69	510						✓	201
70	815			120				506
71	600		90	165				291
72	720			120				411
73	660			420				351
74	740			380				431
75	520			60				211
76	680		300	150				371
77	260						✓	49
78	280						✓	29
79	580						✓	271
80	160						✓	149
81	210						✓	99
82	150						✓	159
83	240			120				69
84	450			150				141
85	300		90	90				9
86	480			110				171
87	210						✓	99

Figure 8.2.2. Continued

M P D M PROCESSING

Method Kerb Laying

Production Unit 4 kerbs

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert (\text{Cycle Time}) - (\text{Mean non - Delay Cycle Time}) \rvert}{n}$
A	Non - Delayed Production Cycles	10500	34	309	127
B	Overall Production Cycles	35455	87	407.5	187.6

		Environment	Equipment	Labour	Material	Management
C	Occurrences	13	3	41	8	2
D	Total Added Time	1305	480	6210	1230	210
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	100.3	160	151.4	1547	105
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.149	0.035	0.471	0.092	0.023
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.246	0.393	0.372	0.377	0.258
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	3.7	1.4	17.5	3.5	0.6

Figure 8.2.3.

MPDM Processing Element, Example 1, County "C"

Example 2 : Kerb Laying at County "D"

This example is concerned with placing kerbs to the carriageway. The operation elements are as follows :

1. Setting up the string line

(a) Drive in a pin at the off-set distances from the peg, less the width of the kerb plus 6mm.

(b) Transfer level of top engineer's peg to pin, using one colour chalk for all these level marks.

(c) Repeat above operations down the line of kerbing, sufficient for one day's kerb laying, plus 20 metres, to allow for continuity in the following day's work.

(d) Commencing at the last pin, measure up or down from the previous level mark and establish level of top of kerb, marking with a different colour from that used in level marking. This measurement up or down is that given on the data sheet.

(e) Commence to fix line at this top of kerb level.

Repeat these operations back down the line to the first pin.

(f) Eye the line in, instructing mate to adjust until a "sweet" line is produced.

2. Placing the concrete of the kerb foundations

In the wet bed method, the concrete is placed to form a rectangular base of thickness not less than 150mm. (see Figure 8.2.1).The width of the base, measured from the front face of the kerb should be sufficient to accommodate the width of the kerb and any specific concrete backing to the kerb.

3. Check that string line is correct for line and level following laying of foundation.

4. Lift kerb into bed and adjust until front face is at correct distance from line, and kerb is vertical.

5. Tap kerb down into concrete until top of kerb is level with string line. Check that top of kerb is horizontal using spirit level.

6. Lift another kerb, tap down "free" end of kerb and then tap down end next to kerb previously laid.

7. Place straight edge along top of kerbs to ensure that each kerb is absolutely level with its neighbours (no lipping).

8. When a reasonable run of kerbing has been laid (10m on short radii, up to 100m on long curves and straights) remove the string line and adjust kerbs as necessary to give a "sweet" vertical and horizontal line. The kerbs adjacent to pins should not be adjusted.

9. Remove pins. Excess concrete from in front of the kerbs should be moved, and can form part of the backing concrete. The backing concrete can now be completed, care being taken to see that the alignment of the kerbs is not disturbed.

10. It is advisable to back all kerbs on the day they are laid, particularly on roads which are open to traffic.

The collection element data for this example is shown in Figure 8.2.4 and the processing element is shown in Figure 8.2.5.

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Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	540			210				337
2	280			90				190
3	250		90					47
4	400	60						197
5	380			60				320
6	240						✓	37
7	370			90				167
8	510					300		307
9	235						✓	32
10	215						✓	12
11	390			90				187
12	520			60				317
13	670			120				467
14	480						✓	277
15	495			205				292
16	370			120				167
17	270						✓	67
18	330			60				127
19	480					120		277
20	170						✓	33
21	120						✓	83
22	450			60				247
23	570	240						367
24	210						✓	7
25	520			145				317
26	125						✓	78
27	240			90				37
28	590				95			387
29	140						✓	63
30	460		200					257
31	690				120			487
32	220						✓	17

Figure 8.2.4.

Production Cycle Delay Sample, Example 2, County "D"

Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	675				90			472
34	240				60			37
35	310				90			107
36	120						✓	83
37	320		90					117
38	100						✓	103
39	240						✓	37
40	165						✓	38
41	440		90	100				237
42	615			260				412

Figure 8.2.4. Continued

M P D M PROCESSING

Method Kerbing

Production Unit 4 Kerbs

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time})-(\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	3050	15	203.3	64.5
B	Overall Production Cycles	15155	42	360.8	180.7

		Environment	Equipment	Labour	Material	Management
C	Occurrences	2	4	15	5	2
D	Total Added Time	300	470	1760	955	420
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	150	117.5	117.3	191	210
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.048	0.095	0.357	0.119	0.048
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.416	0.326	0.325	0.252	0.582
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	2.0	3.1	11.6	3.0	2.8

Figure 8.2.5.

