DOCUMENT RESUME

ED 098 390 CE 002 490

AUTHOR	Bull, A. J. U.; Richardson, E.
TITLE	A Study of the Relationship Between the Practice of Civil Engineering and Student Courses: Volume 1.
PUB DATE	Jul 73
NOTE	359p.
EDRS PRICE	MF-$0.75 HC-$17.40 PLUS POSTAGE
DESCRIPTORS	*Civil Engineering; Curriculum Development; *Data Analysis; Data Collection; Educational Attitudes; Employment Qualifications; Engineering Technicians; *Foreign Countries; Graduate Surveys; Post Secondary Education; Professional Education; Questionnaires; Student Attitudes; *Surveys; *Task Analysis; Technical Education; Training Techniques
IDENTIFIERS	*Australia

ABSTRACT

Australian civil engineers were surveyed for a study intended to establish a model for development based on a list of the basic stock of knowledge and techniques that need to be mastered by the graduate civil engineer. Following a brief introduction and summary, chapters 3-7 review the survey objectives, civil engineering definitions and population, sample design and selection, instrument development and testing, and the processing of the questionnaire responses. Chapters 8-12 discuss results, curriculum development, professionalism, attitudes and opinions revealed by the survey about civil engineering training, and recommendations on survey technique, engineer training, technician training, future work, and broad and specific objectives. About one-half of the document consists of appendixes, largely in table form, concerning aspects of the data derived from the Task Analysis Questionnaire used in the survey. Basic data concerning respondents are presented together with analyses of the following task categories: manual skills, economic/financial, communication/exchange of information, management and personnel matters, and technical matters. The training analysis and responsibility rating sections, job characteristics, and Foreman questionnaire are separately tabulated. The Task Analysis and Foreman's Questionnaires are included. (NH)

A Study of the Relationship between the Practice of Civil Engineering and Student Courses

Volume One

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July, 1973.

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ACKNOWLEDGEMENTS

The authors wish to acknowledge assistance provided by Dr A.J. Sutton, School of Behavioural Sciences, Macquarie University, and Mr A.B. Howson of the School of Economics and Financial Studies at Macquarie University related to defining the civil engineering population and designing the sample, to Mr P. Melhuish of the School of Information Sciences at The N.S.W. Institute of Technology for assistance in computer programming, to Mr E. Storr, secretary of the often mentioned and frequently blamed Institution of Engineers, Australia, to the office staff of the School of Education at Macquarie University for typing, and the staff of the Computing Laboratory at Macquarie University, and finally all those persons in the civil engineering industry, public and private, for their interest and willingness to complete what rapidly became known as the longest questionnaire in history.

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1. INTRODUCTION

This study is the first of its type in Australia and should be considered as providing a model (certainly imperfect) for further development in addition to a body of information on which action in the colleges might be based. During the latter part of our study we came across the following comment in the "Aims of The Civil Engineering Course" document produced by the University of Melbourne.

> "At the same time, the graduate civil engineer obviously must have mastered a basic stock of knowledge and technique which can be brought into play and applied with little or no delay. Can this essential stock of basic knowledge and techniques be listed? The committee knows of no such list, but we would be very helpful to teachers as well as students, as they then would know which material in their courses would need to be mastered to this degree of thoroughness and which would not."

We believe we have produced such a list.

Our thanks are due to the many civil engineers and technicians who gave up to three hours of their own time answering our questions. Without their assistance (and very frequently their encouragement) our work would not have been completed. Even in this introduction we feel obliged to comment on the scarcity of data which exists in Australia. The first part of our study establishing the population of civil engineers, which we naively believed would take a few days of literature search and personal contact, extended to almost a year and became a major task in itself. Random mailing of questionnaires, however, based on a list provided by a professional institution could not, we believe, produce valid results.

In a cross disciplinary study of this type it is easy to establish prestige by using the esoteric jargon of both the engineer and the educationist, but at the same time lose ones audience in the needlessly complicated sentences. This we have attempted to avoid and we hope our report will be readily readable by both groups.

In the section on the curricula we would have wished for more information on which to base our decisions but we believe that we were obliged to provide the comments included as a basis for further action. Present decisions appear to be based on much more flimsy "evidence" than ours and students are being asked to attempt longer, more structured courses on what at best might be described as whims. We do not suggest that a four year course is undesirable - we do suggest that more careful consideration ought to be given to what are included as compulsory components in the theory component and that further consideration be given to practice as a component. Systematic curriculum evaluation is clearly needed. Perhaps the spirit of our comments is best caught in a comment C.P. Snow made concerning the contribution Professor (now Lord) P.M.S. Blackett made to the 1939-45 war effort.

He had "a gift which made him invaluable in the war, and which this country has not recognised sufficiently, of being able to think of practical problems with a kind of depth of insight known to very few."

How far are our current curricula encouraging this depth of insight?

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How far are our current curricula encouraging this depth of insight?

The project was a team effort but the blame for the content and interpretation in the report must be left with the authors.

2. SUMMARY

A study of the relationship between civil engineering practice and student courses is described in the report. In order to make the results representative of civil engineering practice considerable time was devoted to quantifying the industry. As this work progressed it became apparent that available resources would enable only that part of the industry in N.S.W. to be examined.

The study was concerned mainly with civil engineers and technicians, but because of their important role in the industry data were collected also for construction foremen, albeit on a reduced scale compared with that collected for engineers and technicians.

After obtaining quantitative information about the industry and those employed in it, selection of the sample in a statistically rigourous fashion became possible.

It was originally thought that a structured interview technique would be used but as the development of the instrument for examining the tasks of engineers and technicians progressed and reached the pilot stage it became apparent that insufficient time was available. This, coupled with the requirements of the sample size, forced the adoption of a mailed questionnaire procedure. At this point the project committee decided that the change to mailed questionnaire provided an opportunity to examine the utilisation of part of a standard civil engineering curriculum, and a separate questionnaire was developed, based on the design section of a curriculum. Thus three questionnaires were eventually distributed, 1) a Task Analysis questionnanire aimed at collecting data on the tasks performed by engineers and technicians and their views on training and deficiencies in training, 2) a Curriculum questionnaire to collect data on the utilisation of the components of a 'standard' curriculum dealing with the design of structures, and 3) a simple questionnaire distributed at a lower sampling rate to construction foremen seeking information on the tasks performed and their views on training.

The response rate for the Task Analysis questionnaire was 43 per cent, for the Curriculum questionnaire 37 per cent, and for the Foreman's questionnaire 21 per cent.

For much of the data analysis relatively simple techniques were found to be the most efficient and expedient but sophisticated procedures were used to follow some guidelines established, and for the complete analysis of some sections where we believed the more complex programmes had advantages. The amount of data collected was large but its analysis responded to this approach. The basic analysis centred eventually on two levels of employment - engineer and technician, and three types of work - design, construction, and other work. In some cases type of qualification, type of employer, and age were used in addition.

The principal results showed that engineers engaged on design had a different work profile from engineers engaged in construction, the former had a larger technical matters component than the latter. Economic and financial matters were of considerable importance to engineers, particularly construction engineers and those engaged on such work as feasibility studies : management matters were also of considerable importance particularly again to construction engineers and those in the 'other work' group. In the technical matters section which listed 63 'standard' items the items most used by construction engineers differed from those most used by design engineers.

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The main deficiencies in training reported were management, communication, economic matters, and practical work. Concerning how training should be carried out, the major view was that a combination course of theory and practical job experience was the superior method. Technical efficiency was thought in general to be the main criterion in determining success in the job, but for engineers in construction work financial efficiency was as important, and completing the project possibly even more important. Concerning the future all agreed that more "systems" would be used. However, technicians thought new materials would probably be as important over the next few years.

The pattern of responsibility differed between engineers and technicians; engineers had much larger responsibility than technicians. The pattern of responsibility differed between the various types of work, engineers and technicians in construction had larger 'man responsibility' and 'plant/equipment responsibility' than their colleagues in design work.

The analysis of the data gathered by the Curriculum questionnaire will be reported by the N.S.W. Institute of Technology later.

Analysis of the data gathered by the Foreman's questionnaire showed that construction foreman's work is essentially management, safety and concrete.

The problems associated with curriculum development have been enunciated and the data collected by a short questionnaire distributed to C.A.E's and universities about curriculum objectives and content have been analysed and presented. The picture revealed shows that much work needs to be carried out on the clarification and evaluation of objectives and on the determination of the content and processes used to attain these objectives in some curricular.

The particular relevance of the meaning of professionalism with respect to the professional engineer in Australia has been studied and courses examined for items that could be associated with the "production" of an engineer ready in a professional sense to take his place in industry without further training. Some schools of civil engineering are aware of this need but others appear to be more concerned with meeting the preliminary academic requirements for membership of the Institution of Engineers, Australia, (rather than being concerned with the implications for the overall curriculum posed by an acceptance of the traditional meaning of the word professional).

Some of the voluntary comments made to the authors by persons in the civil engineering industry about civil engineering training etc., were summarized and collated in a short chapter.

In chapter 12 recommendations have been made concerning 1) problems associated with surveys of this type, 2) Engineer training, 3) Technician training and 4) Future work in general. The overall recommendation is that more substantial evidence ought to be sought before additional courses are introduced or existing courses are lengthened concerning the need the course seeks to fill and its overall aims and objectives. After introduction evidence ought to be communication, economic matters, and practical work. Concerning how training should be carried out, the major view was that a combination course of theory and practical job experience was the superior method. Technical efficiency was thought in general to be the main criterion in determining success in the job, but for engineers in construction work financial efficiency was as important, and completing the project possibly even more important. Concerning the future all agreed that more "systems" would be used. However, technicians thought new materials would probably be as important over the next few years.

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The detailed data collected during the survey have been presented in appendices in order that the reader may examine and re-interpret if he wishes those areas of particular interest to him.

3. TERTIARY EDUCATION, AND SURVEY OBJECTIVES

3.1. TERTIARY EDUCATION

A relationship between the practice of a vocation and the training for that vocation must exist. It should be readily discerned and easily demonstrated. If the daily tasks associated with a particular vocation are examined one would expect to see a relationship between these and what is offered during the training for that vocation.

With this in mind the Australian Commission on Advanced Education provided funds for a study of the relationship between the practice of civil engineering and the training for it. The study was not limited to professional engineers, but included subprofessional staff also. In addition, because of their importance in civil engineering, it was later decided by the project team that supervisors and foremen should be included. Whilst not strictly covered by the commission's stated interest in advanced education the view was held that the education of foremen, non-existent as it largely is today, could possibly be a part of post-secondary or advanced education in the future.

The whole subject of post-secondary or advanced education in Australia was examined by the Committee on the future of Tertiary Education in Australia (generally known as the Martin Committee). The report* (in two volumes) of this Committee to the Australian Universities Commission was published in August 1964, after three years work by its fifteen members, headed by Professor Sir Leslie Martin. In general, the report recommended an expansion and widening of educational opportunities beyond the secondary school. It stressed the need to build up the resources and raise the quality of the institutions offering tertiary level education outside the universities. The Commonwealth Government's interpretation of the recommendations of the Martin Committee was that Australia, during the next decade (1965 - 1975), should develop advanced education - defined as education beyond the completion of a full secondary education or its equivalent - in virtually new types of colleges. In accepting this idea the Commonwealth Government also accepted a measure of financial responsibility for its implementation.

To assist the Commonwealth Government in planning the longer term program for the establishment of colleges of advanced education a committee was assembled under the chairmanship of Dr I.W. Wark (now Sir Ian Wark). There were seven other members drawn from industry, both public and private, and academic institutions, across all States.

The committee was named the Commonwealth Advisory Committee on Advanced Education. The terms of reference stated that it+ "shall furnish information and advice to the Minister on matters in connection with the grant by the Commonwealth of financial assistance:

a) to Commonwealth Institutions, other than universities, teaching at the advanced education level and

b) to the States in relation to institutions, other than universities, teaching at the advanced education level, whether or not conducted by them."

Further paragraphs dealt mainly with financial matters, awards at institutions concerned with advanced education, and the specific exclusion of teacher training colleges.

The first meeting was held on 29th October 1965.

With this in mind the ustralian Commission on Advanced Education provided funds for a study of the relationship between the practice of civil engineering and the training for it. The study was not limited to professional engineers, but included subprofessional staff also. In addition, because of their importance in civil engineering, it was later decided by the project team that supervisors and foremen should be included. Whilst not strictly covered by the commission's stated interest in advanced education the view was held that the education of foremen, non-existent as it largely is today, could possibly be a part of post-secondary or advanced education in the future.

The whole subject of post-secondary or advanced education in Australia was examined by the Committee on the future of Tertiary Education in Australia (generally known as the Martin Committee). The report* (in two volumes) of this Committee to the Australian Universities Commission was published in August 1964, after three years work by its fifteen members, headed by Professor Sir Leslie Martin. In general, the report recommended an expansion and widening of educational opportunities beyond the secondary school. It stressed the need to build up the resources and raise the quality of the institutions offering tertiary level education outside the universities. The Commonwealth Government's interpretation of the recommendations of the Martin Committee was that Australia, during the next decade (1965 - 1975), should develop advanced education - defined as education beyond the completion of a full secondary education or its equivalent - in virtually new types of colleges. In accepting this idea the Commonwealth Government also accepted a measure of financial responsibility for its implementation.

To assist the Commonwealth Government in planning the longer term program for the establishment of colleges of advanced education a committee was assembled under the chairmanship of Dr I.W. Wark (now Sir Ian Wark). There were seven other members drawn from industry, both public and private, and academic institutions, across all States.

The committee was named the Commonwealth Advisory Committee on Advanced Education. The terms of reference stated that it+ "shall furnish information and advice to the Minister on matters in connection with the grant by the Commonwealth of financial assistance:

a) to Commonwealth Institutions, other than universities, teaching at the advanced education level and

b) to the States in relation to institutions, other than universities, teaching at the advanced education level, whether or not conducted by them."

Further paragraphs dealt mainly with financial matters, awards at institutions concerned with advanced education, and the specific exclusion of teacher training colleges.

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* Tertiary Education in Australia
Report of the Committee on the Future of Tertiary Education in Australia to the Australian Universities Commission.

\+ Appendix B. page 57.
Colleges of Advanced Education 1967-69.
First report of the Commonwealth Advisory Committee on Advanced Education, June 1966, published by Commonwealth of Australia.

The recommendations were detailed and covered all aspects associated with the development of colleges of advanced education across all the Australian States.

A specific recommendation, No. V., concerned a co-ordinated program of study and research into the problem of advanced education; to be sponsored by the Government on the advice of the Committee.

The second report of the Committee devoted some space to the educational research program.* In sub-section 8.16 the selection of four broad areas for research during 1970-72 was mentioned, and in sub-section 8.18 specific reference is made to the need to study the relationships between the colleges and industry - "In particular the requirements of future employers for college graduates, the advice of earlier graduates on course structure, and the needs of industry with respect to consulting and investigation demand consideration." This present study therefore arose as a result of this express interest by the Commonwealth Advisory Committee on Advanced Education. Incidentally, this Committee has now been replaced by the Australian Commission on Advanced Education, with almost completely new membership under the chairmanship of Mr T. Swanson. The representation is as wide as previously.

3.2. Survey Objectives

The nature of the survey and its objectives, suggested by Dr. E. Richardson, were developed jointly by Dr. Richardson, School of Education, Macquarie University, and Mr. K. Doyle, Assistant Registrar, The New South Wales Institute of Technology. The final submission to the Commission for funds was made on the basis of a joint effort by the two bodies, supervised by Dr. Richardson and Mr. Doyle together with Dr. G.J. Haggarty, Head of the School of Civil Engineering at the N.S.W. Institute of Technology and Mr. G. Hermann, of the School of Education, Macquarie University. Unfortunately later Mr. Hermann was seconded at short notice by Macquarie University to the Ford Foundation in the Philippines.

The application to the Committee for funds contained a preamble dealing with the purpose of the project. It said "Many problems are associated with the preparation of suitable undergraduate courses intended to train persons to enter the civil engineering profession. A wide range of activities fall within the compass of civil engineering and because of this diversity in activities there are many different specialisations whose claim for inclusion in a course at a given level can be strongly argued. It is thus important when designing a course to be able to identify those elements which are essential. It is equally important to be able to identify those tasks which are most appropriate to a given level of competence (i.e. technician or technologist). This proposal is concerned with initiating a research project to obtain factual information which will help to establish criteria for identifying those elements and tasks. Some reference will also be made to wastage rates in existing courses examined as a function of their relevance as seen by employer and student (i.e. the employer concerned with only one aspect of a course).

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5.

This project is seen as a means of overcoming the very poor feedback from those involved in the practice of engineering to those concerned with the academic training of engineers; engineering courses tend to be self-perpetuating and courses tend to grow out of existing courses (e.g. technician courses from diluted technologist courses) rather than out of the needs of the community which the academic institutions serve.

Although the results will be of direct applicability to courses in civil engineering, it is hoped that they will serve as a model upon which other courses can be based. This project is also viewed as the first part of a long range study which will be outlined in the research plan.

The research plan was split into three parts:

Part A:-

1) Complete task analysis of the field of civil engineering:

   a) preparation of a suitable instrument
   b) personal visit to representative firms to employ instrument

2) Allocation of tasks e.g. by expert panel, to the technologist and technician category, e.g.

   a) skill required, b) responsibility involved,
   c) frequency of task occurrence

3) Production of suitable curricula at one or more levels, or an evaluation of existing curricula to determine which cover the task analysis findings most effectively.

Analysis etc: a) liberal education

b) skill training

c) core content

d) "transfer of training" expectation

e) articulation, school/post-school and technician/technologist

Part B:-

An investigation of failure/success rates in sandwich and part-time day courses in civil engineering at The N.S.W. Institute of Technology. Attempts will be made to identify educational, cognitive and social reasons for failure (e.g. method of least misfits) in courses as they exist. Particular attention will be given to wastage as a function of irrelevance (as viewed by students and their employers).

Part C:-

To be submitted along with some of Part B for a future research proposal.

Examine the output of the courses in civil engineering:

a) those who have passed - number of attempts

b) those who have dropped out - stage of wastage

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b) those who have dropped out - stage of wastage

Note 1) trend in employment after 3+ years, that is, what tasks are being undertaken by the technologists and technicians. Is there an interchange of employment? If so, is it related to a) personality b) aptitude as compared with academic qualifications?

2) Effect of different course patterns on initial employment (between six months and three years). Is the sandwich principle as sound in practice as theory?

3) Job satisfaction related to level of training. Turnover characteristics.

The funds made available by the Committee on Advanced Education were less than expected but were sufficient ($25,500) to assemble a project team and start the work with expectation of reaching at least some of the targets. As work progressed it became apparent for a number of reasons, mainly the lack of any data quantifying civil engineering and the people who work in it, that only the first part of the plan, i.e. Part A, and that only the first two sections of this Part A would be reached with any certainty in a meaningful way.

It is perhaps a convenient point to comment on the preparation of research objectives and plans for submission when applying for funds. It is difficult to plan research, but planning can be made easier if objectives are precise. Interaction between objectives and planning is obvious. The detailing of the plan leads to an appreciation of the resources required to reach objectives. Thus the three aspects - objectives, plan and resources should be developed in concert. This applies to surveys or research of the sort under consideration in this report, and organised planning leads to a clearer statement of objectives with a clearer understanding of the steps involved in reaching those objectives, and the resources needed to reach them.

A major confusing factor in this present study was the amount of data concerning technicians and engineers assumed to exist, which in fact did not exist, or did not exist in reliable form. It would seem that either advance funds are required, or some facility within the Department of Education is needed, to formulate effective plans for research much as is the general practice in industrial and Government Research organizations.

In the case of this research project a simple development of the plan quickly revealed the magnitude of the task outlined in the research objectives in comparison with the resources allocated to reaching the objectives. The result was inevitable - the objectives were drastically reduced in number.

They can be re-stated as follows:

1) Complete task analysis of the field of civil engineering:

   a) preparation of a suitable instrument
   b) definition of 'population' under study
   c) selection and setting up of a suitable sample
   d) employment of instruments over sample.

2) Allocation of tasks to engineer a technician

   e.g. a) skill required, b) responsibility involved,
   c) frequency of task occurrence.

3) Production of a suitable curriculum or part of, based on the results of the survey.

There were various unstated objectives and hopes. Not the least of these was that the work might pave the way for similar studies concerning vocational education. Whilst our optimism did not run to the extent of believing the methodology we developed and adopted could and would be applied unaltered to other vocational studies, we nevertheless hoped it could serve as a guide from which better and more elegant instruments could be rapidly developed. We certainly have gained much invaluable experience for future use.

The supervising committee appointed, in May 1971, two research assistants to work full-time on the project. They were Messrs. A.J.U. Bull and M.J. Payne; the former a biologist and engineer with wide experience in managing research programs in manufacturing industry, the latter with post-graduate qualifications and experience in civil engineering. After eight months Mr. Payne resigned, and his position was taken by Miss A.Dwight newly graduated with strengths in psychology and mathematics. Miss Dwight resigned after six months to join the Public Service Board in Canberra. The N.S.W. Institute of Technology seconded Miss T. McIntosh to work full-time on the project at the start of 1972. Miss McIntosh, also newly graduated, had strengths in psychology and industrial sociology. She returned to the Institute of Technology at the end of 1972. During the last stages of the work in early 1973 Mr. Michael Davis, a fourth year student in the School of Education at Macquarie University, provided part-time assistance.

The resources of both Macquarie University and The N.S.W. Institute of Technology were made freely available to the survey team throughout the duration of the project.

4. CIVIL ENGINEERING, DEFINITIONS AND POPULATION

4.1. DEFINITIONS

A number of terms were used in the statement of the Research Objectives, e.g. civil engineer, civil engineering, technologist and technician, and in order to avoid confusion it was thought desirable to define them early in the study.

4.1.1. Civil Engineering

Two definitions of civil engineering are

1) "The principal branch of engineering concerned with things constructed as opposed to things manufactured, mined, grown or generated"

2) "The engineering of systems of constructed facilities"

Both of these are good simple definitions but one of our problems was in drawing the line between what are known traditionally as civil engineering works on the one hand, and small buildings such as domestic residences on the other hand. Quite clearly we were not concerned with small individual domestic residences but domestic residences were not entirely excluded because the design and construction of a very large block of residential flats or home units could utilise the skills of a civil engineering organisation. Thus we tended to find that size of project in domestic residence construction afforded a means of drawing a line of demarcation. In broad terms therefore domestic building apart from large projects involving high rise construction was decided as outside the scope of the term "civil engineering".

4.1.2. Technologist and Technician

The term technologist is not used a great deal in Australia. The use of the term in the same breath as the use of the term technician may be confusing to people unfamiliar with the distinction. On the other hand there seems little confusion or misunderstanding about the term "technician". In what are usually understood to be the professions there is little misunderstanding of the meaning of the term sub-professional. However, it is not beyond the bounds of possibility that a technologist may be thought of as a super technician, or at the top of the sub-professional stratum of activity.

Because of this we took a closer look at the word engineer, and whilst in Australia it has connotations of skilled tradesmanship, the word engineer preceded by a descriptive word such as mechanical, chemical, electrical, or civil is usually taken to mean a professional engineer engaged in the mechanical, chemical, electrical or civil fields. All things considered and particularly bearing in mind the large interaction with the civil engineering industry, that was bound to take place, the project team decided to use the term civil engineer in place of technologist. This in turn led to a readily understood distinction between a professional civil engineer on the one hand and sub-professional staff and technician on the other hand.

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The use of the term civil engineer not only has the merit of being readily understood in Australia but we believe that word engineer has a lot to commend it from a semantic viewpoint. The verb"engineer" in the English language has come to mean the things that engineers are expected to do well and has many connotations of non-technical activities, e.g. communication, management, responsibility and so on. In fact a good engineer is remembered not only for the magnitude of his technical intellect, but also for his ability to get things done i.e. produce results in the form of engineering works. We felt these shades of understanding should be left in the study and could be retained by use of the term civil engineer. In any event the term 'civil engineering technologist' is not used and does not exist.

One final thought occurred in connection with the term technologist - had it been defined? One attempt that reads well is: +

> "technologist has the qualifications and experience required for membership of a professional institution. A technologist has studied the fundamental principles of his chosen technology and should be able to use his knowledge and experience to initiate practical developments. He is expected to accept a high degree of responsibility and in many cases to push forward the boundaries of knowledge in his own particular field."

It seemed that this was not markedly different, from the engineer we had in mind, and we were not worried, therefore, about replacing, for the purposes of the study, the term technologist by the term engineer.

One could continue indefinitely on the purification of definitions, and it is possible that both engineer and technician could be defined in an absolute way that would permit of no ambiguity or misunderstanding. However, it seemed reasonable, to adopt the definitions produced at the international conference of representatives from the Engineering Societies of Western Europe and U.S.A. (E.U.S.E.C.) in 1953. Both the definition of an engineer and that of a technician are rather lengthy but they can usefully form a basis for the purposes of this present study. They are as follows:

a) "<u>A Professional Engineer</u> is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge notably in research, designing, construction, manufacturing, superintending and managing and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine, mental or physical character. It requires the exercise of original thought and judgement and the ability to supervise the technical and administrative work of others.

"His education will have been such as to make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information and applying it independently. He is thus placed in a position to make contributions to the development of engineering science or its applications.

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"His education will have been such as to make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information and applying it independently. He is thus placed in a position to make contributions to the development of engineering science or its applications.

"His education and training will have been such that he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own branch. In due time he will be able to give authoritative technical advice and to assume responsibility for the direction of important tasks in his branch."

+ Technical Education. Comd. 9703, Feb. 1956. H.M.S.O. U.K.

The technologist or professional engineer thus seemed well on the way to definition.

However, we were bothered by the adjective professional but found no easy way of avoiding this. A person was, or could become a professional engineer if his qualifications permitted his or her becoming a member of a recognized engineering institution. In Australia such an institution is the Institution of Engineers - Australia. However, the Institution states clearly + "the only acceptable method of meeting the initial educational requirements of the engineering profession is that of undertaking an ordered course of study in an engineering school accredited for the purpose". This refers only to educational requirements and whilst one does not deny that educational courses tend to determine what sort of label is hung around the neck of an individual working in civil engineering, the industry itself is quick to point out that this is only a part of the issue, the work carried out by that individual influences his status. Thus it is not impossible for a civil engineer with the correct educational background to give him a label of "professional engineer" to be actually performing a so-called sub-professional job. One can also recall the General Foreman of a large construction company with a five figure salary matching his responsibility who would have no chance of ever receiving the label "professional engineer". Therefore, whilst we used the term professional engineer, for a variety of reasons we were not happy with the use of the adjective professional. Perhaps the use of the term chartered engineer has much to commend it.

Coming to another point, this use of the word professional to describe an engineer has led to the support staff or technicians being described as sub-professional staff. A lot of comment has been passed about the term sub-professional but it has a very limited meaning.

Anybody who is not a professional is non-professional. The prefix sub both elevates "professional" and lowers those labelled "sub-professional". The realities of life, however, are such that professional with the prefix sub is to many a means of indicating a higher status type of job than some other jobs which are thought to be lower down the social scale. For our study the term meant nothing and whilst perforce we occasionally had to use it, it was of no value in defining the sort of person we were interested in. These people are known as technicians. To commence with, we took the E.U.S.E.C. definition of an engineering technician which reads as follows:

b) "<u>An Engineering Technician</u> is one who can apply in a responsible manner proven techniques which are commonly understood by those who are expert in a branch of engineering, or those techniques specially prescribed by professional engineers.

Under general professional engineering direction, or following established engineering techniques, he is capable of carrying out duties which may be found among the list of examples set out below.

In carrying out many of these duties, competent supervision of the work of skilled craftsmen will be necessary. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of a task in the light of well-established practice. An engineering technician requires an education

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+ Basic requirements for a professional engineering course. Consolidation of various previous statements, 20 March, 1971 Institution of Engineers, Australia.

"Working on design and development of engineering plant and structures; erecting and commissioning of engineering equipment and structures; engineering drawings, estimating, inspecting, and testing engineering construction and equipment; use of surveying instruments; operating, maintaining, and repairing engineering machinery, plant and engineering services and locating defects therein; activities connected with research and development, testing of materials and components, and sales engineering, servicing equipment, and advising consumers."

This definition like that of the professional engineer is lengthy and we therefore looked for other technician definitions. One we particularly liked occurs in "Technicians, Today and Tomorrow" by J.T. Young. * It reads:

"A person expert in applying specific proven techniques associated with science and technology; in particular one who has undergone a systematic course of instruction related to those techniques."

We were concerned about the lack of reference to management skills in this definition. We liked the reference to both job and training but we did not believe there was a hard and fast line drawn between a professional engineer who used and knew about management techniques and a technician who did not use and did not know about them. In fact, there are many engineers who know little or nothing about management techniques and many technicians who hold jobs which demand the use and knowledge of management techniques.

There are adequate references to the use of management skills in the definition of the engineer, and we think that the definition of a technician should be extended to also include management techniques. Thus the technician not only applying proven techniques in technology, but who may also be applying proven management techniques e.g. the foreman, supervisor, and overseer, would be covered by the definition.

Our definition for a technician would therefore read:

"A person expert in applying specific proven techniques associated with science, technology, and management; in particular one who has undergone a systematic course of instruction related to these techniques. "

Whilst all the definitions discussed refer to engineers and technicians, in general, we think they can apply to civil engineers and civil engineering technicians in particular.

Summarising then for the purposes of this study a civil engineer is defined by the E.U.S.E.C. definition of a professional engineer previously mentioned, with the proviso that where the term engineer occurs it is qualified by use of the word civil. For a civil engineering technician a modified version of Young's definition is used.

4.1.3. Foremen

One problem requires further consideration, whilst our definition of a technician has been extended to include management techniques associated with technical skills and thus to cover supervision,it is

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Whilst all the definitions discussed refer to engineers and technicians, in general, we think they can apply to civil engineers and civil engineering technicians in particular.

Summarising then for the purposes of this study a civil engineer is defined by the E.U.S.E.C. definition of a professional engineer previously mentioned, with the proviso that where the term engineer occurs it is qualified by use of the word civil. For a civil engineering technician a modified version of Young's definition is used.

4.1.3. Foremen

One problem requires further consideration, whilst our definition of a technician has been extended to include management techniques associated with technical skills and thus to cover supervision, it is useful to examine a foreman in isolation. A study of what a foreman does led to the development of the following definition:

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* Young, J.T. "Technicians, Today and Tomorrow" Sir Isaac Pitman & Sons, London, 1965.

+ A foreman supervises the work of skilled craftsmen (or tradesmen), and unskilled workers, may also work himself as a skilled craftsman or tradesman, and may have undergone a formal course of instruction in technical and management subjects relevant to his work as a civil engineering foreman/supervisor.

This definition thus covered the man in whom we were interested, but it differed from that dealing with a technician. The view has been expressed that civil engineering needs basic general technicians and more specialised technicians. * In the same way our examination had revealed that two categories of person were involved - technician and foreman.

These, however, may not entirely equate with the two categories mentioned by Stoker* but the position concerning technicians is not simple and uncomplicated, a number of types, or levels of activity, are involved.

It should be borne in mind that in the realities of industry there will be areas of overlap between civil engineer and technician during their everyday activities. An engineer will occasionally do technician's work and a top level technician will do engineer's work. In addition, the boundaries between what is called engineer's work and technician's work will be diffuse. This is unavoidable, but poses no problem in the pursuit of the survey objectives. It is the substance of the differences that is of interest.

4.2. CIVIL ENGINEERING POPULATION

4.2.1. Civil Engineering Data

There were few data available concerning the civil engineering population. This was not entirely unexpected, but the collection of statistics is time consuming and well over six months were spent assembling quantitative data on civil engineering of sufficient accuracy to enable us to proceed with some confidence to the main study. During the course of this work Commonwealth and State Government Departments were asked for numerical details about their civil engineering staff, Local Government instrumentalities were contacted in writing or by telephone for similar details, individual private consulting organisations were approached about their civil engineering staff, a short questionnaire was prepared and circulated to members of the Australian Federation of Construction Contractors (the membership list being supplied by the Federation), major companies in general industry were contacted for information about civil engineering employees and every other possible means were used to piece together the data. Unhappily, also, it became apparent as the collection of data proceeded

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+ 1. Kangan, M. The duties and training of foremen, Personnel Practice Bulletin (Bulletin of Industrial Psychology and Personnel Practice). Vol. 9 No. 4 Dec. 1953, pp.32-39.

2. Mandell, M.M. & Duckworth, P. The Supervisor's Job: A Survey. Personnel Vol. 31. No. 5 March 1955 pp.456-462, Sept. 1955 p.75.

3. Poidevin, B.L. The functions of the industrial supervisor.

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  3. Poidevin, B.L. The functions of the industrial supervisor. Personnel Practice Bulletin Vol. 12 No. 1 March 1956, pp.18-25.

* Stoker, G., Education and Training of Technicians - Report of an Expert Conference held at the College of Education (Technical) Huddersfield, U.K., Oct. 1966. H.M.S.O. London, U.K. 1967.

that our efforts could have to be confined to N.S.W. only; collection of data for the whole of Australia whilst possible, would have left no money with which to carry out the main purpose of the study.

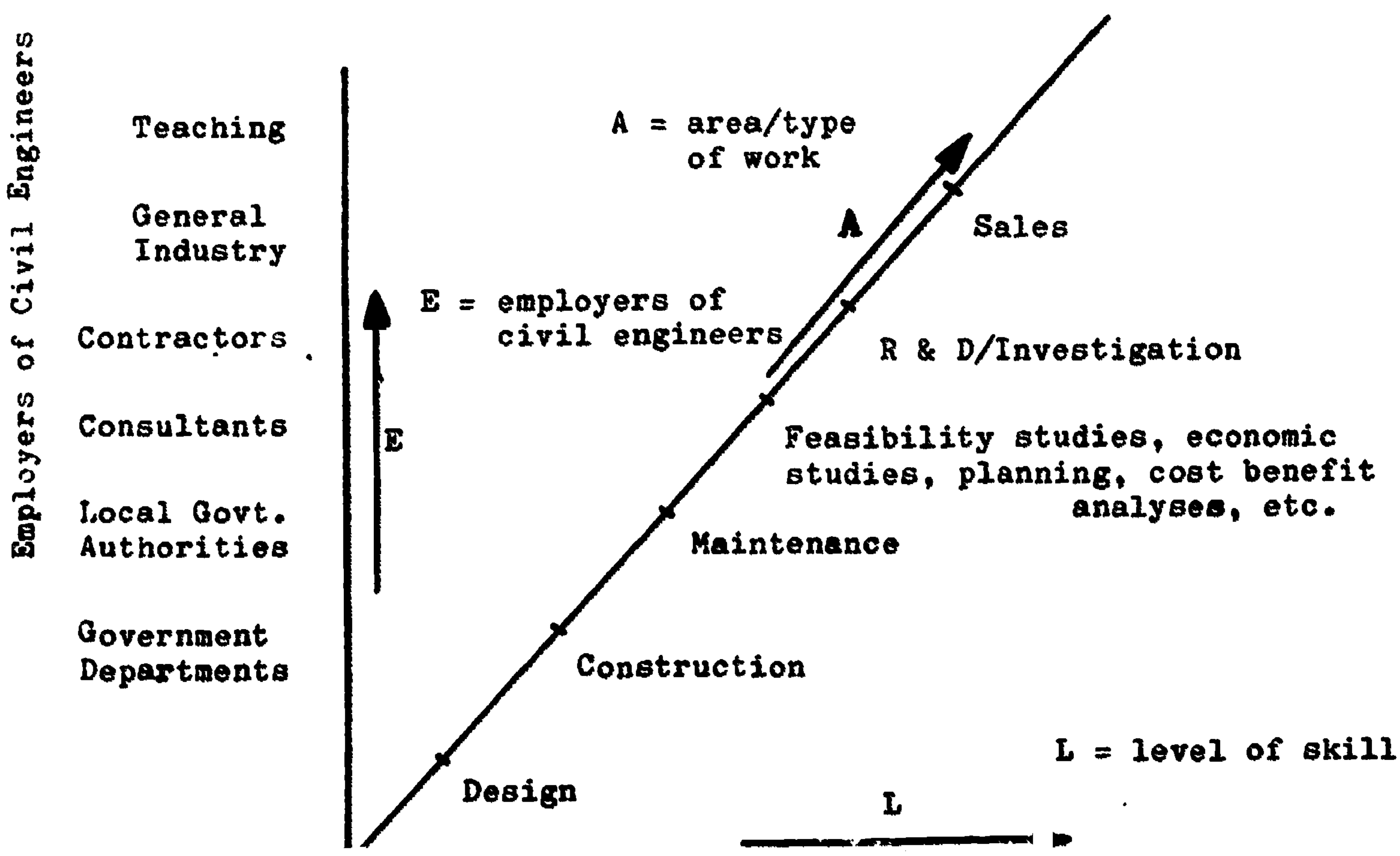
It could be asked why we decided to spend time collecting data about civil engineering and the people employed in civil engineering, and why we could not have simply sent questionnaires or conducted interviews with engineers and technicians selected on some arbitrary basis. The answer to this must be that we thought the survey was not worth carrying out unless we were sure the results could be related to the entire industry. For our sample to be representative, therefore, it was necessary to have quantitative information about the entire civil engineering industry.

Had we decided to select a sample on an arbitrary basis no data concerning the technicians existed to permit even this. In the case of the engineers, the Institution of Engineers, Australia, had no information relating specifically to the civil engineer segment of their membership. They were able to make an estimate of the proportion of their members who were civil engineers, but these could only be part of the total civil engineers in employment (about 50 percent for N.S.W. as we later discovered).

4.2.2. Model of Civil Engineering Industry.

Early in the study a model of the civil engineering industry population was devised. It was based on the idea that the industry was still substantially organised on traditional lines. It was realised, however, that there would be some lack of fit, or misfit in some instances, but it was thought that such misfit would occur in only a few places. The model selected was three-dimensional; the three dimensions being type of employer, type of employee and area of work. It can be depicted as follows:

FIGURE 4.2.1. MODEL OF CIVIL ENGINEERING INDUSTRY



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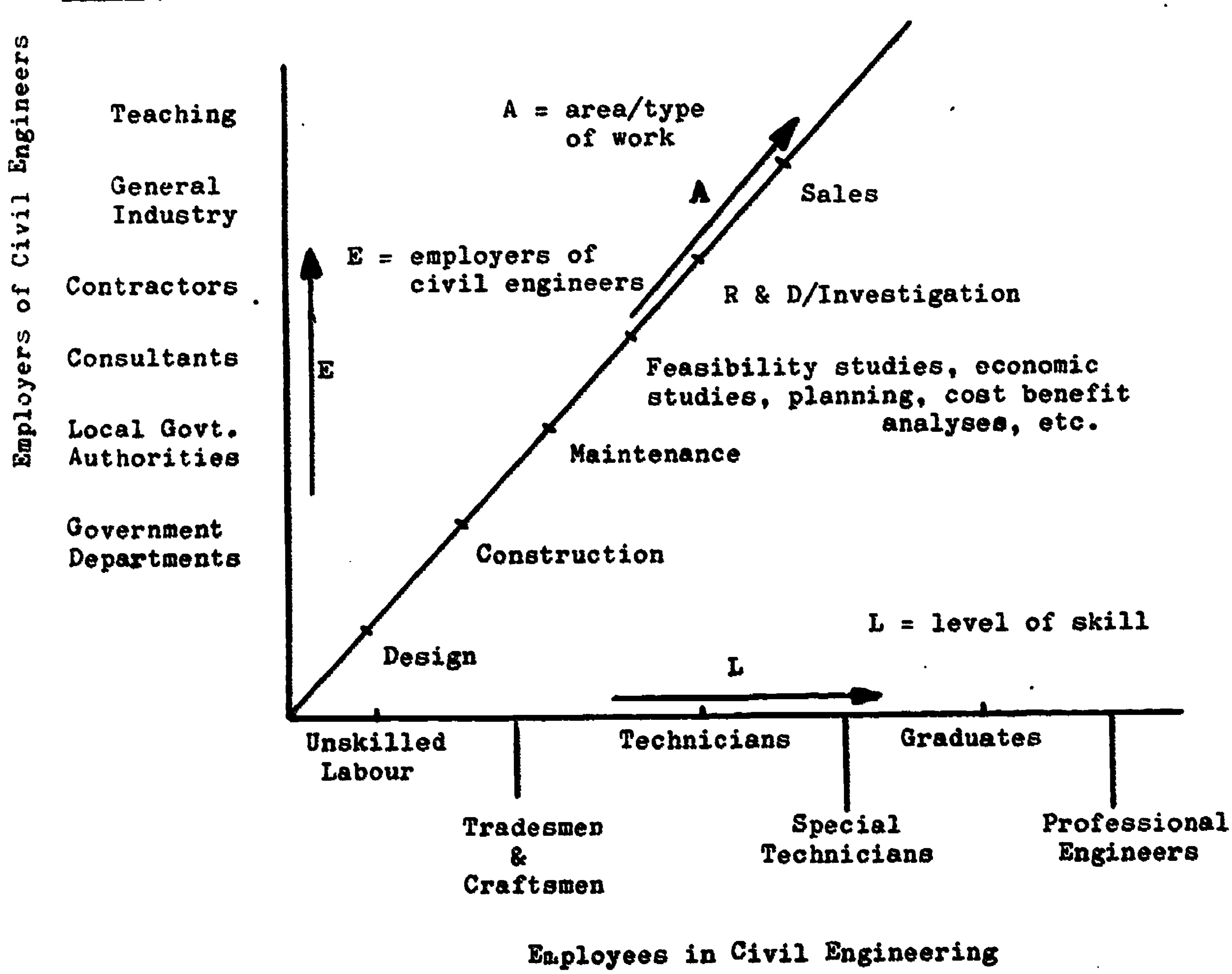

For dimension A - the areas of work, the model for this dimension compared favourably with the labour and Industry survey, which was confined to the Professional Engineer Level, but covered all engineers. This is shown in the following table:

TABLE 4.2.1. Comparison between models of dimension A - areas of work, between the present survey and the Department of Labour & Industry survey.

PRESENT SURVEY		DEPT. OF LABOUR & INDUSTRY SURVEY
A_{11}	Construction	Construction/Installation
A_{12}	Design	Engineering design
A_{13}	Feasibility studies	Planning including long range and resource planning, evaluation of capital.
A_{14}	Maintenance	Maintenance of plant, equipment and transport.
A_{15}	Research and development	Research/development/experimental engineering and testing
A_{16}	Sales	Sales/Marketing Management/supervision Production Industrial Engineering Teaching/Training

In our study Management/Supervision was excluded as a separate area of work since it was decided that rather than being an isolated activity, it could only be considered in conjunction with, and as an integral part of other areas of work, e.g. Manager of design activities. Therefore, although this did not exist as a separate category in our classification, elements involved in managerial work were still included in our model. Production and Industrial Engineering which accounted for only 0.5 percent of the total Australian civil engineering population could be (and were) legitimately excluded from the study. Teaching/Training had previously been excluded since the employment could be regarded as "teaching" rather than civil engineering practice.

The complete three-dimensional model can be reduced to a series of two dimensional models each concerned with one level of skill. They are represented qualitatively in the following tables, where X represents empty or near empty cells as discerned from the Labour & National Service survey and also our knowledge of the activities involved.

As the study of the population progressed the dimension E, i.e. employers of civil engineers was modified as follows:

a) Government departments were split into two, viz. Commonwealth Government - State Government departments ;

b) Teaching was excluded;

and the final classification of the E dimension was therefore:-

E_1 = Commonwealth Government

E_2 = State Government

E_3 = Local Government

E_4 = Consultants

E_5 = Contractors

E_6 = General Industry.

The listing compared favourably with that used in an earlier investigation carried out by the Department of Labour and National Service which aimed to * "determine recent trends and changes in the pattern of employment of engineers in various industries and to obtain current data on the structure and composition of the Profession".

The six levels of skill shown in the model were modified and reduced to three levels by including graduates with professional engineers as "engineers"; technicians and special technicians were grouped together as "technicians"; and a third category of skill, "the foreman", was introduced. Whilst the foreman can be regarded as a separate category of technician, for a variety of reasons he was placed at a separate level of skill in this study.

Dimension A, area/type of work, at the three different levels comprised:-

<u>Level 1.</u> <u>Engineer</u>

A_{11} = Construction

A_{12} = Design

A_{13} = Feasibility studies

A_{14} = Maintenance

A_{15} = Research and Development

A_{16} = Sales

<u>Level 2.</u> <u>Technician</u>

A_{21} = Drafting

A_{22} = Surveying

A_{23} = Laboratory work (viz. Quality control and materials testing)

A_{24} = Construction (viz. General Foreman) and the final classification of the E dimension was therefore:-

E_1 = Commonwealth Government

E_2 = State Government

E_3 = Local Government

E_4 = Consultants

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A_{15} = Research and Development

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A_{21} = Drafting

A_{22} = Surveying

A_{23} = Laboratory work (viz. Quality control and materials testing)

A_{24} = Construction (viz. General Foreman)

<u>Level 3</u>. <u>Foreman</u>

A_{31} = Construction

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* Department of Labour and National Service Survey conducted 1971.

TABLE 4.2.2. Level L_1 - Engineer

Employer (E)		Area of Work (A)					
		CONSTRUCTION	DESIGN	FEASIBILITY	MAINTENANCE	RESEARCH	SALES
	SYMBOL	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
COMMONWEALTH GOVT.	E_1						X
STATE GOVT.	E_2						X
LOCAL GOVT.	E_3					X	X
CONSULTANTS	E_4				X		X
CONTRACTORS	E_5		X	X		X	
GENERAL INDUSTRY	E_6						

TABLE 4.2.3. Level L_2 - Technician

EMPLOYER (E)		Area of Work (A)			
		DRAFTING (Draftsmen)	SURVEYING (Survey Technicians)	LABORATORY WORK (MATERIALS TESTING & QUALITY CONTROL)	BUILDING & CONSTRUCTION
	SYMBOL	A_{21}	A_{22}	A_{23}	A_{24}
COMM.GOVT.	E_1				
STATE GOVT.	E_2				
LOCAL GOVT.	E_3				

		CONSTRUCTIO	DESIGN	FEASIBILIT	MAINTENANC	RESEARCH	SALES
	SYMBOL	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
COMMONWEALTH GOVT.	E_1						X
STATE GOVT.	E_2						X
LOCAL GOVT.	E_3					X	X
CONSULTANTS	E_4				X		X
CONTRACTORS	E_5		X	X		X	
GENERAL INDUSTRY	E_6						

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		DRAFTING (Draftsmen)	SURVEYING (Survey Technicians)	LABORATORY WORK (MATERIALS TESTING & QUALITY CONTROL)	BUILDING & CONSTRUCTION
	SYMBOL	A [illegible]	A_{22}	A_{23}	A_{24}
COMM.GOVT.	E_1				
STATE GOVT.	E_2				
LOCAL GOVT.	E_3				
CONSULTANTS	E_4		X	X	X
CONTRACTORS	E_5				
GENERAL IND.	E_6				

TABLE 4.2.4. Level L_3 - Foreman

	Symbol	Area of Work (A) Construction A_{25}
C'WEALTH GOVT.	E_1	
STATE GOVERNMENT	E_2	
LOCAL GOVERNMENT	E_3	
CONSULTANTS	E_4	X
CONTRACTORS	E_5	
GENERAL INDUSTRY	E_6	

4.2.3. Structure within strata along the dimension - employer

Since there was no central body which could identify the elements included in our sub-populations, so defined, it was necessary as mentioned earlier, to approach each of the various organizations included within each of the broad categories E_e, requesting figures on the number of staff at each level and their corresponding areas of work. The figures which were compiled could only at best serve as estimates of the quantitative distributions of the sub-populations. In most cases the information obtained was incomplete and/or constituted a sample of the sub-populations, so that estimates had to be made of the pro-rata population figures. It also became evident that the categories provided in dimension A were in many cases not exclusive, in that employees could be involved in a number of areas of work, and often information of this sort was simply unavailable. An interesting, although obvious fact is that degree of specialization varies directly with the size of the employing body. Since size of organisation can thus influence type of activities performed by the individual this may constitute an interesting field of investigation as well as a point which should be considered in the sampling design. Keeping these factors in mind each of the strata in dimension E was analyzed in detail and where possible given quantification.

STRATUM E1 - COMMONWEALTH GOVERNMENT

A list of departments employing Civil Engineering staff in the Commonwealth Government was obtained from the Commonwealth Public Service Board. The figures provided, applied only to Professional Staff in Australia as a whole. It was thus necessary to build up a picture of the N.S.W. distribution, by approaching each individual department. There is a great dearth of information on area of work, since the number of civil engineering staff in each department is small, thus not allowing for specialization. The following structure was obtained.

TABLE 4.2.5. COMMONWEALTH GOVERNMENT

Department	Engineer L	Technician L_2	Foreman L_3
Works	97	92	84
Atomic Energy	6	3	5
Civil Aviation	12	10	4
Army	20	20	50
National Dev.	5	11	2
Totals	140	136	145

STRATUM E2 - STATE GOVERNMENT

This stratum consists of a number of large departments with clearly differentiated and specialized activities. These organisations undertake large civil engineering projects and thus employ a range of civil engineering specialists to deal with each state of the project, viz. planning, design construction and maintenance. Thus employees are fairly readily classified according to area of work.

TABLE 4.2.6. STATE GOVERNMENT

	Engineers						Technicians					Foremen
	A_{11} C	A_{12} D	A_{13} F	A_{14} M	A_{15} R	Total	A_{21} Draft	A_{22} Survey	A_{23} Lab	A_{24} Const.	Total	A_{31} Construction
MAIN ROADS	200	72	66	0	0	348	522	5	168	2	697	242
M.W.S. & D.Board	105	117	58	24	0	304	327	47	27	27	428	1,071
RAILWAYS	24	42	0	50	0	116	48				65	65
PUBLIC WORKS	181	42	39	4	4	270	35	0	0	185	220	53
HOUSING COMM.	8	12	0	3	0	23	12	0	0	21	33	8
ELECTRICITY COMM.	15	39	6	0	0	60	45	0	0	63	108	3
MARITIME SERV.	18	24	0	0	3	45	39	1	11	0	51	25
MOTOR TRANS.	0	5	0	0	0	5	16	0	0	0	16	19
CONSERVATION						220					148	56
TOTALS (ESTIMATES)	654	417	209	97	14	1,391	1,147	53	247	317	1,766	1,590
PROPORTIONS	0.47	0.30	0.15	0.07	0.01	1.00	0.65	0.03	0.14	0.18	1.00	1.00

STRATUM E3 - LOCAL GOVERNMENT

From a total of 92 municipalities and 133 shires compiled from Local Government 1971 List of Municipalities, Shires, County Districts, and Urban Areas, a sample was taken which provided the following estimates pertaining to number of staff at each level and within each area of work. Since, however, the number of staff employed is small seldom more than twenty employees are usually required to work in several of the activities listed.

TABLE 4.2.7. LOCAL GOVERNMENT

	Engineers						Technicians					Foremen
	A_{11} C	A_{12} D	A_{13} F	A_{14} M	A_{15} R	Total	A_{21} Draft	A_{22} Survey	A_{23} Lab	A_{24} Const.	Total	A_{31} Total
MUNICIPALITIES	.31	.34	.16	.19	-	1.00	.25	.55	.03	.15	1.00	-
SHIRES	.37	.27	.16	.19	-	1.00	.32	.52	.16	.12	1.00	-
TOTALS (ESTIMATES)	105	90	48	57	-	300	110	174	38	56	378	453
PROPORTIONS	0.35	0.30	0.16	0.19	-	1.00	0.29	0.46	0.10	0.15	1.00	1.00

STRATUM E4 - CONSULTANTS

A list of companies was compiled from "The Association of Consulting Engineers' List of Members", and supplemented by the Pink Pages section of the telephone directory headed "Engineers - Consulting". Details concerning the staff employed were obtained for each company and a distribution of companies according to size was compiled. Size was measured by the total number of civil engineering employees. This distribution is shown in Figure 4.2.2.

The estimated numbers are:-

TABLE 4.2.8. CONSULTANTS

Engineers A_{12} Design	Technicians A_{21} Drafting
552	804

STRATUM E5 - CONTRACTORS

A brief questionn[illegible] was circulated to members of the Australian Federation of [illegible]ction Contractors seeking details of numbers of staff employ[illegible]. This was supplemented by consulting the Pink Pages section of the Telephone Directory headed "contractors", and where necessary, figues on number of staff employed at each level were obtained for each company. The final estimates obtained are as follows:

TABLE 4.2.9. CONTRACTORS

	Engineers		Technicians					Foremen
	C	Total	Draft	Survey	Lab.	Const.	Total	Total
TOTALS (ESTIMATES)	357	357	66	48	52	165	331	669
PROPORTIONS	1.00	1.00	0.20	0.14	0.16	0.50	1.00	1.00

The distribution of companies according to size, where size is measured by the total number of staff at each level of civil engineering, appears in Figure 4.2.3.

STRATUM E6 - GENERAL INDUSTRY

Only a small number of companies it appears employ civil engineering staff in New South Wales. A list was compiled from the "Classification and Classified List of Industries" of the Commonwealth Bureau of Census & Statistics, and various business journals. A summary of the final estimates is given in Table 4.2.10.

TABLE 4.2.10. GENERAL INDUSTRY

	Engineers							Technicians					Foremen
							Total	Draft	Survey	Lab.	Const.	Total	Total
TOTALS (ESTIMATES)	34	24	5	9	2	39	113	76	27	15	11	129	152
PROPORTIONS	0.30	0.21	0.04	0.08	0.02	0.34	1.00	0.59	0.21	0.12	0.09	1.00	152

Detailed analysis of each of the strata in dimension E involved considerable time and effort but eventually data were collected and assembled. The degree of misfit turned out to be small. For instance, the concept of the project engineer has become increasingly popular although there are not many organisations yet that use this person extensively. The model described does not provide a position for the project engineer precisely. Another area of misfit arose when it was found that no slots were provided for traffic engineering and town planning, but whilst very important, the number of traffic engineers or people engaged in grappling with the problems of town planning and pedestrian and vehicular traffic is still small.

4.2.4. Quantification of Population Models.

	Engineers		Technicians					Foremen
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PROPORTIONS	1.00	1.00	0.20	0.14	0.16	0.50	1.00	1.00

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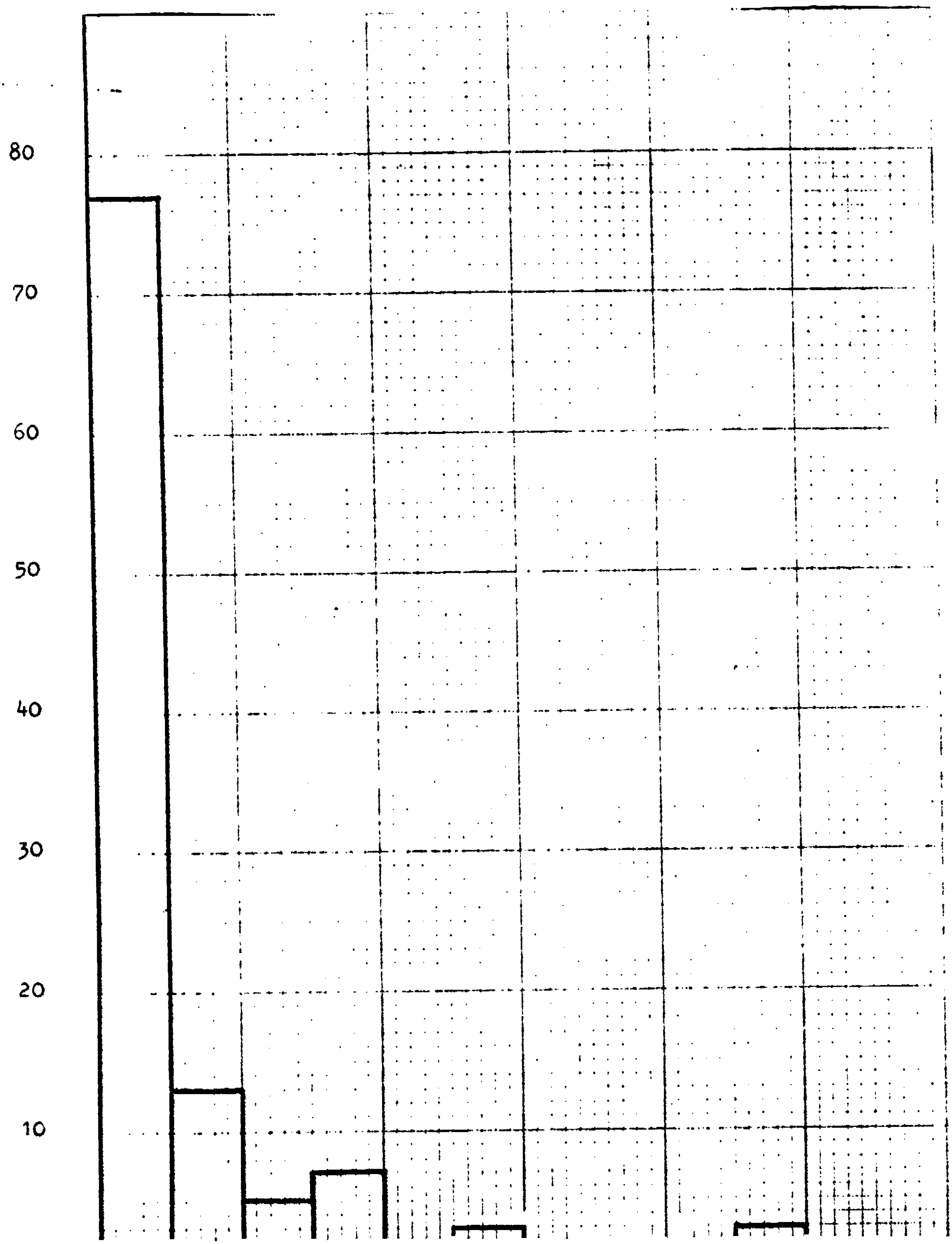
4.2.4. Quantification of Population Models.

The "final" quantitative information on the population in civil engineering is shown in the following Tables 4.2.11 - 4.2.13. This applies to N.S.W. only.

FIGURE 4.2.2.

DISTRIBUTION OF CONSULTING ENGINEERING FIRMS IN N.S.W. IN TERMS OF SIZE AS MEASURED BY THE TOTAL NUMBER OF EMPLOYEES INVOLVED IN THE FIELD OF CIVIL ENGINEERING



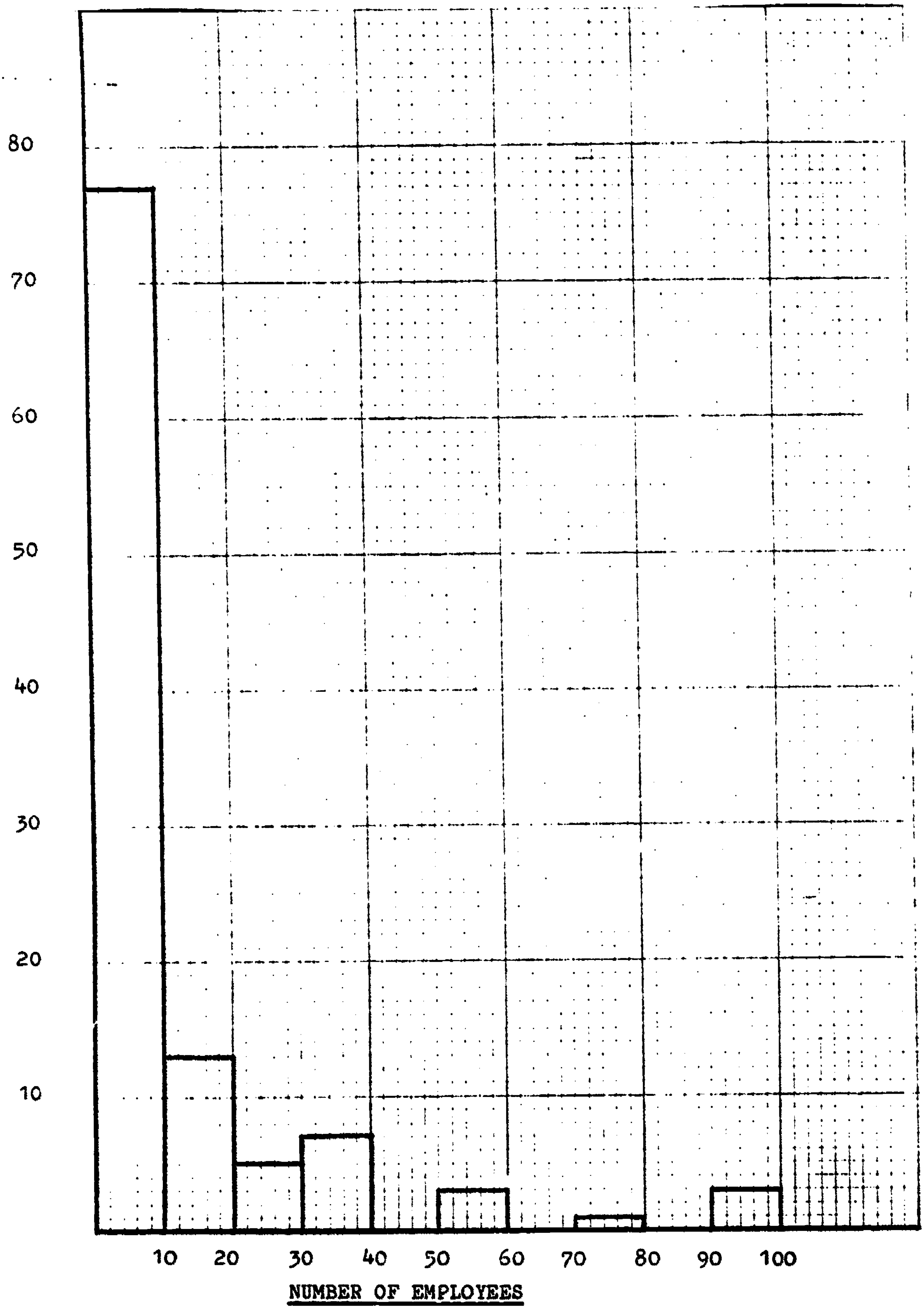

80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
NUMBER OF EMPLOYEES

FIGURE 4.2.3.

DISTRIBUTION OF POPULATION OF CONTRACTORS IN N.S.W. ACCORDING TO SIZE WHERE SIZE IS MEASURED BY THE NUMBER OF CIVIL ENGINEERING STAFF

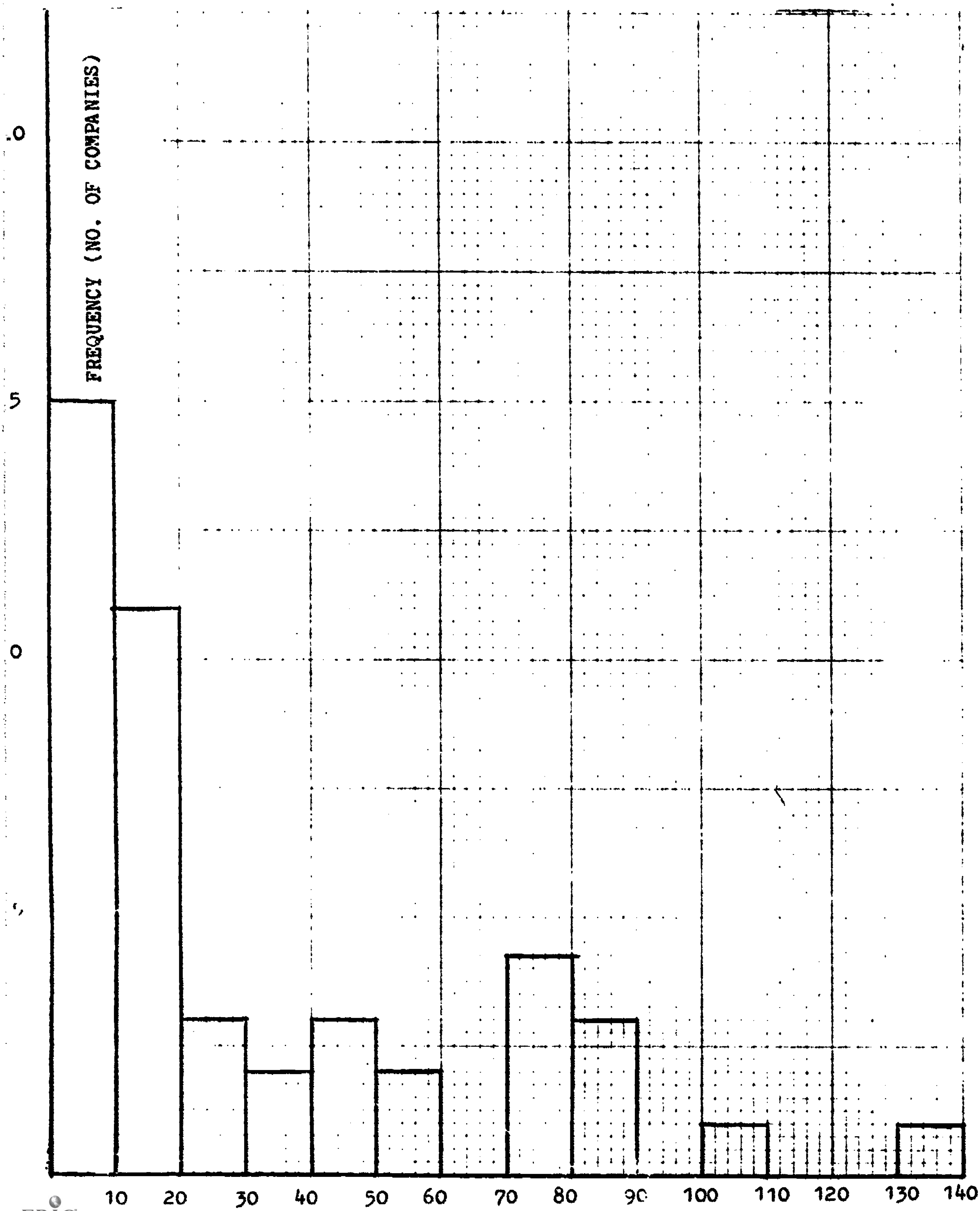


TABLE 4.2.11. QUANTITATIVE MODEL OF ENGINEER LEVEL (N.S.W.)