MPDM Processing Element, Example 2, County "D"

Example 3 : Kerb Laying at County "B"

The operation elements of kerb laying are as follows :

1. Locate work

2. Set out signs and cones

3. Unload equipment

4. Set out line and levels

5. Obtain or mix concrete

6. Shovel out trench

7. Prior to laying, the kerbs are placed end to end on the carriageway, on their bases, with the front face of each kerb towards the carriage-way centre line and slightly angled to it, to facilitate subsequent use of kerb-lifters.

8. Obtain and lay granite kerb on 150mm concrete base

9. Back up kerbs with concrete

10. Create a gap between the kerbs. A gap of 5mm-7mm between the ends of the adjacent kerbs is formed by some specially made spacer. The gap is subsequently filled with sand/cement mortar as specified, trowelled flush with the front and top of adjacent kerbs.

11. Allow for sealing joint between carriageway and kerb and for making good surfaced footway behind kerb.

12. Dismantle line and tidy site

13. Make site safe for public

14. Load tools, signs and cones to vehicle.

The following are the basic tools essential to the operation :

- a crow-bar (not kerb-lifter, although it is not recommended on the ground that the method can be executed by the use of kerb-lifters and a maul without the degree of risk of damage to kerbs associated with bars)

- a tape (length at management's direction)
- rule (folding, 1 metre)
- straight edge
- string line (15 metre minimum)
- spirit level
- boning rods (standard or patent)

The collection data of this example is shown in Figure 8.2.6 and the processing element is shown in Figure 8.2.7

Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	420						✓	221
2	600			130				401
3	600			255				401
4	480			125				281
5	450						✓	251
6	190						✓	9
7	300			180				101
8	140						✓	59
9	180			25				19
10	240						✓	41
11	180			50				19
12	240			40				41
13	195						✓	4
14	420			115				221
15	440			25		130		241
16	1470	780		390				1271
17	500		170					301
18	360						✓	161
19	150						✓	49
20	600			275				401
21	180						✓	19
22	180		125					19
23	150						✓	49
24	100						✓	99
25	145						✓	59
26	100						✓	99
27	120						✓	79
28	190			35				9
29	135						✓	64
30	175						✓	24
31	180						✓	19
32	145						✓	59

Figure 8.2.6.

Production Cycle Delay Sampling, Example 3, County "B"

Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	660		245	245				461
34	120			60				79
35	190			90				9
36	120						✓	79
37	420						✓	221
38	600			130				401
39	600			255				401
40	2280			125	180			2081
41	450						✓	251
42	190						✓	9
43	300			40				101
44	140						✓	59
45	180			25				19
46	240						✓	41
47	180			50				19
48	240			40				41
49	195						✓	4
50	420			25		120		221
51	440			25		120		241
52	1170	390		390				971
53	300						✓	101
54	500			175				301
55	360						✓	161
56	150						✓	49
57	600			190				401
58	180						✓	19
59	120						✓	79
60	165						✓	34
61	170						✓	29
62	120						✓	79
63	190			45				9
64	135						✓	64

Figure 8.2.6. Continued

Method: Kerb laying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: 4 kerbs

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
65	175						✓	24
66	180						✓	19
67	145			30				54
68	660		165	60				461
69	120						✓	79
70	480			170				281
71	380			120	60			181
72	180			120				19
73	240			140				41
74	225			125				26
75	445				110			246
76	600			100	65			401
77	120						✓	79
78	120						✓	79
79	150			85				49
80	195			100				4

MPDM PROCESSING

Method Kerb Laying

Production Unit 4 kerbs

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time})-(\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	7745	39	220	74.9
B	Overall Production Cycles	26495	80	331.2	177.05

		Environment	Equipment	Labour	Material	Management
C	Occurrences	2	4	38	4	3
D	Total Added Time	1170	705	4605	2035	370
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	585	176.2	121.1	508.1	123.3
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.025	0.050	0.475	0.05	0.038
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	1.766	0.532	0.366	1.536	0.372
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	4.4	2.7	17.4	7.7	1.40

Figure 8.2.7.

MPDM Processing Element, Example 3, County "B"

Example 4 : Patching Operation at County "C"

Patching operations in this example refer to remedial and preventative patching.

The sequence of the patching operations in this county was as follows :

1. The defective area shall be identified and a straight-sided, regular area shall be marked out with chalk to cover that area by a margin of at least 75mm, as shown in Figure 8.2.8.

2. All loose material round the edges and from the bottom of the hole shall be cut out and removed.

3. The edges shall be cut back to vertical faces in sound, existing material.

4. The area of repair (not concrete) shall be compacted by a rammer or hand rammer, prior to the application of the primer.

5. After compaction, the whole area and the vertical sides shall be primed with 62% bituminous emulsion or cationic emulsion. There shall be no excess emulsion and the binder must break before the macadam is applied.