		Construction A_{11}		Design A_{12}		Feasibility A_{13}		Maintenance A_{14}		Research		Sales A_{16}		Totals	
		No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.
COMM. GOVT.	E_1	44	0.25	88	0.50	36	0.20	2	0.01	7	.04	-	-	177	0.06
STATE GOVT.	E_2	653	0.47	417	0.30	209	0.15	97	0.07	14	.01	-	-	1,391	0.48
LOCAL GOVT.	E_3	105	0.35	90	0.30	48	0.16	57	0.19	-	-	-	-	300	0.10
CONSULTANTS	E_4	-	-	522	1.00	-	-	-	-	-	-	-	-	352	0.19
CONTRACTORS	E_5	357	1.00	-	-	-	-	-	-	-	-	-	-	357	0.13
GEN. IND.	E_6	34	0.30	24	0.21	5	0.04	9	0.08	2	.02	39	.34	113	0.04
TOTALS		1,193		1,171		298		165		23		39		2,890	
PROPORTIONS			0.41		0.41		0.10		0.06		0.01		0.01		1.00

TABLE 4.2.12. QUANTITATIVE MODEL OF TECHNICIAN LEVEL (N.S.W.)

	A_{21} Drafting		A_{31} Surveying		A_{41} Laboratory		A_{51} Construction		Totals	
	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.
COMM. GOVT.	85	0.65	3	0.02	14	0.11	28	0.22	130	0.037
STATE GOVT.	1,148	0.65	53	0.03	247	0.14	318	0.18	1,766	0.500
LOCAL GOVT.	110	0.29	174	0.46	38	0.10	56	0.15	378	0.107
CONSULTANTS	804	1.00	-	-	-	-	-	-	804	0.227
CONTRACTORS	66	0.20	48	0.14	52	0.16	165	0.50	331	0.094
GEN. IND.	76	0.59	27	0.21	15	0.12	11	0.09	129	0.036
TOTALS	2,289		305		366		578		3,538	
PROPORTIONS		0.65		0.09		0.10		0.16		1.00

TABLE 4.2.13. QUANTITATIVE MODEL OF FOREMAN LEVEL

	A_{31} Construction	
	No.	Prop.
COMM. GOVT.	145	0.05
STATE GOVT.	1,590	0.53
LOCAL GOVT.	453	0.15
CONSULTANTS	0	0
CONTRACTORS	669	0.22
GEN. IND.	152	0.05
TOTAL	3,009	1.00

As mentioned above the tables refer only to N.S.W. This limitation arose solely because of the limitation on resources. Information was collected from the Government Departments in Victoria but it was realised reluctantly that we could not carry this through to cover the whole of Victoria and still have sufficient time and money to reach the first main objective of the study.

Whilst N.S.W. is not Australia, and Victoria differs in some respects from N.S.W., it is hoped that information on the civil engineering population for Australia as a whole could be inferred from what has been determined for N.S.W. Information on training institutions was obtained from all States.

5. SAMPLE DESIGN AND SELECTION

5.1. SAMPLE SIZE

The choice of sample design depends on the physical distribution of the population, the resources available, the characteristics to be studied and on the research objectives. If the sample selection is made to correspond with the variances in the characteristic under investigation, standard error will be reduced and if the populations' distribution and properties are accounted for in the design the expenditure by using a reduced sample size can be lowered without loss in the precision of the estimates. Thus sample design is complex. In addition it is of great importance and we obtained advice from an expert to ensure the methods we used and the sample we selected represented the population, and so made sure that the results we obtained and any conclusions drawn from them were valid.

Examination of the population distribution showed the following major factors which may influence this choice -

(a) clustering - the elementary sampling units fell naturally into clusters, or groups, viz. departments, companies, municipalities and shires.

(b) size - the size of the employing organisation influenced the degree of specialisation or variety of activities performed by its employees and thus can be said to contribute to the variance in pattern of job activities.

(c) stratification - the population was distributed unequally amongst the various cells of the frame (tables 2-4). Both dimensions E and A would appear to influence the type of activities performed by the employee so that each cell represents a relatively homogeneous group in contrast to the total population.

After consideration of these points it was decided to use a stratified sampling procedure since stratification ensures adequate representation from each sector of the population. Where strata are arranged so that elements within strata are relatively homogeneous and differ greatly from elements in other strata with respect to task profile (the variable to be estimated) stratification considerably reduces the standard error. Where the sub-populations within strata have different distribution and characteristics stratification allows for different sample designs and procedures to be used to suit each stratum, whilst still allowing the stratum estimates to be combined to form an estimation of the total population parameter.

Of the dimensions used to characterise the population only the dimension - type of employer, satisfied the criteria for stratification. Area of work could not be used because some employees are employed in more than one area of work, e.g. in the case of the project engineer.

Three separate questionnaires were distributed amongst the population, each designed to analyse the structure and elements involved in civil engineering practice (see Chap. 6.1.), which deals with the development of the questionnaires or schedules). The Task Analysis Questionnaire, and the Curriculum Questionnaire were distributed to levels 1 and 2 (engineers and technicians), whilst the Foreman's Questionnaire was distributed only at level 3 (foremen).

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Of the dimensions used to characterise the population only the dimension - type of employer, satisfied the criteria for stratification. Area of work could not be used because some employees are employed in more than one area of work, e.g. in the case of the project engineer.

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The sample sizes for each level, and for each questionnaire were decided upon in light of the following considerations:

(1) <u>Method of Response</u> - The impersonal mass distribution of questionnaires (discussed later) made it necessary to inflate the sample size by about 30 per cent to allow for a possible high non-response rate.

(This did not eventuate as it happened; our response rate was greater than 43 per cent, c.f. the P.E. Consulting Group (Australia) Pty. Ltd. survey where 36 per cent retrun rate was obtained. Our questionnaire was long and required more than one hour to complete, and much time and effort on our part was devoted to obtaining this comparatively high return rate. We were anxious that any conclusions drawn referred to the real population and not just the enthusiasts who readily returned the questionnaire. Profiles of response taken at various times (discussed later - Chap. 7.) showed clearly that the response pattern did not vary with time.)

(2) Variance - Since levels 1 and 2 contained more variability in types of activities performed than level 3, a larger sample was taken.

(3) Type of Schedule - Since "Schedule B"* was a detailed analysis of "Design" activities, constituting an extension of the more general and fundamental "Schedule A"*, a smaller sample size was chosen for this schedule.

(4) Analyses - Since Schedule A and B were to be distributed at both levels 1 and 2, a comparison between these could be readily made. To enhance this equal sample sizes were taken for each of these levels.

(5) Resources - The amount of time and money which could be allotted to the distribution and collection of questionnaires was limited.

With these points in mind, the Research Committee decided upon the following overall Sample Sizes, which are presented in Table 5.1, together with their corresponding percentages (approximations only) of the population.

TABLE 5.1.1. SAMPLE SIZES

Level	Schedules						Totals	
	Task Analysis Questionnaire		Curriculum Questionnaire		Foreman's Questionnaire			
	Size	%	Size	%	Size	%	Size	%
1	400 (N_1^t)	14	300 (N_1^c)	10	-	-	700	24
2	400 (N_2^t)	11	300 (N_2^c)	9	-	-	700	20
3	-		-		300 (H_3^E)	10	300	10
TOTALS	800	9	600	6	300	3	1,700	18

Using the stratification procedure, the sample sizes of Table 5.1.1. were divided proportionately among the strata E_e, with weights W_e as shown in Tables 5.1.2., 5.1.3., and 5.1.4., where W_e represent the ratio of elements within strata (E) relative to the total population.

Note: Sample Sizes indicate the number of elementary sampling units.

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	Task Analysis Questionnaire		Curriculum Questionnaire		Foreman's Questionnaire			
	Size	%	Size	%	Size	%	Size	%
1	400 (N_1^t)	14	300 (N_1^c)	10	-	-	700	24
2	400 (N_2^t)	11	300 (N_2^c)	9	-	-	700	20
3	-		-		300 (H_3^E)	10	300	10
TOTALS	800	9	600	6	300	3	1,700	18

Using the stratification procedure, the sample sizes of Table 5.1.1. were divided proportionately among the strata E_e, with weights W_e as shown in Tables 5.1.2., 5.1.3., and 5.1.4., where W_e represent the ratio of elements within strata (E) relative to the total population.

Note: Sample Sizes indicate the number of elementary sampling units.

* Schedule A = Task Analysis Questionnaire (called Survey Schedule for field work)
Schedule B = Curriculum Questionnaire

TABLE 5.1.2. SELECTION OF THE SAMPLE - ENGINEER LEVEL - L1

$N_1 = 700$, $N_1T = 400$ $N_1C = 300$

Stratum E	Weights W_e	Sample Size Task Anal.Q. N_eT	Sample Size Curriculum Q. N_eC	Total Sample Size N_e
E_1 Commonwealth Govt.	0.061	24	18	42
E_2 State Government	0.481	192	145	337
E_3 Local Government	0.104	42	31	73
E_4 Consultants	0.191	76	57	133
E_5 Contractors	0.124	50	37	87
E_6 General Industry	0.039	16	12	28
TOTAL	1.000	400	300	700

TABLE 5.1.3. SELECTION OF THE SAMPLE - TECHNICIAN LEVEL - L2

$N_2 = 700$, $N_2T = 400$ $N_2C = 300$

Stratum E	Weights W_e	Sample Size Task Anal.Q. N_eT	Sample Size Curriculum Q. N_eC	Total Sample Size N_e
E_1 Commonwealth Govt.	0.037	15	11	26
E_2 State Government	0.499	199	150	349
E_3 Local Government	0.107	43	32	75
E_4 Consultants	0.227	91	68	159
E_5 Contractors	0.094	38	28	66
E_6 General Industry	0.036	14	11	25
TOTAL	1.000	400	300	700

TABLE 5.1.4. SELECTION OF THE SAMPLE - FOREMAN - LEVEL 3

$N_3 = 300$, $N_3T = 300$

Stratum E	Weights W_e	Sample Size Foreman's Questionnaire	Total Sample Size
E_1 Commonwealth Govt.	0.076	23	23
E_2 State Government	0.504	151	151
E_3 Local Government	0.160	48	48
E_4 Contractors	0.212	64	64
E_5 General Industry	0.048	14	14

		N_eT	N_eC	Size N_e
E_1 Commonwealth Govt.	0.061	24	18	42
E_2 State Government	0.481	192	145	337
E_3 Local Government	0.104	42	31	73
E_4 Consultants	0.191	76	57	133
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TOTAL	1.000	400	300	700

TABLE 5.1.3. SELECTION OF THE SAMPLE - TECHNICIAN LEVEL - L2

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E_4 Consultants	0.227	91	68	159
E_5 Contractors	0.094	38	28	66
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TOTAL	1.000	400	300	700

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E_2 State Government	0.504	151	151
E_3 Local Government	0.160	48	48
E_4 Contractors	0.212	64	64
E_5 General Industry	0.048	14	14
TOTAL	1.000	300	300

5.2. SAMPLE SELECTION

5.2.1. COMMONWEALTH GOVERNMENT - N.S.W. OFFICES ONLY - STRATUM E1.

Elementary sampling units are clustered into a small number of Departments with clearly differentiated activities and as such form different strata rather than clusters, which should be basically homogeneous in structure. The sample sizes at each level, were thus, proportionately stratified across all of the Departments to obtain the final sample sizes for each, as shown in Tables 5.2.1.1. to 5.2.1.3.

TABLE 5.2.1.1. LEVEL 1 - ENGINEERS

Department	Weight	Task Analysis Questionnaire	Curriculum Questionnaire	Total Sample Size
Works	0.69	17	12	29
Atomic Energy	0.04	1	1	2
Civil Aviation	0.09	2	2	4
Army	0.14	3	2	5
National Dev.	0.04	1	1	2
TOTALS	1.00	24	18	42

TABLE 5.2.1.2. LEVEL 2 - TECHNICIANS

Department	Weight	Task Analysis Questionnaire	Curriculum Questionnaire	Total Sample Size
Works	0.68	10	7	17
Atomic Energy	0.02	1	0	1
Civil Aviation	0.07	1	1	2
Army	0.15	1	2	4
National Dev.	0.08	1	1	2
TOTALS	1.00	15	11	26

TABLE 5.2.1.3. LEVEL 3 - FOREMEN

Department	Weights	Foreman's Questionnaire	Sample Size
Works	0.58	13	13
Atomic Energy	0.03	1	1
Civil Aviation	0.03	1	1
Army	0.35	8	8
National Dev.	0.01	0	0
TOTALS	1.00	23	23

5.2.2. STATE GOVERNMENT - N.S.W. ONLY - STRATUM E2.

Again this stratum consisted of a number of Departments with their own specialized areas of activity, and as such should each be represented in the sample selection. The large size of these departments, made it possible to allocate units to "Areas of Work". Since this strata represented approximately 50% of the total population, a twodimensional stratification, was chosen because it would greatly raise the precision of estimates although it could not be attempted in less clearly defined strata. The samples at each level were weighted proportionately across the Departments and then across "Area of Work". The final weights and sample sizes are shown in Tables 5.2.2.1. - 5.2.2.3.

TABLE 5.2.2.1. LEVEL 1 - ENGINEERS

Department	Weights	Task Analysis Questionnaire	Curriculum Questionnaire	Total Sample Size
Main Roads	0.250	48	36	84
M.W.S.&D.B.	0.219	42	32	74
Railways	0.083	16	12	28
Public Works	0.194	37	28	65
Housing Commission	0.017	3	2	5
Electricity Commission	0.043	8	6	14
Maritime Services	0.032	6	5	11
Motor Transport	0.004	1	1	2
Water Conservation	0.158	31	23	54
TOTALS	1.000	192	145	337

TABLE 5.2.2.2. LEVEL 2 - TECHNICIANS

Department	Weights	Task Analysis Questionnaire	Curriculum Questionnaire	Total Sample Size
Main Roads	0.394	78	59	137
M.W.S.&D.B.	0.242	48	36	84
Railways	0.037	7	6	13
Public Works	0.125	25	19	44
Housing Commission	0.019	4	3	7
Electricity Commission	0.061	12	9	21
Maritime Services	0.029	6	4	10
Motor Transport	0.009	2	1	3
Water Conservation	0.084	17	13	30
TOTALS	1.000	199	150	349

TABLE 5.2.2.3. LEVEL 3 - FOREMEN

Department	Weights	Foreman's Task Analysis Questionnaire	Sample Size
Main Roads	0.157	24	24
M.W.S.&D.B.	0.696	105	105
Railways	0.042	6	6
Public Works	0.034	5	5
Housing Commission	0.004	1	1
Electricity Commission	0.002	1	1
Maritime Services	0.016	2	2
Motor Transport	0.012	2	2
Water Conservation	0.036	5	5
TOTALS		151	151

5.2.3. LOCAL GOVERNMENT - N.S.W. ONLY - STRATUM E3.

This stratum consisted of 92 municipalities and 133 shires which was fairly homogeneous with respect to their activities and size. These, therefore, readily formed clusters which were used as the sampling units. The average size of these clusters was small and there was little dispersion. So each was sampled in toto.

This procedure had the advantage of limited the number of contacts which needed to be made, and allowed for easier distribution through the spokesman (Town or Shire Clerk) for each unit. However, since personal contact could not be made with each unit as in other strata (limitation on trunk telephone calls and visits to areas outside Sydney) the sample was inflated to ensure a response rate similar to other sections of the overall population.

Using the average numbers of elements within each cluster as a guide this led to the minimum number of sampling units of 21 and 16 for the Task Analysis Questionnaire and Curriculum Questionnaire. After inflating these figures, Municipalities and Shires were sampled randomly and proportionately to their weights in the population and allocated to either the Task Analysis Questionnaire or the Curriculum Questionnaire in the ratio 4:3. All the local government bodies within each cluster were sampled. The final selections made are shown in Tables 5.2.3.1. to 5.2.3.3.

TABLE 5.2.3.1. NUMBER OF SAMPLING UNITS

Sample Units	Weights	Task Analysis Questionnaire	Curriculum Questionnaire
Municipalities	0.4	10	7
Shires	0.6	14	11
TOTAL	1.00	24	18

TABLE 5.2.3.2. SELECTION OF UNITS FOR TASK ANALYSIS QUESTIONNAIRE

Units	Sample Size Level 1	Sample Size Level 2	Sample Size Level 3 (Foreman's Questionnaire)
MUNICIPALITIES			
1. Singleton	1	1	1
2. Fairfield	5	12	10
3. Drummoyne	2	5	7
•4. Quirindi	2	3	3
5. Manly	2	1	2
6. Young	0	1	1
7. Cooma	1	3	2
8. North Sydney	4	6	5
9. Forbes	1	2	2
10. Glen Innes	1	0	1
SHIRES			
1. Namoi	2	1	2
2. Yarrowlumla	1	0	1
3. Rylstone	2	3	2
4. Tumut	2	2	3
5. Hornsby	7	13	4
6. Shoalhaven	9	12	8
•7. Cudgegong	2	3	3
8. Talbragar	1	1	2
9. Dumaresq	1	1	1
10. Mittagong	2	2	3
11. Canobolas	1	3	3
12. Bingara	1	2	1
13. Warringah	10	8	10
14. Dungog	1	2	2
TOTALS 24	61	87	79

TABLE 5.2.3.2. SELECTION OF UNITS FOR TASK ANALYSIS QUESTIONNAIRE

Units	Sample Size Level 1	Sample Size Level 2	Sample Size Level 3 (Foreman's Questionnaire)
MUNICIPALITIES			
1. Singleton	1	1	1
2. Fairfield	5	12	10
3. Drummoyne	2	5	7
•4. Quirindi	2	3	3
5. Manly	2	1	2
6. Young	0	1	1
7. Cooma	1	3	2
8. North Sydney	4	6	5
9. Forbes	1	2	2
10. Glen Innes	1	0	1
SHIRES			
1. Namoi	2	1	2
2. Yarrowlumla	1	0	1
3. Rylstone	2	3	2
4. Tumut	2	2	3
5. Hornsby	7	13	4
6. Shoalhaven	9	12	8
•7. Cudgegong	2	3	3
8. Talbragar	1	1	2
9. Dumaresq	1	1	1
10. Mittagong	2	2	3
11. Canobolas	1	3	3
12. Bingara	1	2	1
13. Warringah	10	8	10
14. Dungog	1	2	2
TOTALS	61	87	79

TABLE 5.2.3.3. SELECTION OF UNITS FOR CURRICULUM QUESTIONNAIRE

Units	Sample Size Level 1	Sample Size Level 2	Sample Size Level 3 (Foreman's Questionnaire)
MUNICIPALITIES			
1. Rockdale	3	5	16
2. Tamworth	2	9	3
3. Moree	1	0	1
4. Ashfield	1	4	2
5. Taree	1	0	1
6. Marrickville	2	4	3
7. Holroyd	2	14	4
SHIRES			
•1. Lake Macquarie	2	3	3
2. Peel	1	2	2
3. Abercrombie	2	3	3
•4. D[illegible]rling	2	3	3

MUNICIPALITIES			
1. Singleton	1	1	1
2. Fairfield	5	12	10
3. Drummoyne	2	5	7
•4. Quirindi	2	3	3
5. Manly	2	1	2
6. Young	0	1	1
7. Cooma	1	3	2
8. North Sydney	4	6	5
9. Forbes	1	2	2
10. Glen Innes	1	0	1
SHIRES			
1. Namoi	2	1	2
2. Yarrowlumla	1	0	1
3. Rylstone	2	3	2
4. Tumut	2	2	3
5. Hornsby	7	13	4
6. Shoalhaven	9	12	8
•7. Cudgegong	2	3	3
8. Talbragar	1	1	2
9. Dumaresq	1	1	1
10. Mittagong	2	2	3
11. Canobolas	1	3	3
12. Bingara	1	2	1
13. Warringah	10	8	10
14. Dungog	1	2	2
TOTALS	61	87	79

TABLE 5.2.3.3. SELECTION OF UNITS FOR CURRICULUM QUESTIONNAIRE

Units	Sample Size Level 1	Sample Size Level 2	Sample Size Level 3 (Foreman's Questionnaire)
MUNICIPALITIES			
1. Rockdale	3	5	16
2. Tamworth	2	9	3
3. Moree	1	0	1
4. Ashfield	1	4	2
5. Taree	1	0	1
6. Marrickville	2	4	3
7. Holroyd	2	14	4
SHIRES			
•1. Lake Macquarie	2	3	3
2. Peel	1	2	2
•3. Abercrombie	2	3	3
•4. Darling	2	3	3
•5. Eurobodalla	2	3	3
6. Wade	2	1	3
7. Wollondilly	2	2	3
8. Coolah	2	4	3
9. Ulmarra	1	1	1
10. Gundurimba	2	3	5
11. Jerilderie	1	2	2
TOTALS 18	31	63	61

TABLE 5.2.3.3. SELECTION OF UNITS FOR CURRICULUM QUESTIONNAIRE

	Sample Size Level 1	Sample Size Level 2	Sample Size Level 3 (Foreman's Questionnaire
MUNICIPALITIES			
1. Rockdale	3	5	16
2. Tamworth	2	9	3
3. Moree	1	0	1
4. Ashfield	1	4	2
5. Taree	1	0	1
6. Marrickville	2	4	3
7. Holroyd	2	14	4
SHIRES			
*1. Lake Macquarie	2	3	3
2. Peel	1	2	2
*3. Abercrombie	2	3	3
*4. Darling	2	3	3
*5. Eurobodalla	2	3	3
6. Wade	2	1	3
7. Wollondilly	2	2	3
8. Coolah	2	4	3
9. Ulmarra	1	1	1
10. Gundurimba	2	3	5
11. Jerilderie	1	2	2
TOTALS 18	31	63	61

5.2.4. CONSULTANTS - N.S.W. ONLY - STRATUM E4.

As described in chapter 4.2., the elementary sampling units were grouped into companies which varied in size according to figure 4.2.2. Since the variance in size of companies was great and has been shown to effect the job activities of employees (viz. degree of specialization) this was accounted for in the design by stratification. The following 2-stage sampling process was used.

Stage 1:

Companies were arranged into 3 strata according to size, where size of cluster was measured by the number of civil engineering staff. The strata decided upon by inspection of the distribution of companies, figure 4.2.2., were as follows:

Stratum a: $0<E\leq10$
Stratum b: $10<E\leq50$
Stratum c: $50<E\leq100$

A random selection of companies was made from each stratum, by selectin[illegible]

MUNICIPALITIES			
1. Rockdale	3	5	16
2. Tamworth	2	9	3
3. Moree	1	0	1
4. Ashfield	1	4	2
5. Taree	1	0	1
6. Marrickville	2	4	3
7. Holroyd	2	14	4
SHIRES			
*1. Lake Macquarie	2	3	3
2. Peel	1	2	2
*3. Abercrombie	2	3	3
*4. Darling	2	3	3
*5. Eurobodalla	2	3	3
6. Wade	2	1	3
7. Wollondilly	2	2	3
8. Coolah	2	4	3
9. Ulmarra	1	1	1
10. Gundurimba	2	3	5
11. Jerilderie	1	2	2
TOTALS 18	31	63	61

5.2.4. CONSULTANTS - N.S.W. ONLY - STRATUM E4.

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Stratum a: $0<E\leq10$
Stratum b: $10<E\leq50$
Stratum c: $50<E\leq100$

A random selection of companies was made from each stratum, by selecting proportionately to the number of companies from each stratum in the population, and allocated to the Task Analysis Questionnaire or Curriculum Questionnaire in the ratio 4:3. The total number of companies sampled was determined by dividing the required sample sizes in terms of elementary units by the average number of employees per company for a given level. The maximum estimate was taken which would allow for the required sample sizes at each level.

TABLE 5.2.4.1. SAMPLE SIZES FOR SELECTION OF COMPANIES

	No. of Companies	Weight	No. of Coys. for T.A. Quest.	No. of Coys. for C. Quest.	Total
Stratum a	83	0.722	11	8	19
Stratum b	25	0.217	3	3	6
Stratum c	7	0.061	1	1	2
TOTAL	115	1.000	15	12	27

The details of the names etc. of the firms of Consultants are omitted for obvious reasons. After consideration of the three strata of companies, and the numbers of employees in each company within strata a random sub-sample of employees, proportional to the number of employees employed at the two levels - engineer and technician was selected, (foremen were excluded as they were not part of the population as far as consulting firms were concerned).

These are shown in the following tables:

TABLE 5.2.4.2. LEVEL 1 - ENGINEERS

Stratum	No. of Employees	Weight	T.A. Quest. Sample Size	C. Quest. Sample Size	Total
a	160	0.289	22	16	38
b	195	0.354	27	20	47
c	197	0.357	27	21	48
TOTAL	552	1.000	76	57	133

TABLE 5.2.4.3. LEVEL 2 - TECHNICIANS

Stratum	No. of Employees	Weight	T.A. Quest. Sample Size	C. Quest. Sample Size	Total
a	156	0.194	18	13	31
b	351	0.437	40	29	69
c	297	0.369	33	26	59
TOTAL	804	1.000	91	68	159

5.2.5. CONTRACTORS - N.S.W. ONLY - STRATUM E5.

A two-stage sampling process was used for this stratum similar to that used for stratum E4, whose structure differed only in size distribution. The strata, according to size of company, were determined [illegible]nspection of the distribution in figure 4.2.3. and are as follows:

			T.A. Quest.	C. Quest.	
Stratum a	83	0.722	11	8	19
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Stratum a : $0 < E \leq 20$ civil engineering staff
Stratum b : $20 < E \leq 60$ " " "
Stratum c : $60 < E \leq 140$ " " "

Since many companies, although large, do not employ large numbers at each level it was necessary to take a sample size of fifteen companies to obtain the desired number from each of the strata - a, b, and c, at each level. The ratio of 4:3 for Task Analysis Questionnaire to Curriculum Questionnaire could not be exactly maintained and the fifteen companies were divided into nine and six for the respective questionnaires.

The following table shows the final distribution.

TABLE 5.2.5.1. SAMPLE SIZES FOR SELECTION OF CONTRACTORS

	Number of Companies	Weight	Task Analysis Questionnaire	Curriculum Questionnaire	Total
Stratum a	26	0.528	5	4	9
Stratum b	10	0.222	2	1	3
Stratum c	9	0.200	2	1	3
TOTAL	45	1.000	9	6	15

The numbers of employees selected for each of the strata - a, b, & c, at each of the three levels - L1, L2 & L3 are shown in the following three tables:

TABLE 5.2.5.2. LEVEL 1 - ENGINEERS

Stratum	Total Employees	Weight	Task Analysis Questionnaire	Curriculum Questionnaire	Total
a	55	0.15	7	6	13
b	92	0.25	13	9	22
c	219	0.60	30	22	52
TOTALS	366	1.00	50	37	87

TABLE 5.2.5.3. LEVEL 2 - TECHNICIANS

Stratum	Total Employees	Weight	Task Analysis Questionnaire	Curriculum Questionnaire	Total
a	76	0.218	8	6	14
b	82	0.235	9	7	16
c	191	0.547	21	15	36
TOTAL	349	1.000	38	28	66

TABLE 5.2.5.4. LEVEL 3 - FOREMEN

Stratum	Total Employees	Weight	Foremen's Questionnaire	Total

The following table shows the final distribution.

TABLE 5.2.5.1. SAMPLE SIZES FOR SELECTION OF CONTRACTORS

	Number of Companies	Weight	Task Analysis Questionnaire	Curriculum Questionnaire	Total
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TOTAL	349	1.000	38	28	66

TABLE 5.2.5.4. LEVEL 3 - FOREMEN

Stratum	Total Employees	Weight	Foremen's Questionnaire	Total
1	113	0.159	10	10
2	217	0.305	20	20
3	382	0.536	34	34
TOTALS	712	1.000	64	64

Again for obvious reasons, details of the actual companies sampled cannot be given.

5.2.6. GENERAL INDUSTRY - STRATUM E6.

Since the number of companies in general industry employing civil engineering staff is small, and each company employs only a small number of staff at the specified levels, no grading of companies according to size was attempted. Again a 2-stage sampling process was used, firstly using companies and secondly employees as the primary sampling unit and a random selection made without stratification.

In the first place a sample of twelve companies was randomly selected, which was more than that indicated by the average number of employees per company, since the distribution of employees over each level was very uneven. The larger sample size thus ensured adequate representation at each level.

From the selected companies a further random sample was made of employees to obtain the required sample size. This resulted in the following numbers:-

Level 1 - Engineers	16 Task Analysis Q, 12 Curriculum Q.
Level 2 - Technicians	14 Task Analysis Q, 11 Curriculum Q.
Level 3 - Foremen	6 Foreman's Questionnaire.

5.2.7. GENERAL REMARKS

In many cases the spokesman for a company or department elected for security reasons to randomly distribute questionnaires to a sample of his employees. This defensive attitude received some encouragement at that time from references and reports in the press and on television about the invasion of individual privacy threatened by the proliferation of data banks. On occasions we found we had to spend considerable time obtaining permission to distribute questionnaires, and in some instances an elaborate system of interviews with organisation heads including legal representatives, took place before agreement was given to distribute questionnaires within an organisation.

In cases where organisations did not want to give us a staff list from which we could select a sample, a simple procedure of systematic sampling was used by the senior officer of an organisation whereby if a sample of x is to be chosen from a total list of y employees at a given level within a given branch, the chance of selection will be x/y or 1/k for each element. By dividing the list into intervals of k elements and selecting a random number in this interval e.g. 3, every 3rd person may be selected to yield a random sample of the required size. For example, if it is required to select a sample of 6 Engineers working on Construction in the Department of Railways from a total of 24, (Sampling fraction = ¼), the list is divided into intervals of 4, a random position chosen between 1 and 4, e.g. 3 and the person occupying every 3rd position in the groups of 4 selected. The persons selected would thus be Nos. 3, 7, 11, 15, 19 and 23.

This procedure also had the advantage of being self correcting where the overall sampling fraction was known for a strata which was not being cluster sampled e.g. E_2. That is where population figures may be in error or have fluctuated from the time estimates were made employees as the primary sampling unit and a random selection made without stratification.

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This procedure also had the advantage of being self correcting where the overall sampling fraction was known for a strata which was not being cluster sampled e.g. E_2. That is where population figures may be in error or have fluctuated from the time estimates were made to the time of sampling, the "correct" sample sizes would automatically be implemented by using this procedure.

In general this was a time consuming part of the study but it was considered to be of the utmost importance if a valid picture of civil engineering was to be established. It would have been much easier, but we believe of little value, to have distributed questionnaires en masse to any civil engineers whose names we could easily obtain and assumed that the response was typical of the total work force at the three levels.

Finally, it must be kept clearly in mind that although this sample design sought, it is hoped with success, to model the population distribution, the final distribution in terms of actual responses would inevitably be somewhat different. One could not assume or hope that the non-response rate would be uniform from widely differing strata. It was necessary, therefore, when final estimates of parameters were made to take note of disproportionate representation from particular strata.

6. INSTRUMENTS, PILOT AND PRE-TEST RUNS, RELIABILITY AND VALIDITY, METHODOLOGY, AND DISTRIBUTION.

6.1. INSTRUMENTS.

The development of the instrument and its administration are the focus of a survey study. The choice of technique depends on the research objectives and the resources available to achieve them. No situation is ideal and the clash of needs with resources that arose in this study would certainly not be uncommon. We believed that a structured interview would best provide the information we needed, but lack of resources sufficient to cover the large and scattered 'population' forced us to use the questionnaire as the best alternative available.

6.1.1. Task Analysis Questionnaire.

The first objective of the research as stated in the research plan was to carry out an analysis of the tasks performed by civil engineers and civil engineering technicians. There was no novel idea in this, job evaluation has been used by industrial organizations across all industries for many years now and in essence job evaluation was what was required in this study.

Job evaluation arose primarily to meet the need to determine equitable differentials between wage rates. However, other benefits resulted, industrial relations improved, a mechanism had been created whereby it was possible to avoid square pegs being thrust into round holes, aptitudes could be fitted to tasks, and occupations could be systematically evaluated and training of applicants thereby aided.

Since job evaluation aims at fixing rates of pay, determining remunerations, etc. we were obviously not concerned with job evaluation in its entirety. The basic step in job evaluation is job analysis or as we will refer to it - task analysis. Task analysis is usually only concerned with the way the time performing a job is split over responsibilities, knowledge and skills. Various other avenues of approach to task analysis were studied but all lead to this basic trilogy of characteristics. For a variety of reasons we decided to treat responsibility separately from the broad task analysis which left knowledge and skills of various sorts.

The following categories of task were eventually selected:-

Technical matters
Psychomotor skills (later called manual skills)
Economic/Financial matters
Communication/Exchange of Information matters
Management and Personnel matters

Further development was straightforward in that each category of task was further broken up into a number of relevant activities, or sub-categories of task, on conventional lines. However, the classification of tasks in the Technical category was not easy. In fact, the problems associated with this were representative of the problems generally associated with task analysis. Ideally one would like to observe (as in time and motion study) an engineer or a draftsman at work. At the outset categorisation would be simple enough, the elements would be large and easily discernible, but a great deal of work on classification and terminology would be required if fine definitions were needed.

Prior to a final decision being made on implementation procedure, a pilot schedule of questions was devised based on observation on site and discussion with many working engineers and technicians and tested using the standard face to face interview procedure. A number of conclusions were reached at the end of this pilot run, (a) the schedule was too lengthy for face to face interview, taking an average of just over an hour to administer, (b) the broad structure and design of the instrument was satisfactory with the exception of the technical matters section which failed badly.

No taxonomy was available with which to describe the activities associated with the technical part of civil engineering jobs, yet it was an important part of the questionnaire, and in addition, no matter how much we tried otherwise, it was a lengthy and time consuming part of the questionnaire. To develop such a taxonomy would moreover, require a very lengthy and expensive program of work. Much has been written on the need for clarity in defining the elements of a technician's task and proceeding from this to a definition of the objectives to be attained in the training of a man for that task. To do the same with an engineer is more difficult because of the less precise and unrestricted nature of a professional engineer's role but nevertheless this was really the objective of the task analysis. There appeared to be no simple way of splitting up the technical segment of an engineer's task without reference to the elements in the generally accepted engineering curricula, but this procedure using conventional curriculum items seemed basically wrong. However, when the technical matters section of the questionnaire was re-designed after the poor results in the pilot run recourse was made to standard curricula terminology. Despite efforts to the contrary, to be of any value this section became steadily more complex and time consuming and inevitably brought us to the point where a face to face interview became impossible. To avoid the 'hindsight' approach wherever possible, ample space was left after each section of the task analysis for the inclusion of additional tasks identified by the respondents who were specifically encouraged to add new material we had failed to identify and categorise.

Concurrently the collection of data on the 'population' of civil engineering staff had progressed to a point where a reasonably accurate determination of the sample size could be carried out. This sample was larger than anticipated and re-inforced our decision concerning face to face interviewing. Thus very reluctantly we were forced to relinquish the idea of face to face interviews with a pre-determined structure, i.e. schedule of questions, and resort to a questionnaire administered by post.

At this stage it was agreed that the sample size could and should be increased to deal both with the larger than expected 'population' and also the reduced response that would be obtained with a questionnaire sent through the mail.

As mentioned previously it was decided to treat the responsibility aspect of task analysis as a separate item. This attitude was adopted because of the problems associated with identifying and quantifying the elements of responsibility in jobs. The problem was certainly no easier for civil engineering jobs than other aspects of engineering, perhaps it was more difficult, since civil engineering may have more than its share of the various aspects of responsibility.

Some published information was available concerning categories of responsibility.

In Canada the Council of Professional Engineers has defined each level of responsibility by reference to 5 factors:-

i) duties
ii) recommendations, decisions and commitments
iii) supervision received
iv) leadership, authority and/or supervision received
v) entrance qualifications

A simple hierarchical approach was used by Halden* in his study of electrical engineers in Sweden.

i) executive managers in companies > 100 employees
ii) executive managers of small firms and heads of departments
iii) heads of small departments and heads of divisions in big firms
iv) heads of sections
v) younger engineers

Patton & Littlefield+ in their text on Job Evaluation, analyse the nature of responsibility and break it up into responsibility for certain things; e.g. in the case of salaried and clerical staff responsibility for determining and applying company policy, for money and materials, for confidential data, and executive responsibility. Again, when evaluating executive positions, responsibility was broken up into initiative, accountability, effect on profits, responsibility for personnel relations, for policy making and policy interpretation.

In the Factor Comparison method, responsibility is defined as - what is entrusted to him that is valuable to the company and that may be affected by his decisions and judgements.

In combination approaches and special plans, accountability is defined as - the requirements of independent responsibility for what happens. Since results are measured in terms of financial health and growth, responsibility winds up sooner or later in terms of money. This phrase - "in terms of money" - seems to be one of the keys in assessing responsibility. Supervision, given and received, also is an important factor. Safety questions, social responsibility, are also involved.

Taking into account all these points of view we devised a scheme for assessing responsibility based on the following factors:-

1. Number and type of staff for which responsible.
2. Incidental expenditure, running expenditure, cheque signing limit.
3. Capital expenditure limit.
4. Value of plant and equipment for which responsible.
5. Place in organization hierarchy.
6. Responsibility for technical decisions.
7. Connection with policy making.
8. Involvement in policy interpretation.
9. Safety decisions.
10. Social responsibility and legal responsibility.

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* Halden, F., "The evolution of the tasks and functions of engineers". Policy Conference on Hi hly Qu lifi d M power, Pari 1966, 201

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\+ Patton, J.A., Littlefield, C.L., & Self, S.A., "Job Evaluation - Text and Cases". Richard D.Irwin Inc. Homewood, Illinois, U.S.A.,1964

In addition, because in any organized job evaluation and salary grading system responsibility is one of the major factors considered when placing a salary tag on a job we thought that a useful check on the scoring system we had devised would be the salary of a respondent. For the usual reasons the salary classification we used in the questionnaire was very broad.

We make no claims that the scheme we devised is perfect, in fact there were obvious defects but it was a serious attempt to come to grips with the problem of quantifying responsibility in a job. It was felt from the outset that any attempt at task analysis should include reference to responsibility.

From this point onwards the effort with the instrument was aimed at sharpening its composition, and simplifying its format, for example, the various categories of tasks were sub-divided into readily understood broad elements, e.g. management was split into ten sub-categories covering accepted management functions and personnel functions.

Overall, the Task Analysis Questionnaire followed the generally accepted pattern of having firstly, a "warming up" page of easy non-emotional questions, followed by the pages with the more complicated questions and finishing with a page of questions where the respondent could express his own views and sentiments.

6.1.2. Curriculum Questionnaire.

After the change from structured interview to mailed questionnaire it was decided that an opportunity existed to examine in fine detail the usage of the material taught in one section of an average civil engineering curriculum. "Design", a common component in university, C.A.E., and technical college courses, was selected for study and a questionnaire was prepared in which a curriculum was broken down into more than 100 elements. This Curriculum Questionnaire, as it was called, (to differentiate it from the original Task Analysis Questionnaire) was sent to a part of the sample which had been originally selected. The N.S.W. Institute of Technology was directly responsible for the designing of this questionnaire having as they did specific knowledge of the elements of a civil engineering design curriculum. The final questionnaire was produced as a collaborative effort with a group from Sydney Technical College with the specific interest of measuring the overlap between the traditional Technical College and C.A.E. curriculum in design.

6.1.3. Foreman's Questionnaire.

Early in the study the important role played by general foremen, supervisors and similar people in civil engineering was perceived, also our definition of a technician referred to management techniques. It seem important therefore, to bring foremen into our study of civil engineering. However, the complex nature of the two main questionnaires precluded their distribution to foremen. They also did not deal with the question of training in a way that could be applied to foremen. Consequently a questionnaire was developed that was simpler to understand, easier to complete and aimed specifically at foremen. The basis of the distribution was different from that used for the two main questionnaires, being much smaller in scope, partly because of the nature of the population, and partly from a wish to not allocate too much of the total resources to this possibly marginal aspect of the main study.

6.2. PILOT AND PRE-TEST RUNS.

Reference was made in the section dealing with the Task Analysis questionnaire (6.1.1.) to a pilot run with the questionnaire which had been originally developed for use in a face to face interview. The conclusions reached as a result of carrying out the pilot run were that the schedule was too lengthy, taking an average of just over an hour to administer, and the technical matters section was a failure, although otherwise design was satisfactory. The reasons for changing over to a mailed questionnaire rather than conducting interviews were dealt with in 6.1.1. This led to a further extensive general re-design of the questionnaire which coupled with a completely re-modelled section dealing with technical matters meant it was necessary to carry out a further trial run. At the same time also we intended to carry the operation through to the punch card stage to test out the procedure for editing and coding the questionnaires and data.

When conducting surveys a pre-test of the questionnaire is essential. The pre-test should show not only the adequacy of the instrument and detect any problem in administration and scoring but also may serve to demonstrate the reliability and validit of the questionnaire. The pre-test should resemble as closely as possible what is planned for the main run.

Three separate pre-tests were involved, each dealing with one of the three questionnaires. This report deals with those connected with the Task Analysis Questionnaire and the Foremen's Questionnaire. The N.S.W. Institute of Technology carried out the pre-test of the Curriculum Questionnaire and details will be published later.

6.2.1. Task Analysis Questionnaire - Pre-Test.

One aim of this pre-test was to ensure that the data obtained from the questionnaire in its final form could be placed on computer cards. In addition the pre-test was an exercise in the procedure actually to be used in the main run of the survey so that any administrative problems could be eliminated.

For these reasons as well as ease of access it was decided to choose one medium, a large sized organization not used in the main survey which could be approached through the hierarchy.

This was done and agreement reached for distribution of the questionnaires. No "pep talk" was given because

(1) people involved in the main run would not receive a "pep talk".

(2) a covering letter was enclosed seeking their co-operation and explaining the project.

(3) an unbiased estimate of the response rate would be gained.

The response rate to the questionnaire, obtained without any form of pressure, was twenty-five percent. This did not cause undue worry as it was planned that for the main run means would be available for "chasing up" outstanding questionnaires thus increasing the response rate.

The data from the returned questionnaires was closely examined for apparent difficulties or misinterpretations in the answering of questions. None being revealed, and no adverse comments being received from respondents who filled in the questionnaire, it was decided that it needed no further alterations.

The data from these schedules was then examined for the best way in which it could be edited for the computer. Although preliminary layouts for the editing had been considered before the pre-test, it was found that reconsideration had to be given in certain areas to allow for a wider range of answers than was at first anticipated. In addition, the open ended questions could not be categorized until real answers were examined and suitable categories arrived at. It was envisaged that further modifications might be necessary after the main run of the questionnaire as some additional categories might be reported.

Throughout the questionnaire at strategic points "other(specify)" categories were included. This, however, presented difficulty for punching as each "other" related to a specific section. On the basis of the response from the pre-test in which only an occasional "other" was completed it was decided to leave room in sequence for the punching of the "other" and its related figures. At this stage the data was only categorized as "other". Such "other" categories were then to be rated and punched on a separate card together with the respondent's number. All such "other" data could then be computed separately and it could be determined which and to what extent certain "elements" had been neglected by the questionnaire. (Later, when editing the main run, it was found that very little had been left out.)

For the responsibility rating it was decided that instead of punching each individual item of responsibility, three responsibility ratings could be arrived at by assigning predetermined values to certain answers which could then be summed. Thus, ratings or scores were obtained for each of the responsibilities for staff, money and policy.

The scores obtained through the responsibility rating scheme were also compared, as a measure of validity, with the salary bracket indicated by the respondent, i.e. if there was a great deal of consistent variation between the two then one of them was not a valid estimate of responsibility.

The size of the pre-test was too small to indicate the exact relationship between level of responsibility and salary. Some alterations were made to the original scheme, however, as a result of the indications provided by the pre-test. These were in the quantitative values assigned to various items in the scoring system.

6.2.2. Foreman's Questionnaire - Pre-Test.

The basic character of this questionnaire was similar to that of the main study and was essentially a simplified form. Various experts with knowledge of foremen's activities who had expressed interest in the questionnaire suggested modifications in the wording and content of some of the restructured questions so that ambiguity would be eliminated and the questions would become easier to interpret.

The questionnaire was then subjected to a pre-test using a number of foremen from construction sites. These foremen in all cases fulfilled our definition of foremen and represented varying levels of authority and responsibility for work and workers.

Each foreman was interviewed prior to the pre-test and the nature and purpose of the project was explained to him. It had been originally intended that a lengthy interview should take place with each foreman guiding him through the questionnaire and discussing any difficulties or queries he might have had about any of the questions. This procedure had, however, to be abandoned owing to the nature of a foreman's job - that he has not sufficient time to devote to long interviews. In consequence it was found necessary to ask them to complete the questionnaire in their own time noting down any comments about the questions and any problems they encountered. It was anticipated that this method would result in a critical feedback of information. When the forms were collected much additional information was obtained.

It was realised before conducting the pre-test for the foreman's questionnaire that the nature of a foreman's job allows him little time for filling in forms and a low response rate must be expected in the main run. To compensate for this low response rate it was decided that a larger sample of foremen should be taken in order to achieve a response rate comparable with that of the rest of the project.

The pre-test resulted in two of the questions from the list of elements being eliminated owing to ambiguity. Other modifications also made the questionnaire simpler to complete. After these changes the questionnaire was then ready for the main run.

Although the procedures for the pre-test differed from those of the main run it was felt that the effects of these differences would be minimal. Instead of the explanatory interview an explanatory letter was included with every questionnaire sent to foremen.

It can also be asked whether differences in conditions between pre-test and main run will have any appreciable effect on reliability and validity. The only problem that could arise from this is a slight difference in reliability - a highly structured interview being different from a highly structured questionnaire. In this case the interview was more in the nature of a verbal background to the project and directive concerning the questionnaire and was comparable therefore to the covering letter dealing with the same items.

6.3. RELIABILITY AND VALIDITY.

Questions of reliability and validity in surveys demand attention and much has been written on them. Concerning reliability a general view is that questionnaires are reliable particularly when the answer alternatives are clearly laid out, as they were, we hope in the questionnaires used in the present study, and the respondents report fact as distinct from opinion which might vary with environmental conditions. No tests were carried out to determine if a respondent were approached a second time with one of the questionnaires whether his answers would have been essentially the same as those he gave the first time. Our choice was deliberate. The questionnaire to be of real value was long and required considerable time to complete. To ask for a group to complete the questionnaire a second time meant either selecting a favourably disposed group who could not be considered to be representative (and thus become merely a formal exercise since reliability is frequently checked this way) or risking the resentment of a random group to their time being "wasted" answering the same questions as we had previously asked them. Subterfuges were considered but were not adopted since we considered that for a questionnaire of this type, with the mature audience of highly qualified workers to whom it was administered, no more precise measure of reliability could be obtained.

When discussing the choice between oral and written verbal responses Galtung* said "the one does not exclude the other" and later "we can easily muster arguments for a discussion in time, using the flexibility of the interview method in the beginning of a project and at the end" .... "and using the standardisation of the questionnaire technique in the middle phase for confirmation". This is broadly what we did in this present study, individual interviews, group interviews, small and large questionnaires were all used.

With particular reference to reliability Galtung wrote "In general it is difficult to say. The interviewer is better trained to record than the respondent, but the respondent knows himself what he wants to answer and will get an immediate re-inforcement and check when he circles or underlines an alternative. Thus, one extra human and fallible link is cut out, but even more important, we think, is the visual check provided by the manual operation with the questionnaire. There is nothing quite corresponding to this in interviewing. The interviewer may read aloud what he has written, but this will probably only lead to a lengthy argument, since the respondent did not possess the answer alternatives in advance as he does for the questionnaire".

Apart from such areas as open-ended questions (answers) and free comments which traditionally have low reliability we felt our decision not to expend valuable funds pursuing the reliability question in depth in this broad large scale project was a safe one. We did attempt to improve reliability in one important open-ended question dealing with deficiencies in training (last part of Task Analysis Questionnaire) by posing the same question in more than one way.

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* Galtung, J., "Theory and Methods of Social Research" George Allen and Unwin, London, 1967. p.118.

However, questions of reliability are also questions of reproducibility and these latter have been borne in mind concerning possible errors in the translation of data from the questionnaires to the punch cards and also in the analysis of the data, where frequent checks took place both of the computer print-outs, and the computations used in the final presentation of the data.

To minimise error in the transference of data random checks at a rate of one in five were made on all edited questionnaires at the lay-out sheet stage. Punched cards were all verified. Sets of punched cards were thoroughly examined to establish that each subject (respondent) had the correct number of data cards, and that each subject who completed a questionnaire was represented by a set of data cards. In addition cards were listed thereby making it possible to establish whether residual errors existed in cards. Much of the checking was done by the authors who were aware of many instances cited in the literature where extensive and carefully designed systematic plans were thwarted by poor recording by junior assistants.* In all we took as much care as possible to establish a pure bank of data.

Overall we claim reliability is high.

We believe that problems of content of validity were minimised in our study as a result of the extensive interviewing phase at the start of the project when the team members spoke to many people at all levels in civil engineering about the project, what its aims were, and what benefits it was hoped it would have. They also collected as much verified information as possible on real civil engineering practice.

Concerning the validity of the questionnaire as an accurate and valid means of collecting information it is difficult to resolve the problem of standardisation and flexibility. Galtung wrote "The literature seems to favour questionnaires for many reasons, but the authors do not agree between themselves. Thus there is argument to the effect that the flexibility provided by the interviewing permits more refinement, more resources and thus more validity and there is the argument that the skilled interviewer will have a number of soothing techniques for the embarrassing question that can never be quite imitated in the questionnaire. We are inclined to say that 'it depends' but that in general questionnaires seem to be more valid".

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An opportunity did, however, present itself during the study to gain some appreciation of the reliability and validity of the Task Analysis Questionnaire, particularly that section dealing with the Broad Task Analysis over a fixed period of working time i.e. a fortnight.

Halfway through the data processing operation some information in tabulated form was prepared for presentation to two discussion groups. It was based on data from 191 respondents. At the end of the data processing phase we had the same tabulated information from 318 respondents. One pair only of several similar sets of results at the two time intervals are given in Table 6.3.1.

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* Grubman, Hulda, "Evaluation activities of curriculum projects" AERA monograph series on curriculum evaluation. No.2. pp. 48-50. Rand, McNally, U.S.A., 1968.

TABLE 6.3.1. BROAD TASK ANALYSIS - ENGINEERS AND TECHNICIANS.

a) n = 191, Engineers 121, Technicians 70.

CATEGORY OF TASK	Eng's %	Tech's %
Technical matters	33	33
Manual skills	8	35
Economic/Financial matters	14	8
Communication matters	12	12
Management/Personnel matters	18	9
Other (e.g. legal)	3	1
Other - general	1	1
Rounding off 'error'	1	1

b) n = 318, Engineers 195, Technicians 123.

CATEGORY OF TASK	Eng's %	Tech's %
Technical matters	33	33
Manual skills	9	41
Economic/Financial matters	15	7
Communication matters	22	10
Management/Personnel matters	18	7
Other (e.g. legal)	2	1
Rounding off 'error'	1	1

Other similar pairs of tables agreed as closely. This supported our belief that our data collecting process had good reliability and was valid.

6.4. METHODOLOGY AND DISTRIBUTION.

The manner in which questionnaires eventually reached the civil engineers and technicians in the groups of employers differed somewhat for each group but the guiding principle adopted was that as far as we could achieve it the selected numbers of engineers and technicians would receive the questionnaire kits. To do this we had in many cases to obtain permission from the heads of the various Commonwealth, State and Local Government bodies, Consulting firms, Contractors, and other companies. Notes about the procedures adopted for each of the strata of the population are given below.

6.4.1. State Government Departments.

These were approached at first by phone and then by personal interview with a view to explaining to heads of Civil Engineering Divisions or other senior administrators the nature and aim of the project and to gain their co-operation for the selection of the sample. Their co-operation was necessary to obtain the names of staff, and also for ease of distribution and collection. Most departments preferred for reasons of staff security (discussed earlier) to distribute the questionnaire to the sample chosen by the research team or to the sample they had selected under direction of the research team; and in some cases agreed to collect them and notify us when they had been completed. However, in some cases they were unwilling to supply the names of the people selected which presented a problem because names were necessary so that follow-up procedures could be used if necessary. To all departments it was stressed that employees should not be directed to complete the questionnaire, each individual must elect to assist with the research, theirs was the choice to make.

Each potential respondent was given a questionnaire, a return addressed envelope and a covering letter explaining the nature of the project, which also requested his co-operation by completing the questionnaire.

6.4.2. Commonwealth Government Departments.

Here the procedure followed for State Government Departments was largely used. The major difference being that it was the Sydney Branches of the departments that were contacted and these largely by.phone - requesting their co-operation and explaining the nature of the project. The departments were asked for names of employees so that a sample could be selected. Questionnaires were then sent by post to the relevant departments for distribution - each questionnaire being personally addressed (where names had actually been given).

These questionnaires were accompanied by the same explanatory material as the State Government questionnaires. Respondents could mail the questionnaires direct to the project, or, if agreed to by the department head, return them to him for forwarding to us.

For both Commonwealth and State Government Departments more than one type of questionnaire was distributed. The engineer and technician staff for the sample were divided into two groups, 4/7 to be given the Task Analysis Questionnaire and 3/7 the Curriculum Questionnaire. The subjects for each section were selected randomly. A sample of foremen was also taken to whom the foreman's questionnaire was given.

6.4.3. Consultants.

The approach taken for consultants differed somewhat from that taken for State and Commonwealth Governments. The principals of each concern were approached by telephone firstly to determine the numbers and type of civil engineering staff employed and secondly to seek their co-operation for the main run and to explain the project in detail. The questionnaires were then, in most cases, delivered personally and the details of distribution discussed. Again it was stated that no pressure should be placed on respondents. In most cases no names were given which meant that follow-up was difficult.

6.4.4. Contractors.

Contractors had in many cases been contacted by mail early in the study to obtain information on the number of civil engineering staff employed. After the sample of companies had been selected further approaches by telephone were made to gain the support of the managers for the distribution of the questionnaires. In most cases names of individuals were not given and the company was left to select its own sample according to the directions provided. Questionnaires were then mailed to the companies.

For consultants and contractors questionnaires were again of the three types - Task Analysis, Curriculum and Foreman's Questionnaire. However, no one organization received all three. Companies were selected randomly as to which would receive Task Analysis and which Curriculum Questionnaires. Foreman's Questionnaires went only to those companies receiving Task Analysis Questionnaires. This was done to simplify administration and distribution of the questionnaires.

6.4.5. Local Government.

This stratum of the sample received a treatment totally postal in nature. Letters were first sent to a random sample of local governments requesting the numbers of civil engineering staff in specific categories. A number of councils were then randomly dropped owing to the numbers of civil engineering staff exceeding the required sample size. The remaining councils were then divided in the proportion 3/7 and 4/7 for Curriculum and Task Analysis respectively. The councils were contacted again requesting their help in distributing the questionnaires to specific numbers and categories. Specific instructions were given as to the manner of distribution. Records of the questionnaires (all numbered) were kept, and also which were to go to engineers, which to technicians, and which to foremen. These questionnaires were bundled and clearly labelled and sent together with the letter to the council clerk for distribution. Councils selected for both Curriculum and Task Analysis received Foreman's Questionnaires. The larger number of Foreman's Questionnaires distributed to Local Government was in anticipation of an expected low response rate for foremen generally.

The sampling method for Local Government was based upon the numbers of councils and not upon the population of civil engineering staff - all civil engineering staff being used in each selected council. This method was chosen for Local Government owing to the lack of explicit data as to the distribution of engineers, technicians, and foremen in local government.

6.4.6. General Industry.

A large range of industries were initially approached to determine whether civil engineering staff were employed. A small number of industries in a limited range of activities were found to employ civil engineering staff. These companies were subjected to random selection and the sample so picked divided 3/7 and 4/7 for Curriculum and Task Analysis Questionnaires and the required numbers of respondents determined for the sample. These companies were again approached for their co-operation. Due to the limited numbers in general industry, foremen were chosen from both 'curriculum' and 'task analysis' companies to give a fuller picture of a foreman's job in general industry.

Much of the data on staff was gathered from Head Offices interstate, and it was found upon contact with local branches that the figures given by Head Office for N.S.W. were often innaccurate, thus disturbing the calculated numbers for the sample. This was overcome by taking more from those companies with a numerically larger civil engineering staff.

The managers of these companies were contacted again to seek their co-operation in distribution of the questionnaires. Further letters were written enclosing detailed instructions for the distribution of particular questionnaires according to number, questionnaires were bundled, clearly labelled and posted to the relevant person. Again there was no real means of follow-up as names were not supplied although the distributing letter requested that such a list of names be forwarded to us after distribution.

6.4.7. General Comments.

As can be seen the overall procedure for each stratum of employers was the same although specific methods varied. Each stratum of employers had different coloured questionnaires to facilitate distribution and ease of grouping returns. Questionnaires were individually numbered for easy reference and punching. Each questionnaire was accompanied by a covering letter as already described, and addressed reply (non-stamped) envelope.

It was decided before actual distribution commenced that a minimum response of twenty-five percent must be obtained despite the size of the questionnaire and that follow-up procedures would probably need to be employed. The nature of these would relate to the procedure used for disseminating the questionnaires and would consist either of individual letters or approaches to the people concerned in organisations with distribution of the questionnaires.

Some government departments in addition to requesting that it be specified that questionnaires be completed in the staff member's time also requested that a return time limit be placed upon the completion of the questionnaire. These were largely departments who had offered to collect all returns and keep them for collection.

We held reservations about the likelihood of obtaining a twenty-five percent response rate for the foremen because of all the difficulties already mentioned. However, the population was homogeneous, and the study with foremen had a lower priority. These combined led us to adopt a less rigorous approach to a minimum standard of response.

7. RESPONSE, EDITING, PREPARATION OF DATA, AND DATA PROCESSING

7.1. RESPONSE.

The response to the Task Analysis Questionnaire was fairly even both across employers and within individual groups of employers. Some departures in detail from the sample design did occur and these are discussed in the next Chapter, in 8.1.1. The overall response was slightly higher than 43 percent, i.e. total response against questionnaires effectively distributed. The number of completed questionnaires returned as a percentage of designed sample size was 41 percent.

The response to the Curriculum Analysis Questionnaire was slightly lower at an overall 37 percent and was especially low for the contractor group of employers. This was perhaps understandable as the relevance of "design" to this group was marginal. In fact, the group was almost excluded at one stage of the sample selection. The number of completed questionnaires returned as a percentage of designed sample size was 32 percent.

The response to the Foreman's Questionnaire was the lowest at about 21 percent but bearing in mind the difficulties that many foremen have, e.g. the immediate urgency of the job to keep it moving, and rudimentary office facilities in which to complete the questionnaire, this low figure was perhaps understandable and commendable. An examination of the response to the Foreman's Questionnaire showed the best response from State Government employees, followed by Commonwealth Government, Local Government, and Construction company employees in descending order.

The details of the response are given in the following table, 7.1.1.

TABLE 7.1.1. DETAILS OF RESPONSE

	TASK ANALYSIS QUESTIONNAIRE							CURRICULUM QUESTIONNAIRE						
	Sample Size	Number Distributed	Not Required or Left Address	Effective Distribution	Complete Returned Q's	Returned Not Applicable or Won't Complete	Total Response	Sample Size	Number Distributed	Not Required or Left Address	Effective Distribution	Complete Returned Q's	Returned Not Applicable or Won't Complete	Total Response
STATE (N.S.W.) GOVERNMENT	391	349	7	342	119	17	136	295	257	10	247	75	16	91
COMMONWEALTH GOVERNMENT	39	40	-	40	12	-	12	29	25	-	25	9	-	9
LOCAL GOVERNMENT	85	187	3	184	85	-	85	63	114	7	107	48	-	48
CONSULTANTS	167	151	14	137	73	4	77	125	131	26	105	48	-	48
CONTRACTORS	88	90	10	80	38	-	38	65	65	-	65	10	-	10
GENERAL INDUSTRY	30	32	-	32	4	-	4	23	19	-	19	3	-	3
TOTALS	800	849	34	815	331	21	352	600	611	43	568	193	16	209

.1.1. DETAILS OF RESPONSE

TASK ANALYSIS QUESTIONNAIRE							CURRICULUM QUESTIONNAIRE							FOREMAN'S QUESTIONNA		
Sample Size	Number Distributed	Not Required or Left Address	Effective Distribution	Complete Returned Q's	Returned Not Applicable or Won't Complete	Total Response	Sample Size	Number Distributed	Not Required or Left Address	Effective Distribution	Complete Returned Q's	Returned Not Applicable or Won't Complete	Total Response	Sample Size	Number Distributed	Complete Returned Q's
391	349	7	342	119	17	136	295	257	10	247	75	16	91	151	92	32
39	40	-	40	12	-	12	29	25	-	25	9	-	9	23	22	5
85	187	3	184	85	-	85	63	114	7	107	48	-	48	48	159	26
167	151	14	137	73	4	77	125	131	26	105	48	-	48	-	-	-
88	90	10	80	38	-	38	65	65	-	65	10	-	10	64	62	11
30	32	-	32	4	-	4	23	19	-	19	3	-	3	14	10	-
800	849	34	815	331	21	352	600	611	43	568	193	16	209	300	345	74

7.2. EDITING AND PREPARATION OF DATA.

Questionnaires were edited and coded to a pre-determined plan. Classification of answers to the open-ended questions in the Task Analysis Questionnaire presented no great problems although the possible answers to one small group of questions was fairly extensive. Editing and coding the returned questions was therefore a simple job, albeit a very time consuming one. The volume of information was large and 13 punch cards were required for each Task Analysis Questionnaire, ten for each Curriculum Questionnaire and five for each Foreman's Questionnaire.

The answers were first transferred in code form to punch card layout sheets. As mentioned in the previous chapter a randomly selected 20 percent of these sheets were then re-checked completely. Errors at this stage were low, averaging slightly less than 0.1 per cent. Some defects in classification and/or coding were detected as the work of examining the data progressed and all layout sheets were modified to eliminate these. These defects were connected with specific items such as the responsibility rating.

Cards were punched and verified by the punch card machine system in the computer facility at Macquarie University. As the cards were returned they were examined to establish that each respondent had the correct number of cards, and that each respondent who had completed a questionnaire was represented by a set of data cards. Cards were computer listed to determine if errors in cards, traceable to editing, existed, or any other errors could be detected. Every effort was made to establish a pure bank of data.