6. The wearing course shall be spread or placed in sufficient depth to allow for compaction.

7. All materials shall be rolled by vibratory roller or compacted by vibrating plate to refusal.

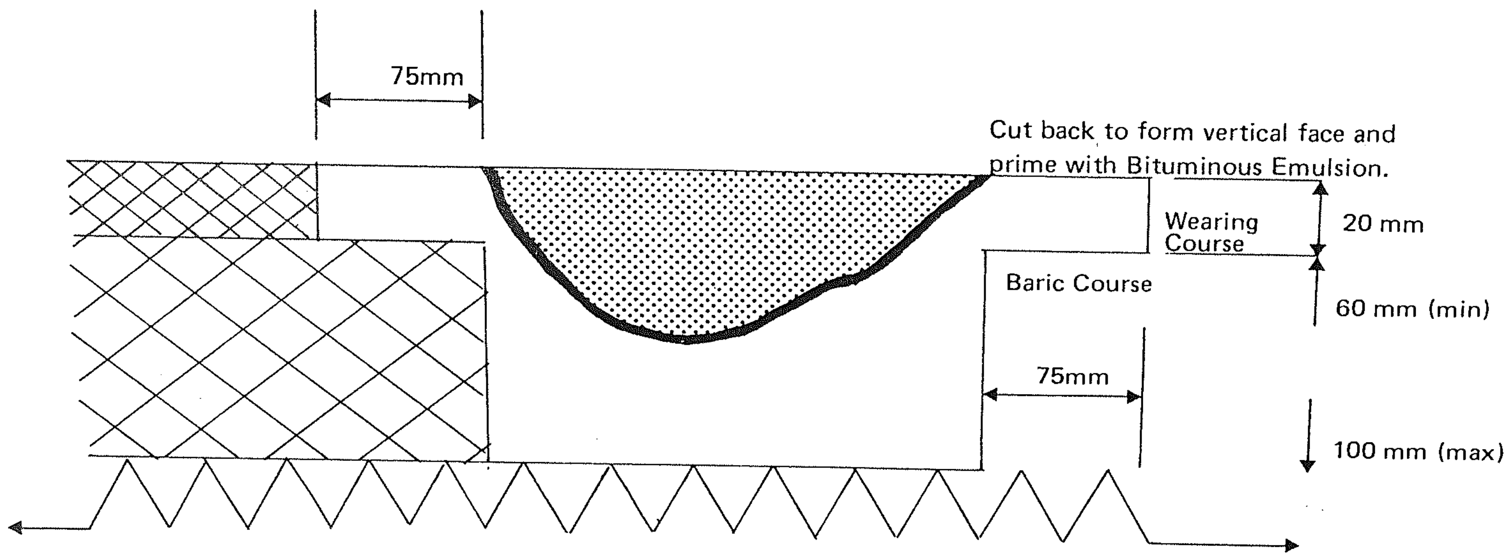

Fig. 8.2.8: Patching operation at county 'C'

8. The surface of the repaired area shal be plane and regular so as to be flush and uniform with the existing surface, or not more than 3mm proud of that surface.

9. Brush in coated grit to seal the surface.

The material used included :

Bituminous macadam - 6mm graded bituminous macadam shall be used in depths of up to 20mm ; for greater depths up to 75mm the material used shall be 20mm (nominal size) graded.

Cold asphalt - Fine cold asphalt shall not be used in greater depths than 20mm ; any excess depth shall be made up with bituminous macadam of correct size.

62% cationic bituminous emulsion.

The plant used included a petrol breaker, a rammer, vibratory roller and a three-ton lorry which was used for delivering the material.

The collection element of this example is shown in Figure 8.2.9 and the processing element is shown in Figure 8.2.10.

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	705			90		120		504
2	2595		190					2394
3	740		190					539
4	400	40		40				199
5	500		60					299
6	90						✓	111
7	260		60					59
8	120						✓	81
9	220						✓	19
10	340			125				139
11	465				150			364
12	480			60				279
13	150						✓	51
14	360			80				159
15	325				205			124
16	160						✓	41
17	230		30	40	110			29
18	990	90	180	60				789
19	480	80	140					279
20	480		90	140	90			279
21	540			240				339
22	120						✓	81
23	120						✓	81
24	60			55				141
25	480			60	110			279
26	860		150	150				659
27	1230		60	30	290			1029
28	160						✓	41
29	205						✓	4
30	630			250	290			429
31	4230			180				4029
32	430		120					229

Figure 8.2.9.

Production Cycle Delay Sampling, Example 4, County "C"

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	270			80				69
34	120						✓	81
35	605			115				404
36	290			45				89
37	690						✓	489
38	360			210	60			159
39	90						✓	111
40	420	25			45			219
41	420			200				219
42	700				60			499
43	130						✓	71
44	475	40		60				264
45	295						✓	94
46	450					120		249
47	120						✓	81
48	250		30	100				49
49	360				30			159
50	495		80					294
51	90		30	30				111
52	340		40	30				139
53	240			30				39
54	125						✓	76
55	260			65		35		59
56	150			100				51
57	155		30					46
58	685	145		105	110			484
59	570	105			115			369
60	150			90				51
61	300			180				99
62	210						✓	9
63	150						✓	51
64	240						✓	39

Figure 8.2.9. Continued

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
65	540						✓	339
66	1080	315		250				879
67	1305	60						1104

MPDM PROCESSING

Method Patching

Production Unit Patch

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time})-(\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	3815	19	200.8	98.5
B	Overall Production Cycles	32285	67	481.9	322.2

		Environment	Equipment	Labour	Material	Management
C	Occurrences	9	17	31	13	3
D	Total Added Time	900	1540	3290	1665	275
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	100	87.6	106.1	128.1	91.7
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.134	0.254	0.463	0.194	0.045
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.208	0.188	0.220	0.266	0.19L
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	2.8	4.8	10.2	5.2	0.9

Figure 8.2.10.