7.3. DATA PROCESSING.

Some initial processing of the data was carried out on the IBM 1460 equipment at Macquarie, but most of the work made use of the services of the Compunet organization and their Univac 1108 equipment.

A problem with a survey of this nature is deciding what the approach to processing the data will be. Some broad decisions were taken early on to the effect that the data from the Curriculum Questionnaire would be examined and processed by the N.S.W. Institute of Technology. The editing of Curriculum Questionnaires and the preparation of punched cards were carried out by the project team at Macquarie but the data cards and other information were transferred to the Institute for processing there since the questionnaire had been designed by the staff of the Institute and they were therefore in the best position to analyse the data. This particular analysis will be reported separately in Volume II of this report later this year. It was decided that the Task Analysis Questionnaire data and the Foreman's Questionnaire data would be analysed by the project team at Macquarie.

In the approach to data processing there is often perhaps a tendency to think that a programme package exists which when placed with the data cards in the computer will produce all the important information and tables needed. Thus the possibility that any important correlation would be missed or that any null hypothesis would fail to be rejected at acceptable confidence levels, would be eliminated. We spent some time examining this approach but a number of factors became apparent in this present study. We did not readily come across a suitable programme package, that is not to say one doesn't exist. In the Task Analysis Questionnaire data bank, about 250,000 bits of

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In view of this a simple approach to data processing was adopted. It was not until near the end of the present part of the study that data was streamed onto magnetic tape and disc (two separate files, one at Macquarie University and one at N.S.W. Institute of Technology) with a view to using more sophisticated overall programmes, e.g. McQuitty's cluster analysis method, modified by the School of Behavioural Sciences, Macquarie, or more intricate searches and classifications of the data of the sort used throughout the processing.

Thus our first approach to processing the data from the Task Analysis questionnaires and the Foreman's questionnaires was based on devising the most powerful analytical tools (ideas), on using the card sorting machine and manual sorting methods, on developing a very simple programme providing percentages and frequencies for certain questions, on using the computer to provide simple percentages and frequencies for hand or machine selected sub-decks of data cards, on using electronic calculators to carry out other complex calculations and so on.

All those steps we could take away from the computer facility we took away. Computers are excellent tools but on occasions it is quicker to utilise the card sorting machine before, and a calculating machine after some simple data processing on the computer than spend considerable time developing or modifying a programme, removing all the defects from it, and then using it.

The question of statistical treatment of the results of data analysis was frequently discussed during the study. The approach to defining the population in the study and the selection of the sample was as rigorous as we could make so that we would be free to use the tools of statistical mathematics later in the study if we so wanted.

As the examination of the data developed no pressing need to use statistical mathematics arose. Gross differences were readily detectable, and in considerable number, we never got as far as examining small differences and determining their significance. The raw data is included in Appendices to this report for readers to examine and re-interpret as they wish.

8. RESULTS

8.1. TASK ANALYSIS

8.1.1. Examination of the data

The design of the survey schedule, or task analysis questionnaire as it came to be called during the study, was discussed in Chapter Six. The first part of the questionnaire, labelled "individual data sheet" sought basic information from each subject about what type of work he did, where he worked, his job title and level in the organization, age, education etc.

The collected data concerning this section has been examined in a number of ways, firstly to determine if the respondents as a group appeared unusual in any way, for example were predominantly under twenty-five years of age, or mainly possessed diplomas and also to see if the response in detail matched the design of the sample. The tabulated data are presented in Appendix 1.

Examination of the tables has not suggested the group of respondents is atypical in any way. Also the match between the broad sample design for the Task Analysis questionnaire and the response is good. Overall, however, the number of technicians in the final sample instead of being about equal to the number of engineers is less than the latter (130 technicians and 201 engineers), and was caused by a reduced response from design technicians (draftsmen) and also by technicians engaged in construction activities. Fortunately, however, the ratio in the response (ca. 5:1) agrees well with the ratio in the population. One other area of mis-match concerns the Local Government section of the sample. When the details of this section of the sample were worked out we feared the response would be poor because of the wide physical dispersion of the population, and the great range of size of the employing municipalities and shire councils. To counteract this the sample was increased relative to the samples from other sections of the total population. However our fears were not realised and the response was good. Therefore, relative to the response from other sections of population in the overall sample the response for Local Government is greater. This sub-group was not reduced by random sampling to give the correct weight however, since inspection of the responses showed clearly that these are the "general practitioners" of civil engineering and have a profile of activities which is average compared with those employed in State Government Departments, by Consultants and by Contractors. Furthermore, as the study developed it appeared that type of employer would be a less powerful analytical tool than type of work. In this respect respondents from the Local Government sector would have opted for one or other of the type of work categories in their replies, as did other respondents, even if their work tended to be more of a mixture of activities than respondents from other categories of employer. In all therefore we assumed the effect of over representation of Local Government employees in the response would be minimal.

One final point concerned General Industry, a minor sector of the population, from which the response was poor. Because of its unimportance as an employer of civil engineers, the low response rate and of our limited interest in type of employer as an analytical tool, very little reference to General Industry occurs in this report.

The questionnaire consisted of a number of sections, viz:

The design of the survey schedule, or task analysis questionnaire as it came to be called during the study, was discussed in Chapter Six. The first part of the questionnaire, labelled "individual data sheet" sought basic information from each subject about what type of work he did, where he worked, his job title and level in the organization, age, education etc.

The collected data concerning this section has been examined in a number of ways, firstly to determine if the respondents as a group appeared unusual in any way, for example were predominantly under twenty-five years of age, or mainly possessed diplomas and also to see if the response in detail matched the design of the sample. The tabulated data are presented in Appendix 1.

Examination of the tables has not suggested the group of respondents is atypical in any way. Also the match between the broad sample design for the Task Analysis questionnaire and the response is good. Overall, however, the number of technicians in the final sample instead of being about equal to the number of engineers is less than the latter (130 technicians and 201 engineers), and was caused by a reduced response from design technicians (draftsmen) and also by technicians engaged in construction activities. Fortunately, however, the ratio in the response (ca. 5:1) agrees well with the ratio in the population. One other area of mis-match concerns the Local Government section of the sample. When the details of this section of the sample were worked out we feared the response would be poor because of the wide physical dispersion of the population, and the great range of size of the employing municipalities and shire councils. To counteract this the sample was increased relative to the samples from other sections of the total population. However our fears were not realised and the response was good. Therefore, relative to the response from other sections of population in the overall sample the response for Local Government is greater. This sub-group was not reduced by random sampling to give the correct weight however, since inspection of the responses showed clearly that these are the "general practitioners" of civil engineering and have a profile of activities which is average compared with those employed in State Government Departments, by Consultants and by Contractors. Furthermore, as the study developed it appeared that type of employer would be a less powerful analytical tool than type of work. In this respect respondents from the Local Government sector would have opted for one or other of the type of work categories in their replies, as did other respondents, even if their work tended to be more of a mixture of activities than respondents from other categories of employer. In all therefore we assumed the effect of over representation of Local Government employees in the response would be minimal.

One final point concerned General Industry, a minor sector of the population, from which the response was poor. Because of its unimportance as an employer of civil engineers, the low response rate and of our limited interest in type of employer as an analytical tool, very little reference to General Industry occurs in this report.

The questionnaire consisted of a number of sections, viz:

(a) Broad Task Analysis
(b) Sub-categories of task-analysis
(c) Technical matters - usage
(d) Training analysis
(e) Open-ended questions on deficiencies in training etc.

The data concerned with these sections are presented in Appendices 2-8 with the exception of the Broad Task Analysis, part of the data for which is presented in this chapter.

The analytical approach to all the data was, in the first instance, unsophisticated.

The first analysis was a comparison of the data for engineers with that for technicians. Some discussion took place on what determined whether a respondent was an engineer or technician.

The basis used in this study for sorting respondents into one category or the other took into consideration the title of the job the respondent held and his position in the hierarchy as shown by the outline organisation chart, that is the job done was the criterion not whether the occupant was qualified to become a member of a professional organisation. This avoided the error of classifying some as engineers even though they were employed as technicians, and others as technicians even though they were employed as engineers. Four sub-levels of engineers and three of technicians were allowed for in coding. These are seldom referred to in the report, one exception being Table A.1.10, Appendix 1. In general the number of levels was reduced to two - engineer and technician.

At a later stage of the study we sought the views of two authoratative panels, one of "professional" engineers, and one of technicians, in civil engineering, on what characterized an engineer's work on the one hand, and a technician's work on the other. The opinions we obtained did not provide a hard and fast line of demarcation between the two levels. Theoretically one ought to be able to define an engineer's job as having a certain mix of skills and knowledge and a technician's job another mix, but in doing this one immediately becomes involved in the detailed examination of potential and utilising skills. We did not feel competent to evaluate theoretical combinations and classify one combination as engineer type and another as technician type, and we were unable to obtain guidance in anything like general terms or educational attainments. We felt more competent to look at a man's position in an organisation and say a respondent was employed either as an engineer or a technician. This pragmatic approach was used throughout.

Certainly there is overlap at the boundary between what an engineer does and a technician does, but overlap occurs at any of the other boundaries that exist, e.g. between non-management and management, junior management and senior management, draftsman and chief draftsman and so on. Nevertheless the boundaries can be delineated.

As mentioned earlier, work classification turned out to be a powerful analytical tool. In order to cope with the data this classification was reduced to three (c.f. six depicted in model - chapter four). These three classifications were:-

(a) design
(b) construction
(c) other work

For the purposes of the analysis some combination classifications used in coding and editing, e.g. construction and maintenance were included with the overall construction classification - (b) above.

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For the purposes of the analysis some combination classifications used in coding and editing, e.g. construction and maintenance were included with the overall construction classification - (b) above.

Thus the basic approach to the analysis of the data on tasks was twofold:-

(a) two values of level - engineer, and technician

(b) three values of type of work - design, construction, and other work.

TABLE 8.1.3. **TASK ANALYSIS BY VARIOUS EMPLOYERS**

n = 303;

Consultants	71
Contractors	36
State Government	113
Local Government	83

CATEGORY OF TASK	CONSULTANTS	CONTRACTORS	STATE GOVT.	LOCAL GOVT.
	%	%	%	%
Technical matters	35	31	34	29
Manual skills	33	7	22	20
Economic/Financial matters	7	23	10	12
Communication matters	13	19	18	18
Management/Personnel matters	10	17	12	17
Other (e.g. legal)	1	2	4	4
Rounding off 'error'	1	1	0	0

In the next table - 8.1.4., the time allocated to the categories of task has been analyzed with respect to the ages of the engineers and technicians.

58,59, 60.

TABLE 8.1.4. **TASK ANALYSIS BY AGE**

n = 318;

Engineers	20-30 yrs.	78
"	31-40 yrs.	60
"	41 & over	57
Technicians	20-30 yrs.	84
"	31 & over	39

ENGINEERS

CATEGORY OF TASK	20-30 yrs.	31-40 yrs.	41 & over
	%	%	%
Technical matters	32	35	32
Manual skills	11	7	8
Economic/financial	16	13	16
Communication	23	23	20
Management/Personnel	16	18	21
Other, e.g. legal	2	4	3
Rounding off 'error'	0	0	0

TECHNICIANS	20-30 yrs.	31 & over	
	%	%	
Technical matters	34	41	
Manual skills	44	24	
Economic/financial	5	7	
Communication	8	16	
Management/Personnel	6	9	
Other, e.g. legal	2	2	
Rounding off 'error'	1	1	

Many observations can be made about the results presented in the previous tables, and the nature of the task profiles which have emerged. Apart from the relative percentage time allocations to the various categories of activity, which of themselves are of great interest, the major observations perhaps are:-

(a) Engineers engaged in design have a different work profile from engineers engaged in construction, and engineers on other work. This differs by being concerned more with technical matters and less with economic/financial, and management matters.

(b) The time spent on non-technical and non-manual skills

"	31-40 yrs.	60
"	41 & over	57
Technicians	20-30 yrs.	84
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ENGINEERS

CATEGORY OF TASK	20-30 yrs.	31-40 yrs.	41 & over
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Other, e.g. legal	2	4	3
Rounding off 'error'	0	0	0
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(a) Engineers engaged in design have a different work profile from engineers engaged in construction, and engineers on other work. This differs by being concerned more with technical matters and less with economic/financial, and management matters.

(b) The time spent on non-technical and non-manual skills activities is 64 per cent and 46 per cent for engineers in construction, and engineers in design respectively. Most of this is concerned with communication matters and management matters, but economic/financial matters occupy much time also.

(c) The work of technicians when compared with engineers appears to be more concerned with technical matters and manual skills.

(d) The work of either engineers or technicians does not appear to change much with age, although there is a suggestion that there might be small changes in a technician's work as he gets older.

Data concerning the frequency of use of the various categories of rank are presented in Appendix 2. The pattern of frequency of use follows the pattern of time allocation to the various tasks.

8.1.3. Sub-categories of Task (excluding Technical Matters)

Each category of task viz:- technical matters, manual skills, economic/financial matters, communication/exchange of information matters, and management and personnel matters was composed of a number of individual items. These items, or sub-categories of task were detailed on pages 7 and 8 of the questionnaire and information about the allocation of time to these tasks, the frequency of use, and their importance was sought, similar in nature to that sought about the broad categories of task. Respondents who had indicated nil use of a category of task in the broad task analysis did not complete the section concerned with the sub-categories of that task, for obvious reasons. Thus the information on these sub-categories refers only to those people who used the broad category at some time in their daily work.

The results obtained for the categories of task are detailed in Appendices 3-6 as follows:-

Manual skills	- Appendix 3
Economic-financial matters	- Appendix 4
Communication/exchange of information	- Appendix 5
Management and Personnel matters	- Appendix 6

It is not proposed to discuss these results in detail but attention can be drawn to some of the main features

(a) Manual skills: The various manual skills were all used, but the extent to which they were each used depended on the nature of the work. This applied to engineers as well as technicians. Thus drafting dominated in design work, and clearly drafting is the major manual skill used in civil engineering. Much time was also spent generally using survey instruments, but technicians in construction work and other work spent more time using laboratory apparatus than on surveying. The 'other' category included such skills as driving vehicle.

(b) Economic/financial matters: Here again one particular item dominated, this was "costing of, and costs of projects". The item covered both the estimating aspect of projects and the attention to cost details during the execution of the project. Neither type of work nor level of employment altered the picture a great deal. For those respondents who were involved in this task, and most were, the financial cost aspects of civil engineering works were of great importance and regularly in use.

(c) Communication/exchange of information: The picture here ... s appear to change much with age, although there is a suggestion that there might be small changes in a technician's work as he gets older.

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(c) Communication/exchange of information: The picture here was less one-sided. Sketching used by all, but mostly by engineers and technicians in design work, was also considered very important by them. However, its use did not occupy as much time as the more usual forms of communication. These aspects, writing, talking and reading, were used roughly equally and had similar degrees of importance attached to them.

(d) Management and Personnel matters: Whilst these two groups of activity were combined and listed together in the questionnaire they were in fact separate and the results indicate that for those people engaged in management and personnel matters, their work was predominantly of the management category rather than the personnel category (ratio approx. 5:1). Within the management category the sub-categories were all well represented with possibly directing and organizing being of greatest importance, followed closely by planning.

It must be emphasised that the above comments in total refer to those respondents who indicated use of the various categories of task. In some cases the number of respondents concerned was low, e.g. technicians - construction, and technicians - other work, concerned with economic matters where the values of 'n' were 7, and 6 respectively.

8.1.4. Technical Matters: Sub-Category of Task

The main feature of engineers' and technicians' work is the utilisation of appropriate technical knowledge. Much of this basic knowledge is gained at post-secondary institutions where engineers and technicians are expected to acquire knowledge skills and attitudes from their training that can be applied to their subsequent work activity.

The problems associated with defining the technical items used by civil engineers and technicians were dealt with at length in Chapter 6. The list of "elements" of civil engineering knowledge that was finally assembled amounted to sixty-three separate items and they were all identified in terms used by training institutions not in terms emanating from or having evolved from the work situation. Resources were not sufficient to overcome this weakness and it remains modified we hope in the opportunity liberally provided for the addition of items by the respondents. It gives this part of our work the appearance of using a "standard" curriculum as a target at which shots are being aimed to eliminate certain items. We would rather have been able to define how certain items were used and in what combination with non-technical items or procedures they were used, and thus establish new curriculum objectives or even construct a new curriculum, or part of, rather than merely to suggest deletions or additions to a standard traditional type of curriculum.

Questions concerned with Technical matters occur on pages 3-6 of the questionnaire. The data obtained are detailed in Appendix 7, which is sub-divided into six sections, namely engineers and technicians by the three types of work used hitherto. Criteria used in the examination of this data were

(a) to determine which "elements" of civil engineering knowledge are used most frequently,

(b) which have greatest importance attached to them by the respondents,

(c) which are considered most difficult, and

(d) what level of knowledge is associated with the most frequently mentioned items.

So that these terms are understood at this stage the instructions ment category the sub-categories were all well represented with possibly directing and organizing being of greatest importance, followed closely by planning.

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(c) which are considered most difficult, and

(d) what level of knowledge is associated with the most frequently mentioned items.

So that these terms are understood at this stage the instructions concerning them, detailed in the questionnaire, are reproduced below.

"In the section on pages 4 and 5 dealing with Technical Matters please indicate in connection with -

USE - those elements or parts of civil engineering knowledge which you use in the performance of your job, by placing a tick against them.
Please write 'O' against those you do not use.

For those elements of civil engineering knowledge you use i.e., those you have ticked please indicate -

LEVEL OF KNOWLEDGE - by selecting one of the following code numbers with the meanings as given:-
1 = Advanced level of knowledge of the whole element
2 = General level of knowledge of whole element
3 = Specialised knowledge of part of element
4 = Very specialised knowledge of small part of element

FREQUENCY of use by selecting one of the following code numbers with their meanings as given:-
1 = Regularly, frequently, i.e. every day or every other day
2 = Frequently, i.e. about once a week
3 = Not frequently, i.e. about once a month
4 = Infrequently, i.e. less than 10 times a year

IMPORTANCE - i.e. whether knowledge of the particular element is important in your job. Your answer to be selected from the following code numbers with their meanings as given:-
1 = Very important, easy to acquire
2 = Very important, difficult to acquire
3 = Important, easy to acquire
4 = Important, difficult to acquire
5 = Not important

DIFFICULTY - please indicate how difficult you consider the handling or understanding of this particular element of knowledge to be. Please select your answer from the following code numbers with the meanings as given:-
1 = Very difficult
2 = Difficult
3 = Moderately difficult
4 = Easy

USE IN YEAR - in the last column indicate whether you have used the element of civil engineering knowledge in the past 12 months. Please answer 1 or 0 (used, or not used).

Finally, if there are "elements" of civil engineering knowledge you use, and which are not included in the listing please write about them on page 6, or if there is insufficient space on pages 4 & 5, please continue on page 6, marking the section referred to clearly. Any amplification you think would be helpful would be appreciated."

In the interests of brevity we have severely limited the volume of data we include at this point. This has been done by studying the frequency of response and then ranking the "elements" of civil engineering knowledge for each of the categories of response viz. use/do not use, frequency of use, importance, and difficulty. Thus the rankings in the following table are based on the rankings under all of the responses and not simply the ranking under the use/

For those elements of civil engineering knowledge you use i.e., those you have ticked please indicate -

LEVEL OF KNOWLEDGE - by selecting one of the following code numbers with the meanings as given:-

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TABLE 8.1.5. "ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE OF GREATEST SIGNIFICANCE TO ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK.

	"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE (order below has no significance and follows the list used in the questionnaire)	ENGINEERS - DESIGN	ENGINEERS - CONSTRUCTION	ENGINEERS - OTHER WORK	TECHNICIANS - DESIGN	TECHNICIANS - CONSTRUCTION	TECHNICIANS - OTHER WORK
STRUCTURES	Stress calculations	X					
	Frame analysis(manual methods)	X					
	Design-metal structures e.g.steel	X		X	X		
	" -concrete "	X		X	X		
	" -timber "	X			X		
	" -code of practice	X			X		
	" -safety factors	X		X			
MATERIALS	Mechanical testing					X	
	Quality control		X			X	
	Selection and specification	X	X	X		X	
	Concrete	X	X	X	X	X	X
	Road materials		X			X	
WATER	Solving hydraulic problems			X	X		
	(using formulae and handbooks)						
	Solving hydrology problems				X		
	(using standard procedures)						
SOILS	Field investigations			X		X	X
	Laboratory investigations					X	X
	Foundation design and assessment	X	X	X			
	Earth structure design	X	X	X		X	X
CONSTRUC-TION	Critical path methods		X	X			
	Explosives		X				
	Drilling		X				
SURVEYING	Levelling		X	X	X	X	X
	Setting out		X	X	X	X	X
	Traversing				X	X	X
	Photogrammetry				X		
	Basic maths.,algebra,geometry,trig.	X	X	X	X	X	X
	Equipment and plant		X	X			
	Biology - engineering			X			
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	ENGINEERING KNOWLEDGE (order below has no significance and follows the list used in the questionnaire)	ENGINEERS - DESIGN	ENGINEERS - CONSTRUCTION	ENGINEERS - OTHER WORK	TECHNICIANS - DESIGN	TECHNICIANS - CONSTRUCTION	TECHNICIANS - OTHER WORK
STRUCTURES	Stress calculations	X					
	Frame analysis(manual methods)	X					
	Design-metal structures e.g.steel	X		X	X		
	" -concrete "	X		X	X		
	" -timber "	X			X		
	" -code of practice	X			X		
	" -safety factors	X		X			
MATERIALS	Mechanical testing					X	
	Quality control		X			X	
	Selection and specification	X	X	X		X	
	Concrete	X	X	X	X	X	X
	Road materials		X			X	
WATER	Solving hydraulic problems (using formulae and handbooks)			X	X		
	Solving hydrology problems (using standard procedures)				X		
SOILS	Field investigations			X		X	X
	Laboratory investigations					X	X
	Foundation design and assessment	X	X	X			
	Earth structure design	X	X	X		X	X
CONSTRUC -TION	Critical path methods		X	X			
	Explosives		X				
	Drilling		X				
SURVEYING	Levelling		X	X	X	X	X
	Setting out		X	X	X	X	X
	Traversing				X	X	X
	Photogrammetry				X		
	Basic maths.,algebra,geometry,trig.	X	X	X	X	X	X
	Equipment and plant		X	X			
	Biology - engineering			X			
	Mean "do use" over "elements" above	77%	66%	52%	37%	53%	37%
	Mean "do use" over all "elements"	37%	35%	28%	11%	17%	16%

Of the items listed in Table 8.1.5. basic secondary school maths - algebra, geometry, trigonometry was the most used technical item. Advanced maths, e.g. calculus and numerical methods were used by a large number of respondents but the frequency of response for "do use" tended to be near the mean for this response over the whole sixty-three "elements" or items, and well below the mean of the items selected for inclusion in the table.

Computers - using programmes and writing programmes, formed part of some respondents work but in no case was it near to the extent of the items listed in Table 8.1.5. An exception occurred in the case of the small group of <u>technicians</u> - other work, where computers almost justified inclusion. The use by this group may have been due to those technicians within it engaged on Research and Development work. All groups tended to attach importance to the topic, but did not assess it as very important.

Where respondents indicated they used the "elements" of civil engineering knowledge their use was almost always at the <u>general</u> level. Other studies have revealed a tendency for this neutral type of response to be given. The other three categories - advanced, specialized and very specialized even when grouped together, came nowhere near to matching the frequency of response to the category - "general", either over all sixty-three "elements", or for those "elements" selected for Table 8.1.5. This neutral tendency was not found for other responses given. One must assume therefore that a general level of knowledge of a topic is what civil engineers and technicians are interested in, and they do not see themselves as using specialized knowledge. Doubt must remain, however, about the effect of the attraction of the word "general", and it may be that some other scale for level of knowledge which avoided the term "general" might have been more successful.

It is of interest to recall the study by Lee* in Arizona, U.S.A. who said in his report "No attempt in the survey was made to define 'general' and 'advanced' and in some respects they mean different things in engineering than in the supporting occupations. The results of the survey strongly suggest however, that it is necessary for most engineers and related personnel to have a general knowledge of a wide range of subjects, but it is not necessary for most of them to have an advanced knowledge of more than a few".

Some confirmation of the frequency of use was provided by the response to the "do use/do not use" question. Where an element had a high frequency of "do use" by a group of subjects, that element tended to be used regularly or frequently, i.e. every few days.

In general also the subjects most significant to engineers of a particular group, e.g. design engineers, were also of significance to technicians of the same type, e.g. design technicians (draftsmen). This is not unexpected, but perhaps it hints at a closer relationship existing between the tasks of engineers and technicians engaged in one sort of activity, than is likely to exist between engineers engaged in different activities or technicians engaged in different activities. Within particular activities the boundary between the tasks of engineer and technician may be much less clearly defined than appears overall.

Finally, it may be of some interest to mention those items in the list of sixty-three "elements" that were used least by all selected for inclusion in the table.

Computers - using programmes and writing programmes, formed part of some respondents work but in no case was it near to the extent of the items listed in Table 8.1.5. An exception occurred in the case of the small group of technicians - other work, where computers almost justified inclusion. The use by this group may have been due to those technicians within it engaged on Research and Development work. All groups tended to attach importance to the topic, but did not assess it as very important.

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Finally, it may be of some interest to mention those items in the list of sixty-three "elements" that were used least by all respondents. The "element" - "Electrical Engineering" was used least, the various "elements" under the item "water" were used little, and items connected with computers generally had low frequencies of use.

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* Lee A.M., "Engineering and Technology in Arizona. A report on the education of engineers, technicians, and skilled draftsmen and the educational needs of industry". Arizona Occupational Research Co-ordinating Unit: Arizona State Dept. of Vocational Education, Phoenix, U.S.A., 1968.

As mentioned earlier the detailed frequencies for the eighty "elements" are listed in Appendix 7, which consists of six parts -

8.1.5. Training Analysis, and Open-Ended Questions

8.1.5.1. Training

The last part of the questionnaire dealt with aspects of the respondents' training in civil engineering. Pages 9 and 10 dealt with training in relation to specific categories of task viz. technical, manual, economic, communication, and management. Page 11 contained some open-ended questions mainly concerned with deficiencies in training that had become apparent in the actual work situation since working in civil engineering.

The first analysis of the data from both of these sections was similar to that attempted previously, but instead of using type of work and level (engineer or technician) as the main analytical tools, we decided to use type of qualification (re deficiencies and strengths with respect to a particular course with its own set of aims and objectives).

The coding used in editing the questionnaires allowed for fourteen categories of answer for qualification. For the analysis of the data these fourteen were reduced to eight as shown in Table 8.1.6. Details of the response for each of the original fourteen categories are giben in Appendix 8.

TABLE 8.1.6. CATEGORIES OF QUALIFICATION

CATEGORY	QUALIFICATION	n
1	B.E. (Civil, B.Sc. (Civil Engineering) and Professional Inst. qualifications	106(81+20+5)
2	Diploma - civil engineering	37
3	Local Government certificate	14
4	Degree-other and Diploma-other	18(13+5)
5	Engineering surveying cert.	35(21+14)
6	Engineering surveying cert.	28
7	Materials testing cert. and other certificates	40(4+36)
8	No qualifications and no answer	53(45+8)
	TOTAL	331

Whilst respondents with civil engineering degrees predominated other categories of qualifications were well represented.

Answers were sought with respect to the various categories of task to the following questions

(1) "

8.1.5.1. Training

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8	No qualifications and no answer	53(45+8)
	TOTAL	331

Whilst respondents with civil engineering degrees predominated other categories of qualifications were well represented.

Answers were sought with respect to the various categories of task to the following questions

(1) "The knowledge needed to perform the task - was it part of your post-secondary/tertiary training?

Please indicate by writing a number selected from the 4-point scale.

strongly emphasised	emphasised	some mention	none
1	2	3	4 "

For technical matters and manual skills categories of task the results show slight differences, these are given in Table 8.1.7.

TABLE 8.1.7.

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local govt. cert.	Degree/ Dip. -other	Structural/ Draft. cert.	Eng. survey. cert.	Other certs.	No qual- ification
n =	106	37	14	18	35	40	28	53
Technical matters	%	%	%	%	%	%	%	%
No response	2	3	0	6	11	5	0	11
Answer 1	56	27	43	22	20	38	36	17
2	30	49	43	56	34	28	39	25
3	11	22	7	17	31	29	21	26
4	1	0	7	0	3	0	4	21
Manual skills								
No response	11	24	7	17	26	33	7	25
Answer 1	15	3	7	0	29	18	36	19
2	30	46	43	33	20	30	36	34
3	35	16	43	44	23	13	11	9
4	9	11	0	6	3	8	11	13

For technical matters the high percentage (56%) for "strongly emphasised" shown for respondents with degrees can be contrasted with the more neutral position "emphasised" for those with certificates. For manual skills the position was more or less the reverse and those with degrees indicated they were "mentioned" to "emphasised", whereas those with certificates indicated nearer the "strongly emphasised".

For economic/financial, and communication all qualification categories indicated between "some mention" and "none", and in the management and personnel category the response was strongly towards the "none" mark.

In terms of the tasks performed as engineers and technicians [illegible] the results show slight differences, these are given in Table 8.1.7.

TABLE 8.1.7.

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local govt. cert.	Degree/ Dip. -other	Structural/ Draft. cert.	Eng. survey. cert.	Other certs.	No qualification
n =	106	37	14	18	35	40	28	53
Technical matters	%	%	%	%	%	%	%	%
No response	2	3	0	6	11	5	0	11
Answer 1	56	27	43	22	20	38	36	17
2	30	49	43	56	34	28	39	25
3	11	22	7	17	31	29	21	26
4	1	0	7	0	3	0	4	21
Manual skills								
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Answer 1	15	3	7	0	29	18	36	19
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For economic/financial, and communication all qualification categories indicated between "some mention" and "none", and in the management and personnel category the response was strongly towards the "none" mark.

In terms of the tasks performed as engineers and technicians (Table 8.1.2.1.) therefore, this implies that only 42 percent of an engineer's tasks and 74 percent of a technician's are near adequately covered by the formal training, or perhaps more importantly 58 percent and 26 percent of the tasks of engineers and technicians respectively are not adequately covered.

(2) "Has practical experience been of importance in the acquisition of skill in relation to this task?

Please indicate by writing a number selected from the 4-point scale.

Very much	much	some	very little
1	2	3	4

For all categories of qualification the importance of practical experience rated near to "very much" for technical matters. In manual skills those with certificates rated it "very much", and those respondents with degrees and diplomas still rated it "much".

There was also predominance of "much" to "very much" answers for the economic, communication, and management categories of task. An exception was the trend for those with certificates to not rate practical experience as highly for these latter categories of task, as did other groups.

(3) "What do you think is the best pattern of training for acquiring the knowledge required for the performance of the task? Select one of the following for each of the categories of task. Full time course. Full time followed by part-time. Part-time. Sandwich/block release. T.W.I. (Training within industry). Short intensive course. Correspondence, Self learning. Other."

(4) "Please indicate whether the courses should be at degree or sub-degree level".

The nominated best pattern of training reflected traditional thinking on this subject, i.e. a degree should be obtained full-time and a certificate part-time. It is interesting to refer to Table A1.12. (Appendix 1) which shows that of 164 engineers, 85 gained their qualification full-time and 79 part-time. If the first four education categories are grouped together (this should contain nearly all engineers) the nomination of full-time to part-time as the best method of acquiring knowledge of technical matters is approximately in the ratio of 3:1, not the 1:1 (85:79) indicated for their own training by the respondents. This suggests gaining a degree part-time is not popular in restrospect.

The sandwich pattern of training received fair mention in spite of its novelty.

For manual skills the spread of nominated patternsn of training is wider, but the T.W.I. (training within industry) pattern ranks with the part-time pattern for all categories of qualification.

T.W.I. and short intensive courses are ranked equally for economic, communication and management matters by all groups with the exception of "economics" for those with engineering degrees who nominate full-time equally with T.W.I. Respondents scale.

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T.W.I. and short intensive courses are ranked equally for economic, communication and management matters by all groups with the exception of "economics" for those with engineering degrees who nominate full-time equally with T.W.I. Respondents therefore suggest that economic and financial matters are sufficiently important to be included in the full-time tertiary training course, or to be studied part-time or be taught for a short intensive period whilst in employment. The short intensive course carried out against a background of work activities has, of course, much to commend it.

In reply to the question on what level the pattern of training should be, the response rate was low but sub-degree was nominated most frequently except for technical matters where degree level was nominated more often.

(5) "To what extent is your post-secondary/tertiary training specifically used in the performance of the category of task?

Please indicate by writing a number selected from the following 4-point scale.

almost all	much	some	very little
1	2	3	4 "

For technical matters the trend was "much" for most respondents tending towards "some" for those with certificates, for manual skills the reverse was generally the case, i.e. "some" tending towards "much" for those with certificates. For the remaining three categories of task - economics, communication, and management the answers were predominantly "very little", and tertiary training did not equip respondents with the skills necessary for performance of these tasks.

Reference to Table 8.1.1. indicates how much time is spent on these three sub-categories of task. One would therefore expect training to include some preparation for performing these tasks, but the "very little" type of answer to Question 5 suggests the opposite. The economic matters sub-category of task was mainly concerned with estimating and accounting and one could expect these subjects to be included in a course, particularly if one recalls the unknown American wit referred to earlier in this report who said "a civil engineer is a man who can do for one dollar what any fool can do for two". The importance of this sub-category of task is confirmed by its emergence as a major deficiency in training mentioned by respondents in answer to open-ended questions about deficiencies. (Chap. 8.1.5.2.)

Question six, asked subjects to recommend the best way of acquiring the knowledge for performance of the various sub-categories of task, and to nominate three methods in order of priority. To check if subjects were familiar with the usual methods of acquiring knowledge they were first asked to indicate on a list, those methods of which they had experience. Question six read as follows:-

(6) "The following lists most of the ways of acquiring knowledge -

Live lecture	0	Demonstration, laboratory & outside	5
Tutorial	1	Practical participation/field work	6
Audio-visual methods	2	Simulation/decision making games	7
Individual project	3	On the job instruction	8
Group project	4	Practical job experience	9

Which of these have you had experience of? Please circle number.

What is the best way of acquiring the knowledge for the

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Please indicate by writing a number selected from the following 4-point scale.

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Individual project	3	On the job instruction	8
Group project	4	Practical job experience	9

Which of these have you had experience of? Please circle number.

What is the best way of acquiring the knowledge for the performance of the task? Please state up to three answers in order of priority."

The data show that with the exception of item 7 - "simulation/decision making games" - all methods of acquiring knowledge were known to most subjects in each of the qualification categories. (Table A8.8., Appendix 8). Some certificate holders claimed also to have no experience of audio-visual methods, and some also no experience of group projects.

The preferred methods are summarised in the following table 8.1.8.

TABLE 8.1.8. NOMINATED BEST WAYS OF ACQUIRING KNOWLEDGE FOR VARIOUS TASKS (3 WAYS IN ORDER OF PRIORITY)

CHOICE		QUALIFICATION CATEGORY							
		1	2	3	4	5	6	7	8
TECHNICAL	1	lect.	lect.	lect.	lect.	lect.	lect.	lect.	lect.
	2	tute.	tute.	tute. demo.	tute.	o.j.i.	o.j.i.	o.j.i.	pr./f.w.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.
MANUAL	1	pr./f.w.	lect.	pr./f.w.	lect.	pr.j.ex.	lect.	lect.	pr.j.ex.
	2	demo.	demo.	o.j.i.	demo.	o.j.i.	pr./f.w.	pr./f.w.	pr.j.ex.
	3	pr.j.ex.	-	pr.j.ex.	pr./f.w.	pr./f.w.	pr.j.ex.	pr.j.ex.	pr.j.ex.
ECONOMIC	1	lect.	lect.	lect.	lect.	lect.	lect.	lect.	lect.
	2	tute.	o.j.i.	o.j.i.	tute.	pr./f.w.	tute.	tute.	tute.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	o.j.i.	pr.j.ex.	pr.j.ex.
COMMTN.	1	pr.j.ex.	lect.	lect.	lect.	pr.j.ex.	lect.	lect.	pr.j.ex.
	2	o.j.i.	o.j.i.	pr.j.ex.	o.j.i.	pr.j.ex.	pr./f.w.	pr.j.ex.	pr.j.ex.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.
MANAGEMENT	1	pr.j.ex.	lect.	lect.	lect.	lect.	lect.	lect.	lect.
	2	pr.j.ex.	pr.j.ex.	o.j.i.	pr.j.ex.	o.j.i.	o.j.i.	tute.	pr.j.ex.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.

N.B. in the above table abbreviations mean:-

lect. = live lecture
tute. = tutorial
pr.j.ex. = practical job experience
o.j.i. = on job instruction
pr./f.w. = practical/field work
demo. = demonstration

Of the forty cells in the table above, thirty-five are complete, and of these, twenty-six contain as the first and third choices

TABLE 8.1.8. NOMINATED BEST WAYS OF ACQUIRING KNOWLEDGE FOR VARIOUS TASKS (3 WAYS IN ORDER OF PRIORITY)

CHOICE		QUALIFICATION CATEGORY							
		1	2	3	4	5	6	7	8
TECHNICAL	1	lect.	lect.	lect.	lect.	lect.	lect.	lect.	lect.
	2	tute.	tute.	tute. demo.	tute.	o.j.i.	o.j.i.	o.j.i.	pr./f.w.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.
MANUAL	1	pr./f.w.	lect.	pr./f.w.	lect.	pr.j.ex.	lect.	lect.	pr.j.ex.
	2	demo.	demo.	o.j.i.	demo.	o.j.i.	pr./f.w.	pr./f.w.	pr.j.ex.
	3	pr.j.ex.	-	pr.j.ex.	pr./f.w.	pr./f.w.	pr.j.ex.	pr.j.ex.	pr.j.ex.
ECONOMIC	1	lect.	lect.	lect.	lect.	lect.	lect.	lect.	lect.
	2	tute.	o.j.i.	o.j.i.	tute.	pr./f.w.	tute.	tute.	tute.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	o.j.i.	pr.j.ex.	pr.j.ex.
COMMTN.	1	pr.j.ex.	lect.	lect.	lect.	pr.j.ex.	lect.	lect.	pr.j.ex.
	2	o.j.i.	o.j.i.	pr.j.ex.	o.j.i.	pr.j.ex.	pr./f.w.	pr.j.ex.	pr.j.ex.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.
MANAGEMENT	1	pr.j.ex.	lect.	lect.	lect.	lect.	lect.	lect.	lect.
	2	pr.j.ex.	pr.j.ex.	o.j.i.	pr.j.ex.	o.j.i.	o.j.i.	tute.	pr.j.ex.
	3	pr.j.ex.	-	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.	pr.j.ex.

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lect. = live lecture
tute. = tutorial
pr.j.ex. = practical job experience
o.j.i. = on job instruction
pr./f.w. = practical/field work
demo. = demonstration

Of the forty cells in the table above, thirty-five are complete, and of these, twenty-six contain as the first and third choices lecture and practical job experience respectively. Admittedly this is a simplification, but it must raise again the idea of a combination course of theory and practical job experience as being the superior method of organizing vocational training. Lack of practical work comes high on the list of training deficiencies listed later in this chapter.

Question 7 referred to tertiary civil engineering education in general.

"How do you view your post-secondary/tertiary training? Please indicate by ringing one of the numbers on each of the following 5-point scales:

(a) 1 — 2 — 3 — 4 — 5

1	2	3	4	5
too few general principles of civil engin.		about right	too many general principles of civ. eng.	

(b) 1 — 2 — 3 — 4 — 5

1	2	3	4	5
too little detailed factual subject content re civ. eng.		about right	too much detailed factual subject content re civ.eng.	

(c) 1 — 2 — 3 — 4 — 5

1	2	3	4	5
too little 'general engineering education'		about right	too much 'general engineering education'	

The results were left of centre in each case: those respondents with bachelor's degrees were nearer 3 and those with certificates were slightly nearer point 2. The "straight down the middle" answers to this question were surprising after considering the imbalance in training indicated in answers to earlier questions. Possibly the attraction of the middle answer on a five-point scale proved irresistible. On the other hand the answers to the questions, which relate to content/theory, can indicate that the theory balance was satisfactory.

8.1.5.2. Open-ended Questions

The open-ended questions dealt mainly with training/education. The majority of respondents (about seventy percent) enjoyed their tertiary training overall and about twenty percent did not. The reasons for "not liking" tended to cluster around course structure, difficulties associated with the course, uninteresting content and presentation, inadequate teaching methods, and also personal conditions and pressure. Surprisingly differences between groups with different qualifications were not great.

More far-ranging answers were given to aspects that were liked, e.g. way of life and freedom of thought scored significantly for those with degrees and diplomas, but hardly at all for those with certificates. On the course structure the item labelled practical work was a clear favourite in six of the seven categories of formal qualification (degrees and certificates), followed by various items dealing with course structure, presentation, content and advance of knowledge.

Summarising, most respondents enjoyed their courses, and the part they enjoyed most was the practical work. Of those who didn't enjoy it, curriculum problems were the main reason.

Deficiencies in training, skills acquired through necessity, etc. produced about one thousand responses. These, however, readily reduced to seven items or groups. These are shown in detail in

(a)

1	2	3	4	5
too few general principles of civil engin.		about right		too many general principles of civ. eng.

(b)

1	2	3	4	5
too little detailed factual subject content re civ. eng.		about right		too much detailed factual subject content re civ.eng.

(c)

1	2	3	4	5
too little 'general engineering education'		about right		too much 'general engineering education'

The results were left of centre in each case: those respondents with bachelor's degrees were nearer 3 and those with certificates were slightly nearer point 2. The "straight down the middle" answers to this question were surprising after considering the imbalance in training indicated in answers to earlier questions. Possibly the attraction of the middle answer on a five-point scale proved irresistible. On the other hand the answers to the questions, which relate to content/theory, can indicate that the theory balance was satisfactory.

8.1.5.2. Open-ended Questions

The open-ended questions dealt mainly with training/education. The majority of respondents (about seventy percent) enjoyed their tertiary training overall and about twenty percent did not. The reasons for "not liking" tended to cluster around course structure, difficulties associated with the course, uninteresting content and presentation, inadequate teaching methods, and also personal conditions and pressure. Surprisingly differences between groups with different qualifications were not great.

More far-ranging answers were given to aspects that were liked, e.g. way of life and freedom of thought scored significantly for those with degrees and diplomas, but hardly at all for those with certificates. On the course structure the item labelled practical work was a clear favourite in six of the seven categories of formal qualification (degrees and certificates), followed by various items dealing with course structure, presentation, content and advance of knowledge.

Summarising, most respondents enjoyed their courses, and the part they enjoyed most was the practical work. Of those who didn't enjoy it, curriculum problems were the main reason.

Deficiencies in training, skills acquired through necessity, etc. produced about one thousand responses. These, however, readily reduced to seven items or groups. These are shown in detail in Table A8.16. (Appendix 8) for the eight qualification categories. This table has been further summarised in the following ranking with item 1 the greatest deficiency:

(1) management/personnel items
(2) economic/financial items
(3) communication items

(4) lack of practical work
(5) public relations
(6) computers
(7) environment ideas.

It should be noted that the one thousand responses mentioned above came from 83 percent of the total number of respondents. For those groups with civil engineering degrees or diplomas a mean of 94 percent indicated deficiencies of one sort or another, and for that group with no qualifications 77 percent indicated deficiencies. Thus the response was near to uniform across all qualification groups.

If one excludes for the moment the first three items on the list, the fact that lack of practical work should be the first technical curriculum item is of interest.

In order to be clear about the meaning of the phrase "lack of practical work" the actual responses in the completed questionnaires were re-examined. This examination revealed that there was no confusion in respondents' minds, they were not referring to practical work of the engineering laboratory type but to practical work in the real job situation. There were comments such as "practical experience and relationship of knowledge to a practical situation", "practical application of engineering principles" "lack of connection between what was taught and its practical application", "confidence based on practical experience", "lack of practical experience". Some comments from those working in Consultants' offices were "deficient in practical design training", "more practical design", "practical site experience". From construction companies came "lack of training or practical applications", "subjects not related to actual construction procedures".

Of particular interest also was the comment concerning deficiencies in training "Nil, mainly due to the fact that I worked with civil engineering contractors prior to tertiary (qualification)" from a respondent who had experienced the sandwich course pattern of study.

Clearly then the phrase "lack of practical work" referred to practical training concerning, or practical experience of the non-ideal and non-theoretical real work situation.

This raises again the controversy about engineering education in general: is it biased towards engineering science/theory rather than engineering?

Is insufficient attention paid to the practical application of engineering knowledge? The respondents in our survey have said this was the case and have implied there was imbalance in their training.

The importance of this is still further increased if one recalls the recommendations, discussed earlier, on the best ways of acquiring knowledge for the various tasks, when respondents were strongly in favour of a combination of theory and practical job experience.

The medical profession overcame this problem of producing a "rounded" professional, capable of practising immediately after training, years ago. Should the engineering profession be facing the problem of producing similar "rounded" engineers.

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The sandwich type of course does not fulfil the need if the theoretical/formal training is not closely integrated with the practical job experience. Medical training may have many aspects that engineering training could adopt with benefit.

Management is a difficult subject to teach and for the student full-time course might best be left until after the graduate has had some exposure in industry. Formal courses in the practice and theory of management may well, however, be regarded as forming an essential component of the training of a professional engineer. A few years ago in the U.K. both graduates and Higher National Certificate holders (now no longer recognized) were required to take and pass an endorsement course in the Management of Men as a means of fulfilling the educational requirements for membership of some professional engineering institutions. It is not beyond the bounds of possibility therefore, for graduates being required to attend an organized course on management, say one year, after completing their basic course. It is an unfortunate fact at the moment, however, that formal management training is left to the whim of the individual or his employer. If the entire civil engineering course were remodelled to include as an integral item practical job experience, there would be fewer problems concerned with teaching the basic ideas of management.

Some similar arguments apply to economic/financial matters, and communication matters. However, the former should be introduced alongside technical content. The civil engineer often uses the two types of skill in conjunction, why should he not be taught them in conjunction?

The remaining open-ended questions dealt with such topics as criteria of success in the job, decision making, creativity and the future. A question seeking views on what the training of respondents most fitted them for was not extensively answered. The wording was ambiguous and the answers reflected this. (Some details concerning the latter are given in Table A8.21. in Appendix A 8.)

The views on criteria of success were wide ranging and some twenty-five categories were developed to accommodate the answers. Initially these were examined with reference to the eight categories of qualification but this did not produce significant differences. Respondents were then grouped into broader categories as follows: those with a degree, diploma, or local government qualification; those with certificates; and those with no qualifications. The most frequently selected criteria (in descending order) are given in Table 8.1.9. Also included are those items thought to be of least importance in determining success in one's job.

TABLE 8.1.9. CRITERIA OF SUCCESS IN THE JOB
RANK IN DESCENDING ORDER
(LOWEST RANK = 25)

CATEGORY OF ANSWER	OVERALL RANKING	BROAD QUALIFICATION CATEGORY		
		Degree/ Diploma	Certi- ficate	No qual.
Technical efficiency/competency	1	1	1	1
Knowledge/qualifications	2	4	2	2
Completion of work/project	3	2	-	5
Time efficiency/competency	4	7	3	3
Personal relationships/ diplomacy	5	3	-	22
Good management	6	5	21	-
Financial efficiency/competency	7	6	-	-
Public relations	8	-	7	-
Initiative/drive	9	-	-	4
Experience	10	-	4	-
Decision making	11	-	6	22
Seniority	12	-	4	-
Honesty/Integrity	16	22	-	-
Flexibility	16	-	21	-
Creativity	18	-	24	22
Reliability	22	22	21	-
Conformity/submission to authority	23	-	25	22
Leadership	24	24	-	-
Opportunism	25	24	-	-

The detailed results are given in Appendix A.8. Table A.8.17.

Answers to this question were also examined according to (1) level of employment and type of work, (2) level of employment and age of respondent, and (3) level of employment and type of employer. Data relating to these are given in Tables A8.18, A8.19 and A8,20 of Appendix 8.

These further analyses were carried out to determine any additional views concerning "criteria of success" that might exist between the various levels and types of employment. A close study of the tables in Appendix 8 mentioned above shows many different views do exist Perhaps of greatest interest is the comparison between the views of engineers engaged on design work, and those engaged in construction work. The following table shows the items given the top rankings by engineers working on design and on construction, and by engineers working in consultants' offices and for contractors.

TABLE 8.1.10. CRITERIA OF SUCCESS IN THE JOB (NUMBER OF RESPONSES AND PERCENTAGE OF TOTAL RESPONSE)

	Engineers design		Engineers employed by Consultants		Engineers - construction		Engineers employed by Contractors	
(No. in group) n =	60		35		91		32	
Total no. of responses to question	110		62		156		53	
Item (no significance in order)	Response for item	Percentage of total responses	Response for item	Percentage of total responses	Response for item	Percentage of total responses	Response for item	Percentage of total responses
Efficiency/competency-technical	23	21%	15	24%	21	13%	5	9%
" " -speed	1	1	4	6	13	8	1	2
" " -financial	3	3	2	3	16	10	5	9
Completion of work/productivity	13	12	7	11	18	11	5	9
Knowledge/qualifications	9	8	7	11	10	6	6	11
Personal relationships/ diplomacy	11	10	5	8	11	7	5	9

From the above table it is clear that construction engineers rate "completion of work/productivity" and "efficiency/competency-financial" more important than or as important as "efficiency/competency-technical" for determining success in their job. Design engineers, however, rate "efficiency/competency-technical" much more important than any other item.

The relationship that exists between technical matters and economic/financial matters in civil engineering appears to be strong for the construction engineer.

Whether education was believed to help to develop technical decision making depended to some extent on the type of education received, although differences were not large. Of those with degrees or diplomas who answered, rather more than half thought it did help; of those with certificates from half to less than a half thought it helpful.

The particular part of the education which helped develop this skill was thought mainly to be that part dealing with the design of structures. Table A8.22. in Appendix 8 presents the data in detail.

Asked whether their education encouraged them to develop their own ideas or to use traditional methods, respondents indicated that, in the main, in fact they used traditional methods. Provision was made in editing for a variety of combination answers to be coded, and the details are given in Appendix 8, Table A8.23. Even if allowance is made for the influence of combination answers (of the type "used traditional methods more than developed own ideas") the impression that traditional methods were used most frequently still emerges. It can be effectively argued, of course, that in the majority of cases traditional methods will be easier, cheaper and quicker to use, and that education should be concerned with making students familiar with them and how to use them.

There is some suggestion in the results that respondents with civil engineering degrees received more encouragement to develop their own ideas, and that this was connected with devising "new methods". There is not much difference, however, between the 'degree' group and the 'certificate' group in this respect.

The final question was based on the idea that people engaged in civil engineering would probably have views on the trend of development in the industry, and that if there were a consensus of opinion, this could be of value to those concerned with designing curricula. The data in detail are presented in Tables A8.24 and A8.25, in Appendix 8. The results from the examination of this data have been summarised in the following Table 8.1.11; the main items only have been listed.

TABLE 8.1.11. THE FUTURE

ITEM	GROUP/CATEGORY								
	All respondents	Subjects with degree/dip.	Subjects with certificate	Engineers - design	Technicians - design	Engineers - construction	Technicians - construction	Engineers - other work	Technicians - other work
n =	331	175	103	60	98	91	16	49	15
No. of responses	369	231	97	83	84	120	11	58	15
Improved and/or more systems	1	1	1	1	1	1	1	1	1
New materials	3	5	2	4	2	5	3	4	2
New equipment	6	6	5	6	3	6	-	-	2
More attention to economics	5	4	6	4	-	3	-	5	-
Greater social concern	2	2	3	2	5	4	3	2	4
More specialization	3	3	4	3	4	2	3	3	-
More general education	8	7	-	7	-	7	-	-	-
More use of refresher courses	7	8	-	8	6	-	-	6	-

(NUMBER AGAINST EACH ITEM INDICATES RANK IN THAT GROUP'S NOMINATION FOR MAJOR DIFFERENCE BY 1980)

From the above one can conclude that respondents thought that the 1980 civil engineering scene would differ most from that today by the greater use of systems, and by the improvement to existing systems. Reference to Table A8.24 in Appendix 8 will show that 148 of the total 369 responses selected this particular "systems" item. The second place item "social concern" was some considerable distance behind with a frequency of 50 out of the total response frequency of 369.

Answers to this question were also examined according to level of employment and age of respondent, and finally according to level of employment and type of employer. Data relating to these are given in Tables A8.26. and A8.27, of Appendix 8. However, no major variation on the ranking shown in Table 8.1.11 appeared, slight differences can be detected by comparing Tables A8.26, and A8.27 of Appendix 8.

ITEM	GROUP/CATEGORY								
	All respondents	Subjects with degree/dip.	Subjects with certificate	Engineers - design	Technicians - design	Engineers - construction	Technicians - construction	Engineers - other work	Technicians - other work
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More attention to economics	5	4	6	4	-	3	-	5	-
Greater social concern	2	2	3	2	5	4	3	2	4
More specialization	3	3	4	3	4	2	3	3	-
More general education	8	7	-	7	-	7	-	-	-
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There is little ambiguity about what is meant by greater use of systems and improved systems. In essence, respondents imagine, for example, that more of the parts of a building or bridge will be pre-fabricated off site, brought on site in a systematic way and assembled in a more systematic way in 1980 than is the case today. This already happens, but it will be improved and used to a greater extent by 1980. It is of interest to recall the MIT definition of civil engineering which reads "the engineering of systems of constructed facilities" and their inclusion of systems as one of the five areas of specialization basic to all civil engineering problems and projects. Others have developed this idea (see Chapt. 9.) and see greater utilisation of mathematical models, computer simulation, critical path and PERT techniques.

In concluding this section it should be admitted that it has not been possible to examine every inter-relationship. * The analysis of the data has been limited by the time available. Hopefully the more important factors have been considered.

* This statement ought to be considered in perspective. In fact more than one hundred pages of computer print out (listing) were examined in the preparation of the preceding table and discussion dealing with the "Future".

8.1.6. Responsibility

Our interest in responsibility, and the basis of the scheme we devised for assessing responsibility were discussed in Chapter 6.1.1. The scoring system in this scheme consisted of three parts, the first dealing with responsibility for men, the second with money and the third with policy. Good reasons exist for keeping these three distinct types of responsibility separate, not the least of these being that a combined score would need to take into consideration the relative weight that should be attached to each type of responsibility if scores in each type were to be summed in some fashion. We did not feel competent to weight the types of responsibility although we believe that responsibility for men should be weighted more than the other two responsibilities. This discussion concerning the data has had to be carried out in terms of the three separate types of responsibility.

The factors involved in the present scheme are repeated below:

A. Men responsibility.

(i) Number and type of staff for which responsible.

B. Money responsibility.

(i) Incidental expenditure, running expenditure, cheque signing limit.

(ii) Capital expenditure limit.

(iii) Value of plant and equipment for which responsible.

(iv) Value of work or project for which responsible.

C. Policy responsibility.

(i) Responsibility for technical decisions.

(ii) Connection with policy making.

(iii) Involvement in policy interpretation.

(iv) Safety decisions.

(v) Social responsibility and legal responsibility.

Detailed results are given in Appendix A9. It will be noted that there is no reference to professional responsibility in the broad sense in this section of the report. The subject of professionalism and professional responsibility with respect to engineers is discussed in Chapter 10.

When dealing with men we asked for information on the numbers of men in defined categories for whom responsibility was taken. The defined categories were unskilled staff, craftsmen and tradesmen, technician, graduates, and managers and 5 year graduates. A value was placed on each category, selected without systematic justification, but based on a standard organisation structure, and a score was worked out on the numbers of men and their arithmetic values.

Money responsibility, of four types was scaled on a non-linear five point scale, values assigned and total scores worked out.

Policy responsibility of five types was scaled on a five point semantic differential scale, values assigned and total sums worked.

Th[illegible] recorded on page 12 of the copy Task Analysis these being that a combined score would need to take into consideration the relative weight that should be attached to each type of responsibility if scores in each type were to be summed in some fashion. We did not feel competent to weight the types of responsibility although we believe that responsibility for men should be weighted more than the other two responsibilities. This discussion concerning the data has had to be carried out in terms of the three separate types of responsibility.

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Money responsibility, of four types was scaled on a non-linear five point scale, values assigned and total scores worked out.

Policy responsibility of five types was scaled on a five point semantic differential scale, values assigned and total sums worked.

These scales are recorded on page 12 of the copy Task Analysis Questionnaire (Appendix 13) at the end of this report.

The scheme for rating had, therefore, many defects. The three types of responsibility could not be grouped and their individual scores totalled, because of the difficulty of weighting each of the three types. Within responsibility for men the values assigned to each type of staff were arbitrarily selected and the weightings open to criticism. Within money responsibility the four scales were assigned equal weight but could easily have been otherwise. In addition the scales were non-linear but as a first approximation to give direction rather than quantitative extent were scored linearly for ease of operation. The same comments apply to the five scales within policy responsibility.

In all therefore the scheme, whilst having the appearance of quantitative accuracy was riddled with the inaccuracies associated with any subjective assessment or rating. This should be borne in mind when drawing more than indications or general directions from the data.

The tables presented in Appendix 9 show differences in responsibility between various groups and different types of work. Engineers as a group generally have much greater 'man responsibility' than have technicians. Within engineers those engaged on design work have less 'man responsibility' than those engineers engaged on construction and other work. Within the technician group those engaged on construction appear to have slightly greater 'man responsibility'. Table 8.1.12 which follows shows this.

TABLE 8.1.12. MEAN RESPONSIBILITY SCORES FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK

	LEVEL OF EMPLOYMENT AND TYPE OF WORK					
	Engineers - design	Engineers - instruction	Engineers - other work	Technicians - design	Technicians - instruction	Technicians - other work
n =	60	91	50	98	17	15
(mean score) Man responsibility	15	31	29	3	6	2
Money "	36	56	46	22	34	24
Policy "	58	62	58	32	45	40

The table also shows that engineers and technicians working in construction have greater 'money responsibility' than other groups of engineers and technicians.

The results also indicate, as would be expected, that responsibility increases with age for both engineers and technicians (Table A9.5 of Appendix 9). Mean responsibility scores for engineers, and for technicians for each of the salary ranges (Tables A9.7 and A9.8 of Appendix 9) show that the higher salary ranges are associated with higher mean responsibility scores. This is not unexpected, but it [illegible] of [illegible] which h[illegible] been devised has [illegible] give direction rather than quantitative extent were scored linearly for ease of operation. The same comments apply to the five scales within policy responsibility.

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Clearly this has implications for curriculum construction in vocational institutions which are interested in producing appropriately trained individuals.

The purpose of examining the question of responsibility arose out of the preliminary study of the 'on site' components that are associated with a job in civil engineering. The real life job on the site does not consist simply of knowing certain technical engineering facts about an operation. This operation cannot be put into practice without men, materials and equipment. Real life decisions are not simple since the three factors impinge on each other and compete. Responsibility for part of, or the whole of the decision-making processes is readily measured therefore by a combination of the levels of responsibility given to and accepted by an individual for the factors mentioned previously. Questions must therefore be asked as to whether encumbents understand the diverse parts of a total responsibility component in a civil engineering job and whether they were trained or prepared in any way to assist them to accept such responsibility. It has been argued by some that people vary because of their genetic make-up, in ability to handle responsibility. This in our view is not an answer, it merely avoids the argument. Some may by virtue of their genetic make-up be better than others, or more amenable or teachable than others. Some may be more keen or interested to accept because of motivation, than others, but all such differences are in no way different from those associated with any natural ability or motivation concerned with or related to a wide variety of acquirable skills. Everyone cannot reach the standard of a concert pianist but many can be taught to play an acceptable tune. The tone deaf or those with manual deficiencies might best be advised not to enter the field as practitioners at all. It is probable that some skill in assuming or accepting responsibility can be acquired by most people who are so interested. One can also be taught to delegate authority, for some it is a difficult skill to acquire but it can probably be taught.

Where or how is responsibility taught in the civil engineering training? Where is practice given in decision taking? Perhaps the only evidence that can be mustered concerns responsibility for technical decision but it can be argued that the technical decisions made in a traditional course of training are not real. If students think about it at all they know that no steel will be erected, no concrete poured on their design or construction problem decisions.

Therefore, even an understanding of the responsibility for technical decisions can only come in real work situations and not in the lecture, or whilst working on assignment.

8.1.7. Review of conclusions drawn from examination of data gathered in Task Analysis Questionnaire.

Some attempt will now be made to gather together the main points that have arisen as a result of analysing the data provided by the Task Analysis Questionnaire.

8.1.7.1. Engineers - tasks

The average task profile of an engineer engaged on design work appears to differ from that of an engineer engaged on construction work. In the case of the latter, more time appears to be spent on financial and management matters and less on technical matters compared with the former. Similar indications arose when the tasks of those employed by contractors were compared with the tasks of those employed by consultants.

That such a difference between the tasks of design and construction engineers exists has been suggested by individuals for some time, but this is the first time as far as we know that quantitative evidence has been assembled that confirms the difference.

For engineers as a group 58 per cent of their time is spent on non-technical tasks, but this rises to 64 per cent for construction engineers and drops to 46 per cent for design engineers. The major difference in the non-technical items is in financial matters and management matters, as mentioned earlier. The tasks of the financial matters category consisted of estimating the costs of, and costing work in progress, which for all types of engineer occupied them to a significantly greater extent than either feasibility studies or cost benefit analyses, either separately or in total. In the management category of task all five sub-categories of activity (Table A6.1 Appendix 6) were utilised.

Approximately ten per cent of the tasks of engineers were concerned with utilising manual skills, but differences in how this time was spent were noted between construction engineers and design engineers. The former spent 44 per cent and 48 per cent on drafting and using survey instruments respectively, and the latter spent 70 per cent and 14 per cent on the two manual skills respectively.

Differences between the two groups of engineers exist also in the technical items they use in their tasks.

Thus not only do the two groups have different task profiles, the technical items they use are different. Clearly this has implications for curriculum development.

The responsibility associated with construction work appears to be greater than that associated with design work, particularly with respect to men, and also with respect to money.

8.1.7.2. Technicians - tasks

There appears to be little difference in the way time is allocated to the various categories of task by the three groups of technicians. For all technicians 26 per cent of their time is spent on non-technical tasks. Of these non-technical tasks estimating the cost of, and costing work in progress were predominant in the financial matters sub-category. In management tasks all sub-categories were involved, but organising and directing occupied most time.

In the manual skills sub-category no surprises were revealed. Design technicians were mainly occupied with drafting, but work appears to differ from that of an engineer engaged on construction work. In the case of the latter, more time appears to be spent on financial and management matters and less on technical matters compared with the former. Similar indications arose when the tasks of those employed by contractors were compared with the tasks of those employed by consultants.

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Differences between the two groups of engineers exist also in the technical items they use in their tasks.

Thus not only do the two groups have different task profiles, the technical items they use are different. Clearly this has implications for curriculum development.

The responsibility associated with construction work appears to be greater than that associated with design work, particularly with respect to men, and also with respect to money.

8.1.7.2. Technicians - tasks

There appears to be little difference in the way time is allocated to the various categories of task by the three groups of technicians. For all technicians 26 per cent of their time is spent on non-technical tasks. Of these non-technical tasks estimating the cost of, and costing work in progress were predominant in the financial matters sub-category. In management tasks all sub-categories were involved, but organising and directing occupied most time.

In the manual skills sub-category no surprises were revealed. Design technicians were mainly occupied with drafting, but the use of survey instruments occupied a not inconsiderable time

(84 per cent for drafting and 11 per cent for survey instrument use); for construction and 'other work' technicians the time distribution was different (32 per cent and 17 per cent, and 41 per cent and 19 per cent respectively). In these two latter groups of technicians laboratory work occupied 39 per cent and 28 per cent respectively. Thus a technician in design work is almost exclusively occupied with drafting, but all other technicians in the survey spent, very roughly, one third, one third, and one quarter of their time on drafting, using laboratory apparatus and using survey instruments respectively. The implications of this for technician certificate courses in the industry are obvious.

The technical items used by technicians differ depending on whether they are design technicians, construction technicians or engaged on 'other work'. However, these items have a closer relationship with the engineers in their type of work group rather than with each other. This is readily understood when the objectives of technician training, and the technicians' role as support staff are remembered. Does this mean it may not be all that difficult for a technician to acquire the knowledge and skills to become an engineer within a particular type of work grouping, once he has acquired some knowledge and skills in that type of work?