MPDM Processing Element, Example 4, County "C"

Example 5 : Patching Operation at County "D"

This example of patching involves the application of fine cold asphalt wearing course to the reinstatement of trenches. The gang has to adopt the following steps to finish it.

1. Cut back the edges to a vertical face in sound existing material to a depth of at least 80mm, cutting back the wearing course an extra 75mm all round, with the edges square in plan.

2. Clean away all loose material and thoroughly sweep the reinstatement and carriageway immediately adjacent.

3. Compact exposed base using vibrating roller or plate vibrator. (Use hand punner in awkward corners.)

4. Paint exposed vertical faces of base course with 60% cold emulsion.

5. Place deferred set 20mm open-textured bitumen base course (to B.S.) up to the underside of the wearing course.

6. Thoroughly compact using vibratory roller or plate vibrator. (Use hand punner for awkward corners).

7. Clean away all loose material and thoroughly sweep reinstatement area and carriageway.

8. Paint the exposed vertical faces of the wearing course and the surface of new base course with cold emulsion.

9. Place deferred set 10mm bituman wearing course (to B.S.) laid to maximum thickness of 30mm in the excavation and spread to level with a rake or fork, allowing sufficient material so that, on compaction, a tight joint is formed all round.

10. Thoroughly compact with vibrating roller or plate vibrator until no further movement of the material is evident. The surface of the reinstatement should conform with that of the surrounding carriageway.

11. Clean up any spilled material.

The materials are defined as bituminously bound materials complying with the appropriate British Standard. Other materials used in the method were cold emulsions (binder content 30-50% anionic or cationic, covering capacity 0.25-0.50 litre/m^2).

The plant used included a vibratory roller, an emulsion sprayer and a 3-tonne lorry.

The following are the basic tools essential to the operation : pick, shovel, broom (brush), asphalt rack, tarmac fork. Supplementary to these are : spreader can, tar brush, barrow and hand rammer (square-headed.

The collection data of this example is shown in Figure 8.2.11 and the processing element is shown in Figure 8.2.12.

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	1010						✓	636
2	1420		550	275				1046
3	420						✓	46
4	610			75				236
5	770			135				396
6	465		137			138		91
7	790		185			330		416
8	240			120				134
9	635			60				261
10	345						✓	29
11	495			60	150			121
12	170			50				204
13	405						✓	21
14	225						✓	149
15	550			120	135			176
16	395						✓	21
17	635		140	80				261
18	345			150				29
19	715			40	200			341
20	210			160				164
21	500						✓	126
22	195			85				179
23	700			60	410			326
24	495			285				121
25	510			230	65			136
26	195						✓	179
27	615	90		30	255			241
28	265			130				109
29	1780			380				306
30	430		60					56
31	165						✓	209
32	315						✓	59

Figure 8.2.11.

Production Cycle Delay Sampling, Example 5, County "D"

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	315						✓	59
34	420			70	160			46
35	510			97	98			136
36	300						✓	74
37	320						✓	54
38	835	335		185				461
39	315	155		60				59
40	410	210			170			36
41	210						✓	164
42	400			60				26
43	355	155						19
44	180						✓	194
45	515			60	45			141
46	280						✓	49
47	720						✓	346
48	290			190				84
49	270			90				104

M P D M PROCESSING

Method Patching

Production Unit Patch

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert (\text{Cycle Time}) - (\text{Mean non - Delay Cycle Time}) \rvert}{n}$
A	Non - Delayed Production Cycles	5985	16	374	147.9
B	Overall Production Cycles	24025	49	490	208.9

		Environment	Equipment	Labour	Material	Management
C	Occurrences	5	5	28	11	2
D	Total Added Time	945	1072	3557	2963	468
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	189	214.4	127.1	269.4	234
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.102	0.102	0.571	0.225	0.041
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.386	0.438	0.259	0.550	0.478
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	3.9	4.5	14.8	12.4	2.0

Figure 8.2.12.

MPDM Processing Element, Example 5, County "D"

Example 6 : Patching Operation at County "B"

The operation elements of trench reinstatement to footways are as follows :

1. Pick out temporary macadam surface.
2. Pick trench to depth of up to 150mm.
3. Square edge of excavation.
4. Dig out to depth of up to 150mm and deposit at side of trench.
5. Shovel spoil to lorry from side of trench.
6. Unload black ash to site by hand.
7. Barrow, tip and return 38mm ash and 6mm macadam.
8. Spread black ash up to 75mm thick.
9. Unload from lorry 38mm macadam by hand.
10. Spread 38mm macadam up to 75mm thick.
11. Unload 6mm macadam by hand.
12. Spread 6mm macadam up to 25mm thick.
13. True up edge of 6mm macadam.
14. Roll ash, 38mm macadam and 6mm macadam with $1\frac{1}{2}$ tonne pedestrian controlled vibrating roller (narrow trench compact base). Alternative to $1\frac{1}{2}$ tonne pedestrian controlled vibrating roller. Roll ash, 38mm and 6mm macadam with $1\frac{1}{2}$ tonne tandem roller.

The operation elements of trench reinstatement to carriageway are as follows :

Elements 1-9 as above.