The responsibility associated with construction work appears to be greater than that associated with design work, with respect to both men and money.

8.1.7.3. Engineers compared with Technicians - tasks

The work of the group of technicians has a similar technical matters element to the work of the group of engineers, but a smaller range of technical items is used by the technician group than by the engineer group. Only about 12 per cent of the technical items listed in the questionnaire were used by the technician group compared with 34 per cent by engineers. In addition, for technicians around 60 per cent of the total items that are used by them have 10 per cent or less usage, and for engineers around 20 per cent of the items that are used by them have 10 per cent or less usage. Table 8.1.13. shows this.

TABLE 8.1.13. NUMBER OF TECHNICAL ITEMS WITH FREQUENCY OF 10% OR LESS OF 'n'

	'n'	Number of items with frequency 10% of maximum frequency (n)	% of total 63 items
Engineers			
- design	60	8	13%
- construction	92	13	21
- other work	30	13	21
Technicians			
- design	98	40	63
- construction	17	41	65
- other work	15	37	59

Generally, therefore, it can be said that engineers use more technical items more often than technicians, but a substantial of their time on drafting, using laboratory apparatus and using survey instruments respectively. The implications of this for technician certificate courses in the industry are obvious.

The technical items used by technicians differ depending on whether they are design technicians, construction technicians or engaged on 'other work'. However, these items have a closer relationship with the engineers in their type of work group rather than with each other. This is readily understood when the objectives of technician training, and the technicians' role as support staff are remembered. Does this mean it may not be all that difficult for a technician to acquire the knowledge and skills to become an engineer within a particular type of work grouping, once he has acquired some knowledge and skills in that type of work?

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Technicians			
- design	98	40	63
- construction	17	41	65
- other work	15	37	59

Generally, therefore, it can be said that engineers use more technical items more often than technicians, but a substantial number of items get little use. What implication has this for the content and structure of curricula?

Also of relevance when considering content is the almost exclusive indication that only a general level of knowledge of most technical items is needed in performing the tasks in civil engineering jobs.

The technician group spend much more time utilising manual skills than does the engineers group - 41 per cent for technicians and 9 per cent for engineers.

The question remains however, apart from systematic experience, how much really separated the technician from the engineer, and is this separation measured in terms of what they are capable of doing or by some convenient, if unnecessary yardstick (such as what qualifications did they obtain a decade ago) in order to restrict artificially promotion from technician to engineer.

8.1.7.4. Training Analysis - Engineers, Technicians

The pattern of opinion that emerges from an examination of the data related to training suggests that technical matters and manual skills were emphasised in the formal post-secondary training of respondents but even so practical experience considered deficient was of 'very much' importance in acquiring the skill. Other categories of task, viz., financial, communication, and management were generally not dealt with in training and because of this practical experience was rated of 'very much' importance in acquiring skill related to the task.

When asked to nominate the best pattern of training for acquiring knowledge required for the performance of the various categories of task, even though eight alternative methods were listed the results reflected traditional thinking, i.e. for technical skills a degree should be obtained full-time and a certificate, part-time. For manual skills T.W.I. (training within industry) receives as much support as the traditional part-time pattern. Short intensive courses and T.W.I. are generally nominated for other categories of tasks although those with engineering degrees rank economic/financial matters worthy of inclusion in the full-time course, equally with the T.W.I. pattern or short intensive course pattern of training.

A related question asking respondents to nominate the best ways of acquiring knowledge for performance of the task also reflected traditional thinking and live lectures were most frequently nominated as first-choice. There was some spread of answers for second choice, tutorials, on the job instruction, demonstration, practical job experience, and practical/field work all being selected, but for third choice practical job experience was almost exclusively nominated by all respondents across all categories of task.

This must confirm once again the view that a combination course of theory and practical job experience is thought to be the superior method of organizing engineering training, or perhaps any type of vocational training. From curriculum consideration, however, it remains to be decided whether these should be concurrent or sequential.

8.1.7.3. Open-ended questions

The important part of this section in the questionnaire related to deficiencies in training, and skills acquired through necessity. The main deficiencies, in order of decreasing nomination, were skills and knowledge related to management, financial, communication, and practical work.

The fact that the first three items are listed is perhaps understandable, but lack of practical work should not occupy any position in the list, let alone the fourth position. This must reflect on the training that engineers and technicians in the study received.

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The fact that the first three items are listed is perhaps understandable, but lack of practical work should not occupy any position in the list, let alone the fourth position. This must reflect on the training that engineers and technicians in the study received. Admittedly no training can provide exposure to all the practical problems likely to be met in a real work situation, but it might be expected to provide a great deal of it. This could imply that practical training should run concurrently with the theoretical content of the curriculum.

8.2. CURRICULUM QUESTIONNAIRE

The Curriculum Questionnaire was developed by the staff of the N.S.W. Institute of Technology, and was intended to examine respondents use of, and the importance they attached to the "elements" of civil engineering knowledge associated with that section of a course dealing with structural design. (Chap. 6.1.2.).

It was decided after the questionnaire had been edited and the data transferred to punch cards that the analysis would be carried out by the Institute (Chap. 7.3.). The reason for this was that the staff of the Registrar's Department, Education Research Unit, and the staff of the School of Civil Engineering at the Institute who had been primarily responsible for the questionnaire were thought to be best suited to carry out the data analysis. At the same time it was thought this would divert work from the already over-loaded computer facility at Macquarie University to the computer facility at the N.S.W. Institute of Technology and thus facilitate data processing.

For a variety of reasons, however, this work has not yet been finished. Therefore, in order not to delay the printing of the report of the main work of the survey it has been agreed that the findings of the analysis of the data obtained by the Curriculum Questionnaire will be reported separately as Volume Two later in the year.

8.3. STUDY CONCERNED WITH FOREMEN

8.3.1. Foremen in Civil Engineering

A key person in civil engineering construction activity is the foreman. A major construction site General Foreman has wide responsibility for men, money and materials, and his position in the management hierarchy reflects this. Reporting to him are the foremen responsible for the different sections of the project. Together, this body of men is concerned with executing the work in such fashion that time and money targets are achieved, and design requirements and safe construction codes are complied with.

Thus foremen are an important segment of the entire labour force engaged in civil engineering. The question we had to decide was whether they came within the scope of this present research. It seemed that General Foremen certainly did, both from the nature of their work and from the salaries they were paid, and they were therefore included in the main research as part of the technician population. When it came to the ordinary foreman, supervisor, etc., we were undecided whether or not to include him in the survey. Our indecision was caused by interviews with foremen conducted during the preliminary phase of the study. It was clear that this group was comprised of able men many of whom had not had the opportunity of proceeding to tertiary study and had followed the traditional apprenticeship route. Claims are now made that this route is now followed by a less able group than hitherto because of the wider opportunities for tertiary education based on "comprehensive" secondary education. If fewer foremen are produced from traditional sources,where might they be recruited from - future certificate or diploma courses?

This indecision was resolved by deciding not to include the foreman in the main survey but to include him in a smaller more simple study. Thus the sample of foremen selected was smaller, a shorter

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This indecision was resolved by deciding not to include the foreman in the main survey but to include him in a smaller more simple study. Thus the sample of foremen selected was smaller, a shorter questionnaire was developed, and our whole approach to this small sub-study was, in today's terms, "low key".

Information concerning the sub-population of foremen was collected at the same time as that concerning the overall population of civil engineers and technicians. It was agreed that for this homogeneous sub-population a lower rate of sampling could be used even allowing for the expected poor response due to the outdoor nature of the foreman's work and the difficulty of reaching him. A figure of 10 percent (300 on 3009) was decided upon. Even if a low response was obtained it was thought this could provide some useful preliminary data.

The response to the questionnaire was 74 out of a total of 345 distributed, i.e. 21 percent.

The same standards of accuracy were applied to collecting the data, editing the questionnaires, card punching, data processing, etc., as were applied to the main study.

8.3.2. Characteristics of the Respondents as a Group

Details of the characteristics of the group of respondents are provided in Appendix 11. The five tables presented in the appendix show the distribution of the group over type of employer, the age distribution, the employment pattern, the formal training and where the course of formal training was completed.

The main observations which can be made about the group of respondents are:

a) a large percentage (85%) are employed by government bodies of one sort or another.

b) the age distribution may reflect the depression period and World War II period and the effects of those two events on careers open to school leavers at those times. It has been predicted that with the freer availability of post-school education and training of one sort or another the traditional source of foremen will dry up. However, foremen will continue to be needed whether called by another name, and trained in a more formal way. The marked cut-off below age 31 may indicate persons below this age do not have sufficient experience to be a foreman.

c) there is a tendency for foremen to stay in a job for many years. This may be related to the predominance of government employment.

d) promotion to foreman comes only after several years employment in the industry. This confirms the view expressed at the end of 'b' above.

e) slightly more than half, forty (54%), had completed formal training, eight of the forty had two qualifications, and of these eight, seven had a foreman/overseer certificate and a trade certificate, either one as a first qualification.

f) the majority by far, of those who had certificate qualifications had completed this in a technical college in N.S.W. (N.B. Initial sample limited to N.S.W.).

8.3.3. Elements of Technical and Other Knowledge Used During Job Activities

The main part of the questionnaire distributed to foremen sought information on the usage, the importance, and the level of knowledge or understanding of a list of "elements" of civil engineering. This list comprised technically oriented items, e.g. "placing concrete under water", management oriented items, e.g. "planning a simple construction job" and items such as "interpretation of contracts" and "report writing". The list was kept short and totalled 76 items. Each item consisted of a simple unambiguous phr[illegible]

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a) Usage:-

1. would indicate that you spent almost all your time using that element

2. would indicate that you spent more than half of your time using that element

3. would indicate that you spent less than half your time using that element

4. would indicate that you spend almost no time using that element

b) Importance:-

1. would indicate that the element was very important to your job

2. would indicate that the element was important to your job

3. would indicate that the element was not very important to your job

4. would indicate that the element was not important to your job at all.

c) Knowledge:-

1. indicates complete theoretical and working knowledge

2. indicates knowledge of principles only

3. indicates practical working knowledge

4. indicates basic facts only

5. indicates no knowledge of element required for your job.

A little less than ten per cent of the respondents did not reply to this section at all and the non-answers rose slightly when passing from column A, to column B, to column C. There appeared to be no falling off in the answer rate towards the end of the list.

The results have been analysed simply by constructing a table with the most frequently used "elements" at the top of the list followed by other "elements" in order of decreasing usage. The table has been limited in length. In addition a short table has been formed of those items which are least used.

Two similar tables have been constructed from the data concerning the importance attached to the item or "element".

From the two tables, "elements" most frequently used, and "elements" of most importance, a short combined list has been prepared of those "elements" in a construction foreman's work that he used most, and to which he attaches most importance.

The basic lists are detailed in Appendix 11. The short combination list is given below, with no significance attached to the order of listing:-

TABLE 8.3.1. LIST OF "ELEMENTS" MOST USED AND OF MOST IMPORTANCE.

Safety regulations
Solving problems
Plant
Planning a simple construction job
Training workers on the job
Various aspects of concrete
Developing group morale
Report-writing
Book and record keeping
Calculations concerning reduced levels.

In general the spread of frequencies over the importance aspect of each "element" suggested that the people engaged in those jobs attach importance to more items than they actually use. Perhaps the book of knowledge or information concerning the job needs to be larger and fuller than they actually need most of the time.

The third question we asked concerning each "element" of knowledge was the level of knowledge required. With respect to each of the above items the frequency of answering was as follows:

TABLE 8.3.2.

Element	Level of Knowledge* 1	2	3	4	5	No answer
Safety regulation	31	5	29	3	1	5
Solving problems	22	6	33	4	2	7
Plant	32	4	29	2	2	5
Planning a construction job	37	5	22	4	2	4
Training workers on job	24	4	28	4	5	9
Developing group morale	14	10	29	10	6	5
Report-writing	22	8	23	5	5	11
Various aspects of concrete (12 items) averaged as follows:-)	17	6	26	8	9	8
Lowest ranking item (max. score under column headed by 5)	2	3	5	21	35	8

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Various aspects of concrete (12 items) averaged as follows:-	17	6	26	8	9	8
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*
1 indicates complete theoretical and working knowledge
2 indicates knowledge of principles only
3 indicates practical working knowledge
4 indicates basic facts only
5 indicates no knowledge of element required for your job.

The conclusion to be drawn from this seems to be that where an item is considered important opinion is split roughly equally on whether a complete theoretical and working knowledge (1) or only a working knowledge (3) is required.

Much criticism can be levelled at the width of interpretations of such phrases as "solving problems", "planning a simple construction job", and "plant". Criticism of the terms used to subdivide the frequency of usage, degree of importance, and level of knowledge scales can also be made but pilot testing indicated the terms were understood. Further questions seeking information on how a foreman's working time was spent appeared on pages 8 and 9 of the questionnaire. The answers showed:-

a) most of his time was spent supervising people and dealing with problems associated with the nature of the work.

b) a significant amount of time was spent policing safety regulations.

c) from less than half to very little of his time was spent on writing and reading letters and reports, etc., very little time on industrial relations, and problems connected with the work force, disputes, wages.

d) on the subject of communication, this was effected almost exclusively by talking.

Whilst the questions in this particular section were few in number and specific, the answers do, nevertheless, substantiate the conclusions reached from studying the answers to questions on the usage and importance of certain items of technical and other civil engineering knowledge discussed earlier.

8.3.4. A Foreman's Job

Summarising, one can say that a foreman's job in 1972 consisted of:-

a) supervising people and work
b) being concerned with safety and regulations concerning safety
c) solving problems
d) being concerned with plant and equipment
e) planning
f) training workers
g) group morale
h) report writing
i) all aspects of concrete

Examining this list one must conclude that a foreman's work is largely managerial in nature. Supervision must consist mainly of activities normally labelled management, but we were not prepared for such a clear cut picture as was obtained. In a nutshell the foreman's work is Management, Safety and Concrete.

All reference to responsibility was kept out of the questionnaire sent to foremen but this is not to say that responsibility is not an important factor in a foreman's work; just the opposite, and of such phrases as "solving problems", "planning a simple construction job", and "plant". Criticism of the terms used to subdivide the frequency of usage, degree of importance, and level of knowledge scales can also be made but pilot testing indicated the terms were understood. Further questions seeking information on how a foreman's working time was spent appeared on pages 8 and 9 of the questionnaire. The answers showed:-

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All reference to responsibility was kept out of the questionnaire sent to foremen but this is not to say that responsibility is not an important factor in a foreman's work; just the opposite, and foremen are well aware of this. A job concerned with supervising men and work must involve accepting responsibility. This was discussed at length at a forum organised recently at the University of N.S.W. by the *Australian Institute of Construction Supervisors. G. Kavanaugh-Randell, Past President, Australian Institute of Construction Supervisors, himself a construction supervisor, said at this forum,

> "It has been said that responsibility must be balanced by authority, and an examination of authority given may well define responsibility. In my position the authority of innovation is seldom given and therefore, my responsibility in the areas of design, introduction of new techniques, or of change in procedure is almost zero. My powers of co-ordination are limited to the work force or to the work site except by special delegation which limits my responsibility in this respect to one of co-operation. This leaves two recognized areas of authority - directing and controlling. Directing is a command function designed to attain a pre-conceived objective, and I not only give direction, but I also delegate and sustain directing authority through-out the ranks, this being bounded by area, by my personal efficiency and by the amount of responsibility I am prepared to accept. Complementary to this, is the authority of control, a policing function by which activities are kept within desired bounds, and by which sanctions may be applied to maintain production."

Clearly then foremen, or supervisors in civil engineering, as a body, are well aware of the responsibility factor in their work. It has been said that the worst thing that can happen to a foreman is to have a man killed whilst working on the site. Such responsibility is at a high level and is reflected in the importance attached to safety and safety regulations by respondents to our questionnaire.

8.3.5. Training of Foremen

The views on how someone should be trained for their job ranked as follows:-

1) Part-time course followed by full-time practical experience.
2) Full-time formal course.
3) Full-time followed by part-time course.
4) Short intensive course.
5) Training within industry.
6) Correspondence.
7) Self-learning.

Experience of formal class-room teaching was high and suggested the preference ranking above was based on first hand knowledge of the benefits of formal training. In fact, training was rated of great value generally. However, when examined on how they had been trained, the majority of the respondents had received 'on the job training' or had 'picked it up as they went along.' Only about thirty percent had received formal training and most of these in recent years. There was a wide variety of courses included in the term 'formal training' and only seventeen of the seventy-four (23%) had completed a recognized foreman's course. When [illegible] define responsibility. In my position the authority of innovation is seldom given and therefore, my responsibility in the areas of design, introduction of new techniques, or of change in procedure is almost zero. My powers of co-ordination are limited to the work force or to the work site except by special delegation which limits my responsibility in this respect to one of co-operation. This leaves two recognized areas of authority - directing and controlling. Directing is a command function designed to attain a pre-conceived objective, and I not only give direction, but I also delegate and sustain directing authority through-out the ranks, this being bounded by area, by my personal efficiency and by the amount of responsibility I am prepared to accept. Complementary to this, is the authority of control, a policing function by which activities are kept within desired bounds, and by which sanctions may be applied to maintain production."

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8.3.5. Training of Foremen

The views on how someone should be trained for their job ranked as follows:-

1) Part-time course followed by full-time practical experience.
2) Full-time formal course.
3) Full-time followed by part-time course.
4) Short intensive course.
5) Training within industry.
6) Correspondence.
7) Self-learning.

Experience of formal class-room teaching was high and suggested the preference ranking above was based on first hand knowledge of the benefits of formal training. In fact, training was rated of great value generally. However, when examined on how they had been trained, the majority of the respondents had received 'on the job training' or had 'picked it up as they went along.' Only about thirty percent had received formal training and most of these in recent years. There was a wide variety of courses included in the term 'formal training' and only seventeen of the seventy-four (23%) had completed a recognized foreman's course. When respondents were asked about their employers' attitudes to courses for foremen, sixty percent believed their employer gave encouragement and full support. When asked if they thought there was any alternative to learning a foreman's job other than practical experience, seventy percent said 'No'. Practical experience in combination with a theoretical course was the predominant alternative selected by the other thirty percent.

* "Areas of Responsibility in the Construction Industry" Construction Supervisor. p.19-25, Vol. 6. August, 1972.

An important question concerned topics the respondent thought he would have benefited from knowing more about them. Forty out of the seventy-four subjects replied to this question. As would be expected, the range of topics mentioned was wide but it has been possible to classify them broadly. Whilst the groups have no equivalence, they nevertheless show where deficiencies lie.

The list in order of frequency of mention is:-

Surveying/practical surveying
Human relations/psychology
Management
Accounting/costings/costs
Technical items e.g. concrete, soil mechanics, explosives, public health, sewerage treatment, water supply, drilling, piers, caissons
Report writing
Mathematics
Contracts, contract law, interpretation

In case it be thought that respondents answering this question were merely reflecting their own lack of formal training, thirty out of the forty replying had formal qualifications; the other ten had none. One could conclude that those respondents replying were perhaps more aware of deficiencies, and perhaps even more aware of the need for and value of formal training.

Five of this group of forty said they would have liked the opportunity to progress to a higher qualification e.g. diploma or degree.

One comment that gave pleasure stated - "more surveys of this sort to collate the thinking of up-and-coming foremen" would give benefit. Some engineer's during the early interview stages of the project made comments to the same effect. The questions had caused them to examine more closely what they were doing and they derived considerable benefit and satisfaction from this.

The penultimate question sought general information and was worded, "Please tell us as much as you can about a foreman's job and the training he should receive - you are expert in this type of work and in a position to tell us." Such a question invited a flood of comment and we were not disappointed. A summary of this comment would read - junior management in a technology-based industry. There were variations depending on whether, for example, Local Government, or Construction Company were the employer but these were slight. The work is essentially practical in nature and where technical knowledge is needed, it is practical knowledge rather than theoretical knowledge e.g. soils, concrete. Precisely what is meant by practical knowledge may be open to discussion but it is taken to mean knowledge about doing things and having knowledge about materials and operations that can spoil the end result. Theoretical knowledge often deals with the ideal, practical knowledge with the less than ideal, what makes it less than ideal, and how the 'idealness' can be maximised. Experience counts a great deal, but perhaps this is the only way of acquiring the exposure to and knowledge of management ideas, and also the practical training. Responsibility received fair mention and items such as keeping cost

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To conclude the questionnaire we tested the idea we had developed early in the study that many construction foremen were originally carpenters, and solicited the reasons for this. The following table summarises the response to this.

TABLE 8.3.3.a. RESPONSE TO PREMISE		TABLE 8.3.3.b. REASON IF IN AGREEMENT,/OR NOT	
No answer	13	No opinion, no answer	41
No - disagree	19	Carpenters have broader contacts with other trades and their methods.	10
Yes - agree	33	Nature of a foreman's job.	5
Don't know	5	Civil engineering is based on the type of work a carpenter does, hand construction work.	15
In certain areas only	2	A carpenter's job lasts only 2-3 years on a large site and he therefore takes jobs with other tradesmen and gains inside knowledge.	1
Not necessarily so	1	Carpenters work for themselves at one stage and employers know they can be relied on.	1
Unclassifiable	1	Dependant on area of work	1
	74		74

Our conclusion is that the premise that training for a foreman's job is normally via a carpenter's apprenticeship is not conclusively proven. It may have been the most popular route in the past, and in fact, almost all the respondents agreeing with this premise were over forty years of age. However, not all men over forty thought this was the case.

8.3.6. Conclusion

We must emphasise again that the study of foremen was carried out with less intensity than the main study, but the evidence suggests that when we widened our definition of a technician to include people using management techniques and so brought the construction foremen into the scope of the study we were correct in doing so. Construction foremen are an important sector of the population of skilled people working in civil engineering, they are technicians

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The analysis of the data has given clear indications of the main features of a foreman's work and those people concerned with designing courses for civil engineering foremen or technicians may find value in those items specifically mentioned.

9. CURRICULUM DEVELOPMENT

The overall intent of this study has been to examine the relationship between the practice of civil engineering and student courses in civil engineering. The report so far, however, has been concerned with establishing the features of current civil engineering practice at both the technician and engineer levels. In this chapter we propose to examine some of the factors identified in theoretical studies of curriculum development and then attempt to relate them to courses in civil engineering currently provided by educational institutions. Since the universities have had some effect on the curricula of the new C.A.E.'s data was also collected from all university departments offering civil engineering courses. In this chapter it has been possible to assemble information from every State.*

9.1 LINKS BETWEEN TERTIARY INSTITUTIONS AND INDUSTRY

The curricula of the various civil engineering schools exist in their present form largely as a result of tradition. Some change has been brought about as a result of perceived need, or outside wishes expressed through advisory committees, or inside views and attitudes injected by individual professors and lectures. Industry at large appears to have had little impact other than through advisory committees which, of necessity, must be restricted in size and therefore of limited representation, and because of the industrial duties of its members, meet on infrequent occasions. The limitations of this representation may be even more severe when it is realised that advisory committee members may be either powerful, personable leading men in the industry or individuals whose abilities mark them as committee members or attenders, both of which categories may have little to do with civil engineering at the operational level in spite of possible protestations to the contrary.

The fact that industry at large has had comparatively little impact on vocational education must be attributed to both sides in fair measure, academia claiming to know what is best for student courses, but being unwilling to offer objective evidence from systematic curriculum evaluation; and industry confining itself, when motivated to express views in public, to generalised statements that a graduate needs two years further training in industry before he is of any use, but not being able to formulate in any way suitable for remedial action why this is so.

One can argue at length on the causes that have created this state of affairs and the reasons why it persists. Hopefully the Colleges of Advanced Education with their emphasis on the whole of a vocational training will avoid the conflicting position of some universities, which proclaim their ability and desire to offer "education", but which are forced by economic circumstances to offer ostensibly straightforward vocational courses because large numbers of students demand them for career preparation and until recently have rejected courses in alternative institutions for prestige and other social reasons.+ At the same time perhaps, studies of the sort we are engaged on may dispel some of the myths about employment, in any case, of civil engineers and technicians in industry, both public and private. The mythology of both sides helps to perpetuate the barriers. Essentially, however, both industry and the tertiary institutions are part of the 20th century world, the one cannot survive for long without the other.

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* Replies were received in response to our enquiries from all universities with the exception of the University of Newcastle and all C.A.E.'s with the exception of the South Australian Institute of Technology. The authors are most grateful for the assistance received from the various Heads of School.

\+ See, for example, studies by Katz, F. and co-workers on the Tertiary Education Research Centre, U.N.S.W. on the differing conception of staff and students to the aims of university courses.

Of the few bridges between academia and industry, the most formal and easily recognizable is the advisory committee. In theory the work of an advisory committee is concerned, at least in part, with curriculum development. In order to find out more about the links between tertiary institutions and industry, a small preliminary exploratory exercise was mounted in which the institutions and departments concerned with civil engineering courses were asked what instruments were in use "for assessing industrial needs for manpower, and skills to enable appropriate adjustment of curricula content and teaching methods". Information was sought on the extent of participation of a) permanent research unit, b) part-time research unit, c) advisory committee (standing committee), d) ad hoc committee convened for specific tasks, e) and any other facility of this type. Further questions referred to the amount of work carried out in the areas of task analysis and job evaluation, on industrial manpower needs (concerned with work), on industrial manpower demands, educational research with respect to teaching methods and appropriateness of courses; curricula changes and the reasons for these, and finally information on the systems in existence for reviewing courses and making changes.

This short questionnaire was sent to the

a) six State Departments of Technical Education

b) seven Colleges of Advanced Education

c) nine Universities

offering civil engineering courses in Australia.

Replies were received from -

a) four State Departments of Technical Education

b) five Colleges of Advanced Education

c) four Universities.

Of the replies some were in letter form, unaccompanied by the questionnaire; letters were received from one department saying it had no courses, from another department with a detailed account of technician courses, from one college of advanced education saying its course had been in existence for only a short time, and from two universities who declined to complete the questionnaire as they felt that the information so provided would not present an accurate picture of procedures.

Questionnaires were thus returned by two Departments of Technical Education, four Colleges of Advanced Education and two Universities. The information is summarised below:-

1) The most frequently used instruments for assessing industrial needs for Manpower and Skills to enable appropriate adjustment of curricula content and teaching methods were:

1) Advisory Committee

2) Ad Hoc Committee convened for specific tasks

3) other
   (i) individual contact by head of department
   (ii) contact through sandwich course
   (iii) survey of overseas college syllabuses and educational publications
   (iv) questionnaires
   (v) having outside engineers on board and involved in staff discussions

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Research units, either permanent or part-time were seldom used; with the exception of one state government department.

Answers to questions concerning the number of hours that staff spent in committee work and in research were incomplete, but we formed the opinion that the more senior staff members of a school of civil engineering might spend between ten and forty hours per year in committee, with the average near the bottom of the range. As far as research was concerned, few figures were provided, but the impression was formed that not many people were involved, and of these the best allocation was sixty hours per year, with the average in the fifteen to twenty hour range. The figures concerning research were somewhat suspect because they were not borne out by later answers. In any event they are so near zero as to virtually indicate nil research. The exception again was one state government department of technical education whose division of curriculum research has a staff of 12 professional officers who undertake curriculum development revision and evaluation, industrial surveys, and related research.

Advisory committee or board members were drawn from university professors and staff, state department heads and staff, private enterprise heads and staff, recent graduates, students, and local government personnel.

Later examination of some college handbooks showed that the composition of the course advisory committees varied widely. Footscray I.T. for example has a board to "advise the Department on matters related to Course design, Subject Syllabuses, Teaching methods, Teaching facilities and Liaison with industry." Its composition includes a representative of the Association of Professional Engineers as chairman, four others from industry, a university lecturer and six members of staff three of whom teach civil engineering. The N.S.W. I.T. at the other extreme has three staff members (Ex-Officio), one university professor and twelve representatives of a wide range of public and private industry.

Bendigo I.T. use a different approach and state "It is proposed to appoint an eminent practising civil engineer as adviser to the Civil Engineering Department. His task would be to ensure that the instruction given meets the needs of the profession, and that the examinations and projects are maintained at the appropriate standard. He would be invited to moderate the examinations and projects in the final year."

Some college handbooks make no reference to advisory committees although they may exist, for example Swinborne although the engineering handbook does state "Engineering courses are under constant review to ensure that they remain up to date" it would be of interest to determine when the college advisory boards (or other expert assistance) were established since their effectiveness is clearly greatest during the initial formation of a programme. Subsequent changes are much more difficult to achieve. Roderick of Sydney University in 1971 in discussion with one of the authors explains how they were attempting to alter their courses in the light of the current views on engineering education by getting more practising engineers to lecture and participate in the course.

Within the last five years only one attempt had been made at task analysis, none on job evaluation, two on manpower needs, and four on manpower demands.

"Educational research" in the last five years comprised three studies on teaching methods and four on appropriateness of courses.

Six major changes in curricula were reported. The bases cited for the decision to change were:

(i) to keep abreast of changes interstate,
(ii) to provide a better integrated course,
(iii) [illegible]

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(i) to keep abreast of changes interstate,
(ii) to provide a better integrated course,
(iii) to meet a demand,
(iv) direct request for a particular course,
(v) advisory committee,
(vi) representation from industry
(vii) to meet requirements of a professional institute,
(viii) staff recommendations
(ix) surveys/questionnaires,
(x) availability,
(xi) upgrading,
(xii) obvious need.

It was pointed out by some that curriculum revision is a fairly continuous process. A leaflet supplied later by Bendigo states that the new Diploma course will be reappraised in 1977 "with a view to making any amendments considered necessary in the light of experience gained in the first four years of operation. It may be necessary to amend the syllabus content to incorporate new developments in the sciences and in civil engineering. The course should continue to be reappraised thereafter every five years."

The system for reviewing courses and making changes involved in most cases hierarchical approval. Ten types were revealed:

(i) head of school initiated and conducted the review,
(ii) study area committee meeting regularly,
(iii) individual subject panel meeting regularly,
(iv) new students and new staff providing feedback,
(v) V.I.C. Course Development Committee,
(vi) Engineering Academic Board, and Education Committee of Council,
(vii) Board of Studies,
(viii) the use of questionnaires with students,
(ix) occasional symposia,
(x) by encouraging staff and students to make suggestions for improvement.

The cited uses of the various instruments were as follows:

	Permanent Research Unit	Part-time Research Unit	Advisory Committee	Ad Hoc Committee	Other Methods
State Education Departments (4)	1	0	2	2	2
Colleges of Advanced Education (5)	0	0	3	3	3
Universities (4)	0	0	2	0	1

Reference was made in the free response section to the substantial industrial experience of many of the academic staff. This was emphasised again in the later systematic survey when questions were asked concerning the extent of industrial experience incorporated within the undergraduate course. "The fact that many of the teaching staff in this Department have had significant periods in which they practised engineering prior to entering teaching, makes it a 'natural' for them to want to place all their teaching material in the perspective of the 'real world' engineering environment - the world of 'practice'. Further, we endeavour, by use of specialist lectures by practising Engineers and by active encouragement to attend Institution of Engineers meetings, to bring the student into contact with engineering practice."

Thus extensive use is made by some colleges of indirect rather than direct means of ensuing curriculum validity. Similarly some of the tertiary institutions which responded believed that it was not their function to determine manpower demands although due regard was paid to surveys by the Department of Labour (and National Service). The [illegible] five years."

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Thus extensive use is made by some colleges of indirect rather than direct means of ensuing curriculum validity. Similarly some of the tertiary institutions which responded believed that it was not their function to determine manpower demands although due regard was paid to surveys by the Department of Labour (and National Service). The preliminary survey questionnaire clearly did not reach the effective authority in some colleges where it was known to the authors that tentative manpower surveys were underway. Examples of these, such as the Civil Engineering Employment Survey conducted by K.S. Lennie from Footscray, were caught up in the subsequent more systematic study.

9.2 OBJECTIVES - Engineers

The curriculum process (or cycle) involves a number of steps the first of which is usually the determination of the curriculum aims or objectives. In an ideal cycle the method by which the attainment of these aims is to be measured (frequently regarded as the last step) is considered simultaneously.