10. Spread 38mm macadam up to 125mm thick.
11. Roll ash, 38mm macadam with pedestrian controlled vibrating roller.
12. Unload 6mm macadam to site by hand.
13. Spread 6mm macadam up to 25mm thick.
14. True up edge of macadam.

15. Roll 6mm macadam with pedestrian controlled vibrating roller (narrow trenches, compact base). Alternative to pedestrian controlled vibrating roller : roll base 38mm and 6mm macadam with $1\frac{1}{2}$ tonne tandem roller. Alternative to $1\frac{1}{2}$ tonne tandem roller : roll base 38mm and 6mm macadam with 10 tonne roller.

The materials used included $3\frac{1}{2}$ tonnes of 38mm base course tarmacadam and 2 tonnes of 6mm wearing course tarmacadam.

The equipment used included a $1\frac{1}{2}$ tonne tandem roller, 3 tonne lorry and an asphalt cutter.

Figure 8.2.13 shows the collection data of this example. The processing element is shown in Figure 8.2.14.

Page 1 of 6

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	210						✓	8
2	420			110				218
3	120						✓	98
4	600			180	240			382
5	660		60		120			442
6	185						✓	33
7	270		120					52
8	180						✓	38
9	120						✓	98
10	140						✓	78
11	160						✓	58
12	130						✓	88
13	360			275				142
14	290			185				72
15	310						✓	92
16	210						✓	8
17	900	210		240				682
18	300			130				82
19	560		80					342
20	1260			330	330			1042
21	260						✓	42
22	390						✓	172
23	230						✓	12
24	180			95				38
25	660		55	265				442
26	775			110	60			557
27	565			205	115			347
28	420						✓	102
29	600			120				382
30	480			40	45			262
31	600			255				382
32	525			225				307

Figure 8.2.13.

Production Cycle Delay Sampling, Example 6, County "B"

Method: Patching

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Patch

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	215							
34	705			690			✓	3
35	750			180				487
36	870	145		325				532
37	480			120	120			652
38	260		100					262
39	250							42
40	280						✓	32
41	170						✓	62
42	270		40				✓	48
43	240			70				52
44	390			285				22
45	730	60	145	420				172
46	400		60	60				512
47	945			190				182
48	185						✓	727
49	250			65				33
50	180						✓	32
51	330			240				38
52	300						✓	112
53	235		30	55	90			82
54	660			510				17
55	555			255				442
56	145						✓	337
57	705			390				73
58	750			180				487
59	1050	145		585				537
								832

PRODUCTION CYCLE DELAY SAMPLING

Method: Patching

Production Unit: Patch

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	215						✓	3
34	705			690				487
35	750			180				532
36	870	145		325				652
37	480			120	120			262
38	260		100					42
39	250						✓	32
40	280						✓	62
41	170						✓	48
42	270		40					52
43	240			70				22
44	390			285				172
45	730	60	145	420				512
46	400		60	60				182
47	945			190				727
48	185						✓	33
49	250			65				32
50	180						✓	38
51	330			240				112
52	300						✓	82
53	235		30	55	90			17
54	660			510				442
55	555			255				337
56	145						✓	73
57	705			390				487
58	750			180				537
59	1050	145		585				832

M P D M PROCESSING

Method Patching

Production Unit Patch

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time})-(\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	4790	22	217.7	59
B	Overall Production Cycles	13888	59	430	235.4

		Environment	Equipment	Labour	Material	Management
C	Occurrences	4	9	32	8	O
D	Total Added Time	560	690	7385	1120	O
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	140	76.7	230.7	140	O
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.068	0.153	0.542	0.136	O
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.326	0.178	0.587	0.326	O
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	2.2	2.7	29.1	4.4	O

Figure 8.2.14.

MPDM Processing Element, Example 6, County "B"

Example 7 : Gully Emptying at County "C"

This example covers gully emptying on a trunk road in County "C".

The crew with the machine start their day's work of cleaning the gullies by following certain routes. The procedure is as follows :

1. Fill the tank with clean water from a building site by using a hydrant.
2. At each gully, first open the gully top.
3. Check the condition of the catchpit. If clean, close the top and travel to another one.
4. Clean each dirty gully by pouring clean water inside it, then close the top of the gully and return to the machine.
5. Travel to another gully following the prescribed route.
6. Drain off dirty water using the squeezing lead.
7. Fill the tank again with clean water during daytime.
8. Travel to another gully to complete the prescribed route following the same procedures.
9. Empty the detritus at an outside place (shire counties) or
10. Travel to tip detritus in a depot back yard, and wash lorry.

The plant used was a Yorkshire Gully Emptier. In addition, some tools were used to help with the environmental circumstances. These included brush, hammer, shovels and maul which were kept in a toolbox on the machine.

The collection data is shown in Figure 8.2.15 and the processing element is shown in Figure 8.2.16.

Page 1 of 7 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully Emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	645			45				563
2	325			155				243
3	95						✓	13
4	105						✓	23
5	185						✓	103
6	430	115						348
7	85						✓	3
8	60						✓	22
9	110						✓	28
10	75						✓	7
11	80						✓	2
12	120						✓	38
13	70						✓	12
14	60						✓	22
15	60						✓	22
16	55						✓	27
17	75						✓	7
18	80						✓	2
19	80			15				2
20	55						✓	27
21	80						✓	2
22	55						✓	27
23	60						✓	22
24	65						✓	17
25	50						✓	32
26	55						✓	27
27	90						✓	8
28	55						✓	27
29	50						✓	32
30	180						✓	98
31	65						✓	17
32	60						✓	22

Figure 8.2.15.

Example 7,

Page 2 of 7 PRODUCTION CYCLE DELAY SAMPLING
Method: Gully Emptying
Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	50						✓	32
34	35						✓	47
35	65						✓	17
36	50						✓	32
37	60						✓	22
38	60						✓	22
39	60						✓	22
40	60						✓	22
41	85						✓	3
42	70						✓	12
43	95						✓	13
44	85						✓	3
45	75						✓	7
46	65						✓	17
47	70						✓	12
48	105						✓	23
49	55						✓	27
50	70						✓	12
51	125						✓	43
52	75						✓	7
53	100						✓	18
54	75						✓	7
55	75						✓	7
56	100						✓	18
57	60						✓	22
58	40						✓	42
59	115						✓	33
60	70						✓	12
61	55						✓	27
62	125						✓	43
63	75						✓	7
64	70						✓	12

Figure 8.2.15. Continued

PRODUCTION CYCLE DELAY SAMPLING

Method: Gully Emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
65	85						✓	3
66	65						✓	17
67	85						✓	3
68	625			125	425			543
69	75						✓	7
70	75						✓	7
71	50						✓	32
72	65						✓	17
73	65						✓	17
74	115						✓	33
75	105						✓	23
76	95						✓	13
77	90						✓	8
78	145						✓	63
79	65						✓	17
80	80						✓	2
81	60						✓	22
82	55						✓	27
83	60						✓	22
84	65						✓	17
85	65						✓	17
86	65						✓	17
87	105						✓	23
88	65						✓	17
89	110	25						28
90	60						✓	22
91	80						✓	2
92	70						✓	12
93	130						✓	48
94	85						✓	3
95	65						✓	17
96	75						✓	7

Figure 8.2.15. Continued

Method: Gully Emptying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
97	85						✓	3
98	75						✓	7
99	60						✓	22
100	75						✓	7
101	65						✓	17
102	85			30				3
103	65						✓	17
104	85						✓	3
105	85						✓	3
106	150	30						68
107	90						✓	8
108	60						✓	22
109	70	25						12
110	75						✓	7
111	50						✓	32
112	55						✓	27
113	50						✓	32
114	65						✓	17
115	50						✓	32
116	55						✓	27
117	60						✓	22
118	95						✓	13
119	110						✓	28
120	150	75						68
121	75						✓	7
122	60						✓	22
123	60						✓	22
124	60						✓	22
125	90						✓	8
126	70						✓	12
127	135						✓	53
128	75						✓	7

Figure 8.2.15. Continued

 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully Emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
129	110						✓	28
130	140			60				38
131	90						✓	8
132	65						✓	17
133	75						✓	7
134	210			60	105			128
135	140						✓	58
136	90						✓	8
137	185	90						103
138	170	85						88
139	80						✓	2
140	115	35						33
141	95						✓	13
142	80						✓	2
143	90						✓	8
144	95						✓	13
145	60						✓	22
146	85			30				3
147	60						✓	22
148	40						✓	42
149	685			120	515			603
150	85						✓	3
151	70						✓	12
152	65						✓	17
153	45						✓	37
154	45						✓	37
155	50						✓	32
156	45						✓	37
157	55						✓	27
158	45						✓	37
159	65						✓	17
160	65						✓	17

Figure 8.2.15. Continued

Page 6 of 7 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully Emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
161	80						✓	2
162	110			60				22
163	385	55		60				303
164	65						✓	17
165	55						✓	27
166	60						✓	22
167	65						✓	17
168	50						✓	32
169	55						✓	27
170	60						✓	22
171	290						✓	208
172	565						✓	383
173	80						✓	2
174	75						✓	7
175	60						✓	22
176	65						✓	17
177	65						✓	17
178	75						✓	7
179	60						✓	22
180	55						✓	27
181	50	20						32
182	85	20						3
183	95	30						13
184	70	30						12
185	70						✓	12
186	65						✓	17
187	175						✓	93
188	195						✓	113
189	170	60						88
190	110	30						28
191	180						✓	98
192	110						✓	28

Figure 8.2.15. Continued

Method: Gully Emptying

PRODUCTION CYCLE DELAY SAMPLING

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environ-ment Delay	Equip-ment Delay	Labour Delay	Mat-erial Delay	Manage-ment Delay	Notes	Minus Mean Non-Delay Time
193	115						✓	33
194	85						✓	3
195	85						✓	3
196	140	30						58
197	235	115						153
198	130			40				48
199	95						✓	13
200	85						✓	3
201	405			60	290			323
202	105						✓	23
203	85						✓	3
204	120						✓	38
205	80						✓	2
206	110						✓	28
207	115	10		55				33
208	120		80					38
209	180			60				98
210	90						✓	8
211	100	80						18
212	60	50						22
213	80	50						2
214	90						✓	8
215	80						✓	2
216	110						✓	28
217	95						✓	13
218	125	60						43
219	100	30						18
220	140		80					58
221	180			60				98
222	95						✓	13
223	90						✓	8
224	135			35	35			53

Figure 8.2.15. Continued

Page 8 of 7 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully Emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
225	465	20			270			383
226	540		225	120				458
227	810		265					728
228	1150	360		720				1068

MPDM PROCESSING

Method Gully Emptying

Production Unit Gully

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time})-(\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	15105	44	87.4	24.2
B	Overall Production Cycles	25650	228	112.5	50.6

		Environment	Equipment	Labour	Material	Management
C	Occurrences	25	4	19	6	0
D	Total Added Time	1530	650	1910	1640	0
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	61.2	162.5	100.5	273.3	0
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.110	0.018	0.083	0.026	0
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.544	1.444	0.894	2.430	0
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	6.0	2.5	7.4	6.4	0

Figure 8.2.16.

MPDM Processing Element, Example 7, County "C"

Example 8 : Gully Emptying at County "D"

This example covers cleansing, emptying and inspecting catchpits and emptying gully pots.

Starting from the depot, certain routes were followed and the following procedure adopted.

1. Fill fresh water tank of gully emptier machine with approximately 1800 litres of water from fire hydrant using a 63.5mm stand-pipe.
2. Locate and open the lid of the gully and then empty gully pot.
3. Travel to another gully or catchpit.
4. Lift lid and inspect catchpit, flush with water when necessary.
5. Empty dirty water when the tank is full.
6. Fill the tank with clean water again.
7. Move up at reduced speed between gullies.
8. Remove and dispose of rubbish from side trays.
9. Wash all external surfaces of vehicle.
10. Remove bottom section of pusher plate, wash rear compartment and replace.

The crew consisted of two men, one worked as machine driver and the other operated the gully pipe. They changed their role every other week.

They used the Yorkshire Gully Emptying Apparatus for emptying the gullies in addition to the same tools as in the previous example.

The collection element of this example is shown in Figure 8.2.17, and the processing element is shown in Figure 8.2.18.

 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully emptying   Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	745						✓	589
2	660			390				504
3	515	60						359
4	240	30						84
5	525	90	125					369
6	155						✓	1
7	300			25				144
8	340	90						184
9	255			35				99
10	260						✓	104
11	175						✓	19
12	130						✓	26
13	100						✓	56
14	110						✓	46
15	140						✓	16
16	325						✓	169
17	470		60	50				314
18	360						✓	204
19	575	95		45		60		419
20	160						✓	4
21	320						✓	164
22	235	60						79
23	640	130	60					484
24	515	20		140				359
25	270						✓	114
26	240						✓	84
27	360			25				204
28	390						✓	234
29	185						✓	29
30	205						✓	49
31	705			95				549
32	125						✓	31

Figure 8.2.17.

Production Cycle Delay Sampling, Example 8, County "D"

PRODUCTION CYCLE DELAY SAMPLING

Method: Gully Emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	115						✓	41
34	315	20						159
35	130						✓	26
36	175						✓	19
37	185			25				29
38	80						✓	76
39	80						✓	76
40	95						✓	61
41	125						✓	31
42	115						✓	41
43	160						✓	4
44	210			60				54
45	180						✓	24
46	380	165						224
47	180						✓	24
48	210			20				54
49	145						✓	11
50	180						✓	24
51	225	65						69
52	195						✓	39
53	155						✓	1
54	155						✓	1
55	165						✓	9
56	135						✓	21
57	170						✓	14
58	245						✓	89
59	90						✓	66
60	115						✓	41
61	105						✓	51
62	110						✓	46
63	225						✓	69
64	345	20						189

Figure 8.2.17. Continued

 PRODUCTION CYCLE DELAY SAMPLING
Method: Gully emptying   Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
65	130						✓	26
66	145						✓	11
67	110						✓	46
68	160						✓	4
69	65						✓	91
70	165						✓	9
71	170						✓	14
72	45						✓	111
73	315						✓	159
74	75						✓	81
75	150						✓	6
76	75						✓	81
77	75						✓	81
78	140						✓	16
79	160						✓	4
80	90						✓	66
81	130						✓	26
82	165	30						9
83	150						✓	6
84	130						✓	26
85	140	25						16
86	1030			200	295			874
87	230			40				74
88	120						✓	36
89	100						✓	56
90	95						✓	61
91	105						✓	51
92	190					60	✓	34
93	1155	225		600				999
94	120						✓	36
95	85						✓	71
96	145	60						11

Figure 8.2.17. Continued

PRODUCTION CYCLE DELAY SAMPLING

Method: Gully emptying

Production Unit: Gully

Prod Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
97	150						✓	6
98	200						✓	44
99	125						✓	31
100	220						✓	64
101	135						✓	21
102	115						✓	41
103	250						✓	94
104	60						✓	96
105	160						✓	4
106	135						✓	21
107	75						✓	81
108	65						✓	91
109	105						✓	51
110	195	30					✓	39
111	110							46
112	195	30		15			✓	39
113	95						✓	61
114	115						✓	41
115	155						✓	1
116	90						✓	66
117	80							76
118	570		30	45	30			414
119	430			140				274
120	720			180				564

MPDM PROCESSING

Method Gully emptying

Production Unit Gully

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert (\text{Cycle Time}) - (\text{Mean non - Delay Cycle Time}) \rvert}{n}$
A	Non - Delayed Production Cycles	13755	88	156.3	56.07
B	Overall Production Cycles	26935	120	224.5	109.4

		Environment	Equipment	Labour	Material	Management
C	Occurrences	18	4	18	2	2
D	Total Added Time	1245	275	2130	325	120
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	69.2	68.7	118.3	162.5	60
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.15	0.033	0.15	0.017	0.017
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.308	0.306	0.527	0.724	0.268
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	4.6	1.0	7.9	1.2	0.5

Figure 8.2.18.

MPDM Processing Element, Example 8, County "D"

Example 9 : Gully Emptying at County "B"

This example follows the same operation elements as the other two examples. An example of the format of the information handed to the driver about the routes is shown in Figure 8.2.19.

The collection data of this example is shown in Figure 8.2.20 and the processing element is shown in Figure 8.2.21.

		Gullies	Remarks
Route 4	Start:A Corner Junction X		
	From A Corner to B Lane, turn left to B L , turn and return to C, inc. Council Houses, turn left to D Lane, left into and left into E Lane to F Lane, turn and return to G Lane, X, turn left to B L , turn and return to H Lane, turn left into and to J Top, complete and return to Old C, turn left and return to A Corner, X. Travel left to Council Estate at New C into and complete. Travel to K Lane nr. C depot into and to L Lane, turn, return to M Road.	129	
	Return to depot		
	Total	129	
Route 5	Start:N Corner, B L./A L.		
	From N Corner to P crossroads, turn to Q, turn left into R Lane, X to S, and return, turn left to T Boundary, turn and	32	
	return to P Crossroads, and inc.	58	
	V Road. Travel to W Island.	7	
	From W Island to Y Island, turn	61	
	right to Z Boundary, A L., turn and return to W Island.	27	
	Return to depot		
	Total	185	

Figure 8.2.19.

Route of the Gully Emptying

 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully emptying

Production Unit: Gully

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
1	255						✓	108
2	195						✓	48
3	315	60						168
4	590		360					413
5	230			100				83
6	135			60				12
7	250	50						103
8	615	190						468
9	300	60						153
10	165						✓	18
11	170						✓	23
12	180						✓	33
13	195						✓	48
14	600				345			453
15	295			60				148
16	180						✓	33
17	150						✓	3
18	140	30						7
19	265						✓	118
20	300			60				153
21	155						✓	8
22	220						✓	73
23	180						✓	33
24	185						✓	38
25	180						✓	33
26	285	60		60				138
27	155						✓	8
28	675		215	240				528
29	120						✓	27
30	215						✓	68
31	200	30						53
32	300	40						153

Figure 8.2.20.

Production Cycle Delay Sampling, Example 9, County "B"

Page 2 of 9 PRODUCTION CYCLE DELAY SAMPLING

Method: Gully emptying

Production Unit: Gully

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
33	190						✓	43
34	220						✓	73
35	150						✓	3
36	300			215				153
37	285						✓	138
38	180						✓	33
39	158						✓	11
40	1180		1040					1033
41	375		60					228
42	1815				1800			1668
43	195						✓	48
44	260		60					113
45	170						✓	23
46	85						✓	62
47	50						✓	97
48	80						✓	67
49	80						✓	67
50	70						✓	77
51	190						✓	43
52	95						✓	52
53	75						✓	72
54	90						✓	57
55	95						✓	52
56	95						✓	52
57	80						✓	67
58	2005				1860			1858
59	75						✓	72
60	85						✓	62
61	75						✓	72
62	70						✓	77
63	70						✓	77
64	75						✓	72

Figure 8.2.20. Continued

PRODUCTION CYCLE DELAY SAMPLING

Method: Gully emptying

Production Unit: Gully

Prod. Cycle	Prod Cycle Time (sec/min)	Environment Delay	Equipment Delay	Labour Delay	Material Delay	Management Delay	Notes	Minus Mean Non-Delay Time
65	80						✓	67
66	280			75				133
67	300						✓	153

MPDM PROCESSING

Method Gully emptying

Production Unit Gully

	Units	Total Prod'n Time	Number of Cycles	Mean Cycle Time	$\frac{\sum \lvert(\text{Cycle Time}) - (\text{Mean non - Delay Cycle Time})\rvert}{n}$
A	Non - Delayed Production Cycles	6628	75	147.3	55.6
B	Overall Production Cycles	18073	67	269.8	158.2

		Environment	Equipment	Labour	Material	Management
C	Occurrences	8	5	8	3	0
D	Total Added Time	520	1735	870	4005	0
	Mean Added Cycle Time (Total Added Time/Delay Cycles)	65	347	108.7	1335	0
E	Probability of Occurrence (Delay Cycles/Total Number of Cycles)	0.119	0.075	0.119	0.045	0
F	Relative Severity (Mean Added Cycle Time/Mean Overall Cycle Time)	0.241	1.286	0.403	4.948	0
G	Expected % age Delay Time per Production Cycle (Prob. of occurrence x Relative Severity x 100)	2.9	9.6	4.8	22.2	0

Figure 8.2.21.

MPDM Processing Element, Example 9, County "B"

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