The statement of objectives is no easy task. One frequently reads that engineering curricula are full of dead wood, or are too inclined towards engineering science, less frequently one reads about what should be in the curricula and what its objectives are, or should be. Because this study is concerned with a vocation - civil engineering - objectives must relate to a job and the preparation of a student in such a fashion as will enable him to perform efficiently in that job.

Many authors have commented on the overall aims of engineering courses Earnest* of Fenn College, Cleveland, U.S.A., when talking of Civil Engineers' Education referred in his paper to "one dean of engineering (saying): 'Engineering is rapidly demanding not one but three types of engineers (1) the highly creative composer who can create out of abstract science wholly new systems to replace or fill deficiencies in existing engineering products; (2) the talanted arranger of established knowledge who, on the basis of existing products, can design and build ingenious, improved systems or devices; and (3) an expert in assembling, operating and maintaining complicated machines and engineering works from specifications, required in increasing numbers to make the new technology work'". "To this list I (Earnest) would add a fourth - the old fashioned engineer, civil engineer if you please, who can design and build a good highway system, a safe dam, an efficient bridge, or drain a swamp economically, and do these things under the worst possible physical conditions with an untrained labour force". This last emphasis on economics is very real. An American wit (unknown) is reputed to have described a civil engineer as a man who can do for one dollar what any damn fool can do for two. If this last point is accepted it poses some interesting educational problems.

In attempting to determine what the overall aim and content of his course should be Dietrich+, of Purdue made a study of the institution's engineering alumni to try to determine the educational needs of engineers as these men reflected it from their own experience. The report showed that their ideas differed by age groups. Alumni who had been actively engaged in the engineering profession for one to five years felt they should have taken more practical courses while in college. Those graduated 5-15 years prior to the survey indicated that their curricula should have contained additional courses in mathematics, physics, chemistry and basic science. Those from 15-20 years out of school felt that public speaking, business organisation, finance and labour relations should have been given more time. Graduates with more than 25 years of professional experience maintained that more time should have been devoted to music, literature, drama and art.

A summary of much detailed intelligent thinking that occurred in the last decade in the U.S.A. entitled "Final Report on Goals of Engineering Education"≠ is worthy of close study. The report covering seventy-three pages is divided into three main parts, 'The Engineer in Future Society', 'Basic Engineering Education' and 'Advanced Engineering Education'.

One must ask what the overall aim of a course is and can this be expressed as a set of more detailed objectives. What also are the objectives of certain subjects that are included. What is the objective in mind when, say mathematics occupies a large sector of a degree course, or what will be the

The statement of objectives is no easy task. One frequently reads that engineering curricula are full of dead wood, or are too inclined towards engineering science, less frequently one reads about what should be in the curricula and what its objectives are, or should be. Because this study is concerned with a vocation - civil engineering - objectives must relate to a job and the preparation of a student in such a fashion as will enable him to perform efficiently in that job.

Many authors have commented on the overall aims of engineering courses. Earnest* of Fenn College, Cleveland, U.S.A., when talking of Civil Engineers' Education referred in his paper to "one dean of engineering (saying): 'Engineering is rapidly demanding not one but three types of engineers (1) the highly creative composer who can create out of abstract science wholly new systems to replace or fill deficiencies in existing engineering products; (2) the talanted arranger of established knowledge who, on the basis of existing products, can design and build ingenious, improved systems or devices; and (3) an expert in assembling, operating and maintaining complicated machines and engineering works from specifications, required in increasing numbers to make the new technology work'". "To this list I (Earnest) would add a fourth - the old fashioned engineer, civil engineer if you please, who can design and build a good highway system, a safe dam, an efficient bridge, or drain a swamp economically, and do these things under the worst possible physical conditions with an untrained labour force". This last emphasis on economics is very real. An American wit (unknown) is reputed to have described a civil engineer as a man who can do for one dollar what any damn fool can do for two. If this last point is accepted it poses some interesting educational problems.

In attempting to determine what the overall aim and content of his course should be Dietrich+, of Purdue made a study of the institution's engineering alumni to try to determine the educational needs of engineers as these men reflected it from their own experience. The report showed that their ideas differed by age groups. Alumni who had been actively engaged in the engineering profession for one to five years felt they should have taken more practical courses while in college. Those graduated 5-15 years prior to the survey indicated that their curricula should have contained additional courses in mathematics, physics, chemistry and basic science. Those from 15-20 years out of school felt that public speaking, business organisation, finance and labour relations should have been given more time. Graduates with more than 25 years of professional experience maintained that more time should have been devoted to music, literature, drama and art.

A summary of much detailed intelligent thinking that occurred in the last decade in the U.S.A. entitled "Final Report on Goals of Engineering Education"≠ is worthy of close study. The report covering seventy-three pages is divided into three main parts, 'The Engineer in Future Society', 'Basic Engineering Education' and 'Advanced Engineering Education'.

One must ask what the overall aim of a course is and can this be expressed as a set of more detailed objectives. What also are the objectives of certain subjects that are included. What is the objective in mind when, say mathematics occupies a large sector of a degree course, or what will be the

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* Civil Engineering, Vol. 33, No. 2, Feb. 1963, pp. 52-53.

\+ Civil Engineering, Vol. 35, No. 2, Feb. 1965, pp. 56-58.

≠ Journal of Engineering Education, Vol. 58, No. 5, Jan. 1968, pp. 367-446.

objective if one decides to include management studies in a certificate course. Without doubt the study of objectives is of great importance when considering curricula. Without doubt also, it is not a simple study.

Much has been written on the methods of presenting curriculum objectives. Mager* puts simply the case for writing objectives in behavioural terms. Bloom+ classifies objectives simply into cognitive, affective, and psychomotor domains, and a separate detailed handbook describing the hierarchy of objective levels is available for the cognitive and affective domains. No handbook within the series has been published for the psychomotor domain although some attempts at classification have been made for particular skills.≠

Hulda Grubman** when writing of the difficulties in reconciling the Mager and Bloom approaches says "objectives most readily stated in behavioural terms deal with the lowest levels of the cognitive domain with knowledge and comprehension (in the sense that they are used by Bloom) and with the first two levels of the affective domain, receiving and responding. However, most current curriculum projects have expressed primary concern with such higher cognitive levels as the ability to use knowledge in new situations, with developing creativity (synthesis and evaluation) and with other skills classified as analysis, synthesis and evaluation. Projects have also been concerned with the higher levels of the affective domain, with attitudes of students toward the subject and toward learning in general". Thus it may be possible to define some objectives for a technician course, particularly those concerned with skills, in behavioural terms, but for much of a civil engineering diploma/degree course the use of more general objectives only may be possible.

The Australian Situation

As part of the present study information was sought by letter (and received with two exceptions) from each college and university offering civil engineering courses. Part of this letter read "We should be pleased to receive any explicit statements of course aims or any outline curricula listing compulsory and optional subjects."

Much information was received including handbooks, detailed syllabi or curriculi prepared for new degree/diploma submissions and detailed personal notes. In some cases where it could possibly cause embarrassment to institutions acknowledgement to some will not be made. In other instances due acknowledgement is given in the excerpts below and in the following chapter on professionalism, from which it is difficult to separate part of the current discussion.

In addition to explicit statements on course aims attempts were made to determine implicit aims by reference to statements concerning examinations, course utility, etc.

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* Mager, R.F. "Preparing Instructional Objectives", Fearon Publishers, San Francisco, U.S.A., 1961.

\+ Bloom, B.S. "Taxonomy of Educational Objectives - Cognitive Domain", Longman, London, 1956.

≠ e.g. Sumner, R. The Vocational Aspect, 1968, 20, pp. 137-151, discusses the objectives of craft education and includes a psychomotor group.

** Grubman, Hulda, Evaluation activities of curriculum projects, AERA monograph series on curriculum evaluation, No. 2, 1968. Rand, McNally, U.S.A.

The most detailed statement of aims was received from the University of Melbourne (5 f.s. pages). This document listed and discussed aims under three headings : education appropriate for a graduate; for an engineer, and for a civil engineer. Part of this document is available in the appendix 12. No other detailed objective sets were obtained from universities although a reprint of a more general paper on "Goals of Engineering Education" was received from Professor J.W. Roderick of Sydney University. Statements on course aims and objectives were received from the following Institutes of Technology : Gordon, Capricornia, Preston, Bendigo and Footscray.

Some of the published statements on general aims caused some concern since serious assumptions appear to have been made. "In formulating this submission, the basic aim has been to provide a Degree course of the equivalent standard to that of a University <u>thereby</u>* preparing the graduate to take his proper place in a creative and demanding profession."

This citation on the university for support may depend upon statements such as that of Professor Roderick. "The preference in some industries has been for an engineering education with a strong vocational bias, of comparatively short duration but with ample opportunity for students to undertake courses part-time or on a sandwich basis. The same industrialists have supported diploma courses .... This has implied some criticism of the four year engineering courses given in the universities, namely that they were producing a type of engineer more concerned with the discovery and expansion of knowledge, than with the application of knowledge to the solution of practical engineering problems. Moreover, against this criticism must be set the fact that for many years past about 90% of the universities' output has been entering the profession to become successful practitioners."

A further defence cited by Roderick is the P-E report which asserts "It appears that industry has neither a clear nor uniform picture of its needs in young engineers."

Expansion of education based on this type of philosophy is fraught with problems. Candidates selected from the upper 10% of the ability range might be expected to become good engineers after solid on the job training under the worse circumstances <u>despite</u> their basic education and problems such as over-training leading to frustration and job dissatisfaction (on which evidence is now available overseas) can only be magnified by expansion of the present philosophy. The lessons following the expansion of degree courses in the U.K. (and the consequent (?) decrease in the H.N.C. enrolments) culminating in the Swann report - essentially an enquiry into problems (at the time) of persuading 'pure' scientists to enter industry, have yet to be considered for their potential applicability in Australia.

One senior departmental head recognised the danger and states "Most courses in tertiary institutions do not set out to train 'civil engineers' - they are presumably doing something much more esoteric - in such a case I presume 'clinical' experience is irrelevant."

Most of the C.A.E.'s claimed to produce graduates (or diplomates) immediately useful to industry but some qualifications were made, e.g. "Course aims at developing students ability to the point where they will have gained sufficient expertise to be immediately useful. Nevertheless, they will need to learn the particular techniques and procedures adopted by their employers since it would be impossible in the time available to expose them to many differing aspects of 'practice'".

Little difference was noted between the answers obtained from the universities on the C.A.E.'s, perhaps not surprising in view of some of the earlier comments.

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Only two universities claimed not to be producing an embryo professional engineer. The extremes of the universities views are "No - the intention is to provide the theoretical foundation of civil engineering. He then needs a few years of practical experience before reaching full professional status. Practical training periods during the course are aimed mainly at showing

* Our underlining

The general project which appears in some detailed curricula (accounting for 1/3 of the 4th year in the Bendigo degree course) appears the best opportunity to acquire some of the wider aims and to lend itself best to less classical methods of evaluation.

Among the universities the most interesting response to this question was given by the University of Queensland which offers the following programme.

1st Year (a) A course of engineering in history subdivided into

1) the development of engineering

2) engineering and the environment

3) engineering for the future

(b) A 27 hour project e.g. turning pollution into profit

4th Year (a) 40 hour project, for example

1) the impact of major dam construction on the local community

2) compensation for freeway resumption

(b) Individual seminar on subject with social implications

Examples cited by Horne and Wise indicated some deviation from the standard mass lecture situation particularly in the smaller colleges and also some modification of the former emphasis on end of year examinations. We were a little disturbed to find in one detailed degree proposal kindly sent for our consideration by a college clearly in the forefront of civil engineering education, specific subject objectives listed in most cases under the headings knowledge, abilities, appreciation, interest followed by statements such as "assessment will normally be by final examination of three hours. Satisfactory tutorial and practical work during the course will be a condition of entry* to the examination. Other tests may also be given."

In another subject the methods of assessment stated (a dangerous procedure to adopt!) appeared to contradict in part some of the objectives listed under appreciations and attitudes. Other subjects appeared to be more realistic and assessment could be made on exercises alone, a final examination or a combination of both.

Clearly the relationship between the objectives explicit and implicit, the methods of teaching and evaluation procedures in civil engineering in C.A.E.'s would be a profitable area of study.

9.3 CONTENT - Engineers

Five areas of specialisation basic to all civil engineering problems and projects - structures, materials, soils, hydrodynamics, and systems have been identified by the Massachusetts Institute of Technology, U.S.A. (MIT). The popular notion that the important problems are not technical, but are social, economic, or political is also dismissed by this institute. The MIT view is that the fundamental responsibility of the civil engineer is to ensure technical excellence for if this is not done he will lose the respect of other professions and the public.

Toakley+ and Brotchie take up this point made by MIT on systems, in a paper entitled "Engineering Education - the Relevance of Systems Studies", which deals mainly with the systems approach and utilises mathematical models, computer simulation, critical path and PERT techniques. The authors say that

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* Our underlining

\+ Toakley, A.R. and Brotchie, J.F. Civil Engineering Transactions, The Institution of Engineers, Australia, October 1971, pp. 96-99.

how the engineering theory is applied. They are not intended to provide professional experience." (Note - 40 working days experience required from each student - more than most C.A.E.'s!).

"Yes - our course goes beyond a study of theoretical principles and seeks to expose the students to practical problems .... This would not be our sole objective." (4½ months of practical training in addition to 3 weeks supervised workshop training required from all students - more than all but four of the C.A.E.'s).

In addition to being influenced by direct or implied comparison with the universities the courses in the C.A.E.'s are influenced by the requirements real, inferred, or imagined of the Institution of Engineers, Australia. One head of school was quite blunt "The main aim is to produce graduates acceptable to the Institution of Engineers, Australia, without which they cannot be 'Professional Engineers'."

All other handbooks made reference to the Institution and one college sent a copy of the basic educational requirements of the Institution alongside itw own aims and objectives. The real influence of this body through the immediate bias of its own members and indirectly through reciprocal arrangements with other bodies (e.g. the Council of Engineering Institutions in the U.K.) on the implicit aims of civil engineering curricula cannot be overemphasised. This influence will be discussed in more specific detail in the following section on the content of civil engineering courses.

It is common practice too frequently in educational institutions to have esoteric aims which are clearly negated in the methods used for student teaching assessment and evaluation. It is difficult to teach 'subjects' associated with practical and individual choice by means of mass lectures followed by standard paper and pencil examinations. In our survey of this area we relied heavily on the recent work of Horne and Wise together with such other material as we could glean from college handbooks. Some direct evidence was obtained from answer to the question

In the course what components, if any, are included to cover

"(5) professional responsibility material related to the social effects of engineering decision."

This quotation was borrowed from "Basic Requirements For A Professional Engineering Course" Journal of the Institution of Engineers March 1971 since it was

(a) at least in theory an essential component of any recognised course

(b) it allowed opportunity to demonstrate novel teaching procedures beyond the usual factual recall of low level cognitive skills

The extent of enforcement by the institution and the breadth of interpretation of the non basic science section of the regulations (see earlier quotation) deserves comment. Two colleges made no provision for this area of current popular concern and a further head of school "unable to locate the statement" believed that material used in the final year of design studies was relative to social effects. Most departments cited lists of subjects ranging from aesthetics in Engineering to a specific subject professional practice and including psychology, management, sociology and liberal studies but two pertinent comments were made, "Staff are asked to address themselves to this aspect throughout the course."

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"Substantial : but not in a single course. That would be regarded in the same light as religious instruction is sometimes regarded in state schools.

The sense of professional responsibility has to be imbued <u>at all stages</u> in the student's progress thru his course; he has to meet this consideration whenever he is posed a design problem - otherwise the exercise becomes very sterile indeed."

because of the general applicability of the techniques they may be used as a core for the curriculum providing a common basis for study and communications among the various disciplines.

The position of liberal studies in an engineering curriculum has been debated extensively for several decades. Wood* states that in Australian Institutes at best the time allowance for this component is less than one-third of the average in reputable schools of engineering in the United States of America.

Engineering courses in Australian Universities were discussed by Moorhouse,+ Willis & Lavery in four separate but related papers a few years ago. Frequent reference occurs in these articles to the requirements for professional membership of the Institution of Engineers, Australia, and the effect this has on engineering courses in Australia. Willis refers to work carried out by Gerstl and Hutton in the U.K. when nearly 1000 professional mechanical engineers were interviewed to try and ascertain the usage of various subjects, the criterion being used more than once in five days. They also sought the opinion of those engineers on the ideal course of study. Gerstl‡ & Hutton conclude that there should continue to be an emphasis on mathematics and mechanics, but the traditional technical curricula should be pruned in favour of broadening the education of engineers in communication and liberal studies, particularly human behaviour. Willis adds that these conclusions are generally sound, but would like to see every student study one of the traditional core subjects for a sequence of three stages.

Moorhouse in his paper entitled "General Survey" quotes as he terms it "the gloomy comment of one Australian Professor of Engineering who remarked to an English colleague that his main problems in Australia were: (1) convincing his university that engineering was worth having as a faculty; and (2) convincing industry that engineering graduates were worth employing." To these may be added (says Moorhouse): (3) convincing the general public and many of the families from which students come that engineers use their <u>minds</u> rather than their hands in their work. The perturbing effect of this latter comment on curriculum content is important.

In 1968, well after the appearance of the Martin report on the future of Tertiary Education in Australia, and after an intense period of discussion internationally about the best sort of training for engineers, all of which had impact locally, Vallentine** in a paper entitled "Engineering Education at the University" concluded, rather sadly, that "Australian Universities providing facilities for the education of engineers are slow to adjust to their responsibility of recognising the changing role of the engineer in society. Unless, and until their courses are broadened, made more flexible, less onerous and more generally attractive to the cream of intelligent young people, the quality and quantity of their output will not keep pace with the requirements of the nation.

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* Wood, J.F.D. "The place of liberal studies in Engineering Education", Journal of the Institution of Engineers, Australia, April-May 1969, pp. 67-71.

\+ Engineering Courses in Australian Universities

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(2) Electrical Engineering, C.E. Moorhouse
(3) Mechanical Engineering, A.H. Willis
(4) Civil Engineering, J.H. Lavery

The Australian University, Vol. 2, No. 3, November 1964, pp. 241-294.

‡ Gerstl, J.E. & Hutton, S.P. "Engineers - the Anatomy of a Profession",

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We appear to be training engineers for the immediate present, if not for the past. However, today's graduates will be competing for managerial positions twenty years hence, and therefore our current decisions in engineering education should take into account, as far as can be predicted, the requirements of the next generation."

The Content of Some C.A.E. Courses

An analysis of the diploma and degree courses at Bendigo and a comparison with the degree course at Melbourne and Monash universities was supplied in a programme summary received from Bendigo. This analysis was continued but using slightly different criteria and the results are shown in Table 9.3.1.

Table 9.3.1. **Curriculum Content Analysis**

		Preston	N.S.W.	Footscray	Wait	Swinburne	Bendigo	Bendigo (1)	Bendigo (2)	Melbourne University*	Monash*
			Degree	Dip.	Dip.	Dip.	Dip.	Degree		Degree	Degree
Liberal St.	%	7	6	7	3	7	6	5	10	1	2
Basic Sc.	%	19	24	20	24	17	19	18	24	37	35
Eng. Sc.	%	23	28	30	30	31	26	24	23	31	29
Civil Eng.	%	51	42	43	43	45	49	53	43	31	34

* As calculated by Bendigo using their criteria for classification of subjects. Our classification was based on an assessment of the classification patterns met by all the institutions. For comparison the self classification of Bendigo for the degree is shown in column (2). It was not possible to analyse the Melbourne and Monash curricula from the composite data supplied.

The following comparison is made between the Bendigo programmes and those offered by the Victorian Universities.

"It can be seen that a much greater liberal studies content is envisaged than at Victorian Universities, and the practical bias of the course is underlined by the greater proportion of time devoted to civil engineering applications, while still retaining a solid foundation in the basic and envineering scie-ces."

What justification exists for the components specified?

Colleges have as an external constraint the need for their courses to satisfy the basic requirements for a professional engineering course established by the Institution of Engineers, Australia, not only for the direct benefits of 'graduate' membership of the institution but for the salary benefits following such membership. Statements such as the following appear in all of the handbooks examined.

"The Diploma in Civil Engineering admits the engineer to 'graduate' membership of the Institution of Engineers, Australia, and thus enables graduates to be classified as 'qualified engineer' under the Australian Professional Engineer's Award for salaries" (these salaries were cited by two

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"The Diploma in Civil Engineering admits the engineer to 'graduate' membership of the Institution of Engineers, Australia, and thus enables graduates to be classified as 'qualified engineer' under the Australian Professional Engineer's Award for salaries" (these salaries were cited by two institutes).

Wood is concerned with the influence of the professional institution on the curricula of the institutes and states "it is much more important both for the students concerned and for the community that diploma courses should be designed to suit the ability of the majority of students entering them and the general requirements of employers."

Horne and Wise describe in detail the process which must be followed for course accreditation and this will not be repeated here. They also report that "Interviews with engineering staff in all states revealed that there was dissatisfaction with aspects of the accreditation procedure. If accreditation of courses is as important as the staff had been led to believe it was, then, to them, the actual inspection appeared superficial. In many instances travel timetables, rather than educational issues, governed the extent of discussions. It was often stated by staff that the inspection team which invariably consisted of members of university staffs, appeared to be unprepared to accept the view that the colleges could have different approaches to those of the universities."

"Discussion with IE (Aust.) officers revealed that the number of hours of classes in various areas of a course appeared to be an important criterion in granting accreditation. Pushed to extremes, this approach can reach absurd lengths, as for example, in one college in which a criticism was made by an inspecting group of the particular course that it contained only 495 hours of 'basic science' which was below the minimum of 500 hours previously proposed."

In our much more limited correspondence with institutions we received some similar comments concerning the influence of the institution on curriculum content.

Detailed examination of some curricula sent to us revealed some interesting results. One college stated quite clearly in its mathematics curriculum "The emphasis in the first two years is on mathematics which is actually utilised in other subjects, and which may be utilised in later years in industry. Mathematics 3 contains selected topics which the Degree student may find useful in advanced courses of study. By collaboration between the staff of the Mathematics and Civil Engineering Departments, it is intended to relate mathematical techniques directly to the solution of civil engineering problems whenever possible."

How can one reconcile the highly desirable sentiment of the latter part of the paragraph (the 'correlated' curriculum pattern) with the statement in the first part. The Institute of Engineers in its official statements concerning the increase in the minimum course length for recognition to four years by 1980 merely states "The developments which are taking place in science and technology and the necessity to provide adequate time for private study, individual effort and meaningful vocation experience are such that within a few years a course (full-time) of four years duration from matriculation will be the absolute minimum required to attain a sufficient standard for a professional engineer."

To satisfy the criterion of 'Breadth' under the current regulations the equivalent of two years (not necessarily the first two) should be spent on basic scientific and mathematical material appropriate to engineering and general engineering science material.

Why are these additional academic subjects finding their way into longer courses perhaps at the expense of integrated training experience. Are courses designed as stated earlier by the head of one school for ends much more esoteric than the production of professional civil engineers. To what extent are the universities to blame either directly or by their claimed influence on the Institution. Perhaps a meeting of all parties concerned could resolve some of the issues.

Since the C.A.E.'s are responding to the demand for more basic science, engineering science, and liberal studies* it may be desirable to consider the evidence [illegible] them, the actual inspection appeared superficial. In many instances travel timetables, rather than educational issues, governed the extent of discussions. It was often stated by staff that the inspection team which invariably consisted of members of university staffs, appeared to be unprepared to accept the view that the colleges could have different approaches to those of the universities."

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Since the C.A.E.'s are responding to the demand for more basic science, engineering science, and liberal studies* it may be desirable to consider the evidence available for their usefulness. Clearly much (how much?) of the former

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* These are immediately needed for the understanding of the technology

is needed as a basis for the understanding of technological developments. There is an implication however that some is included because of the greater critical thinking ability, logical behaviour, adaptability these basic subjects produce. The theoretical foundation for this type of basic science - liberal studies approach, however, rests substantially on discounted theories of mental discipline and transfer of training. Explicit references were found in many curricula to the following aims, similar aims were implicit in other statements.

<u>For the sciences (pure and applied):</u>

"Ability to apply the above knowledge to problem solving"
"The ability to apply the above principles to engineering problems"
"Ability to apply fundamental principles to new problems"

<u>For liberal studies:</u>

"An increase in critical judgment, flexibility, creativity, tolerance and sensitivity to the response of others and to ethical and aesthetic values"

<u>For the technology:</u>

"To induce attitudes of logical thinking which are the attributes of the professional"

Much could be written on the effect curriculum content may have in achieving these more general transferable aims but the essence is contained in the following quotations: Hilda Taba (former) expert in Curriculum Development in the U.S.A. "The idea that the study of certain subjects assures a general and automatic transfer, is still alive today. It's evident in certain proposals for the study of liberal arts as the means for developing the intellectual and spiritual powers of men irrespective of how they are taught." D.K. Wheeler expert in Curriculum Development in W.A. "Far too often the element of purpose in learning is forgotten and the subject itself is invested with a mystique and with powers that are totally unjustified. Usually this kind of claim rests upon ideas of faculty psychology and formal discipline, or misconceptions about the nature of transfer; as a result it is claimed that some subjects have greater power to train the mind then others. This leads to the idea that each of these subjects has its own logic, and that study of the facts will not only reveal that logic, but somehow enable it to be assimilated and applied by the learner. In some mystical way the subject produces mental discipline, irrespective of the methods used in learning it; expose the learner to the facts and methods, and he will grasp the essentials and make use of them elsewhere."

These authors would have us believe that transfer is possible providing the teaching procedures are appropriate. Horne and Wise state that small group teaching methods were used in part in most C.A.E.'s and examination of detailed curricula obtained from several institutions confirms this view. Preston Institute for example lists the teaching methods used in the attainment of their objectives which range from the standard lecture to seminars. If these arguments are valid perhaps <u>quality</u> of teaching which cannot be measured by paper summation of total number of hours or a cursory inspection visit ought to be added to the requirements of breadth and depth currently demanded by the Institution of Engineers if this body is the major influence on curriculum development.

Ausubel* the American psychologist however is much more pessimistic concerning the transfer of knowledge and processes irrespective of how they are taught. "critical thinking ability can be enhanced only within the context of a specific discipline. Grand strategies of discovery, like scientific method, do not seem to be transferable across disciplinary lines - either when acquired within a given discipline, or when learned in a more general form curricula to the following aims, similar aims were implicit in other statements.

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* Ausubel, D.P. "Educational Psychology", Holt, Rinehart and Winston, N.Y., 1968

judgment committed by distinguished scientists and scholars who wander outside their own disciplines. The only kinds of transfer that have been empirically demonstrated in problem-solving situations are transfer of specific skills, the transfer of general principles, and the transfer of general approach or orientation to a specified class of problems. Hence critical thinking cannot be taught as a generalized ability; in practice, it can be enhanced only by adopting a precise, logical, analytic and critical approach to a particular discipline."

To counter the frequently advanced argument that the greater rate of change today of the knowledge and practice within a technology make it essential that more basic principles and underlying theory should be taught and less currently useful factual knowledge and practice be taught, since such factual knowledge and practice will more rapidly become obsolescent. Ausubel comments "The argument is also strikingly reminiscent of the objection small boys make to the washing of their faces daily, namely that they will only get dirty the next day. Obsolence is a fact of life that must always be kept in mind; but this does not render futile the assimilation of the current content of knowledge, or council exclusive attention to the process whereby knowledge is acquired. It merely presupposes a readiness to revise those aspects of one's knowledge that gradually become outdated."

Further support for the emphasis on the technology component rather than the basic pure or applied science component is given by Broudy* an eminent American educational philosopher in a discussion of the tenuous links between school learning input and its subsequent out of school use. Broudy argues We may forget, for example, that high level cognitive function involves some replicative and associative uses of learning, and the easy dismissal of the learning of facts can be mischievous. One cannot learn engineering simply by studying logic and physics. Another undesirable consequence is that the applicational use so distinctive of technology will be equated with solving problems at the end of the chapter in a textbook, or going through the predicament - hypothesis - decision routine. Application, however, entails a great familiarity with the phenomena of a given domain, together with the technology for translating theory into operational equivalents. Most of us, outside or field of specialisation, do not often apply knowledge. Most of what we call application outside our speciality is inference by similarity, or suggestive analogy, that is, it is a form of interpretation rather than application."

Clearly more questions ought to be asked concerning the content of some C.A.E. courses. Is their main aim now a replication of what is done (or said to be done) by the universities? Our studies of current practice have shown that much of the 'theory' taught in shorter less sophisticated courses of the past decade is not used in industry yet many bitter complaints are received from graduates concerning their lack of knowledge of the real problems of civil engineering when they enter industry. How they might obtain this practical experience in the technology and the effect it might have on course length and character is discussed in more detail in the next chapter.

9.4 OBJECTIVES AND CONTENT OF TECHNICIAN COURSES

Parallel with this activity concerned with the education of engineers, much discussion, some of it fevered and confused, has taken place on the nature and types of technicians and their education. This concern for technician training started in the post-war decade at the time of a world-wide shortage of engineers. This shortage no longer exists, but the subject of technician training remains important due to the emergence of an understanding of the complementary role that technicians play to engineers in today's technology based societies.

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During the last decade a number of publications on the subject of

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* Broudy, H.S. "Curriculum Theory Network", No. 5, Spring 1970, pp. 16-32, Canada.

technicians and their training have appeared in the U.K., which reveal the extent of the work which had been devoted to establishing some basic guide lines. As frequently happens definitions assumed importance at the commencement of the deliberations. We had a similar problem and the definition we eventually adopted and the reasons that led to this are given in Chapter 4.1. Briefly, this was based on the definition prepared by Young*, but modified to include reference to management techniques. This also broadly agreed with the separate definitions for technical and business technicians proposed in the Haslegrave+ report.

Our definition reads - "A person expert in applying specific proven techniques associated with science, technology, and management; in particular one who has undergone a systematic course of instruction related to these techniques."

Whilst the definition refers to technicians in general, we think it can apply to civil engineering technicians in particular.

A number of important leads for effective curriculum construction are found in the Haslegrave report.

After considering the question of status and technicians the report says with respect to objectives, para. 24 "the technician is neither a superior tradesman, nor a depressed technologist .... One certain way of achieving this status is to ensure that the relevant programmes of training and education are 'custom-built' for technicians, deriving neither from craft courses 'plus' nor from technological courses 'minus'. The programmes must have their own integrity."

The content of a certificate course will relate closely to the needs of a particular type of job. An example from an overseas source is provided by Young (p. 16) when dealing with the proposed City & Guilds (London, U.K.) Construction Technicians Certificate: "This is intended for those who will attain positions in work involving structural detailing and other forms of draughtsmanship, setting out, measuring, taking off, working up, material scheduling, surveying, estimating, inspection, supervision (foremanship), production planning, method study and quality control. The course is complementary to the National Certificate (U.K.) in which the academic requirements are somewhat higher, and teaching techniques different from those used with National Certificate students will need to be employed."

This indicates the type of work that civil engineering technicians do. The latter part perhaps, hints also at a different ratio and type of theory and practical from that in the National Certificate Course.

The Institution of Civil Engineers (U.K.) have presented ideas on what type of work technicians could do in a pamphlet entitled "Scheme for Training of Civil Engineering Technicians". Item 3 states "Trainees under the Scheme should eventually become technicians in, for example, one (or more) of the following aspects of civil engineering work on site and in the office: Specifications and Reports, Estimating, Bills of Quantities and Measurement of Works, Planning and Programming, Surveying and setting out - including use of level and theodolite, Drawing Office work (including elements of design), Work Study, Research and Laboratory work, Plant (application), site cost control, Quality control, Traffic engineering. Opportunities exist for Technicians with the right qualities of leadership and organising ability to proceed to become inspectors of works, site agents and to occupy responsible positions in management."

The implications of the types of work just mentioned for those concerned with certificate course content are clear.

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* Young, J.T "Technicians, Today, Tomorrow", Sir Isaac Pitman & Sons, London, 1965.

\+ Haslegrave "Report of the Committee on Technician Courses and Examinations', H.M.S.O., U.K., 1969.

In the N.S.W. Technical Education Department the Division of Civil Engineering is within the School of Mechanical and Civil Engineering, and offers sixteen individual courses, of which nine are certificate courses, five are post-certificate, and two are special courses.

Certificate courses are	Administrative Survey Drafting Cartography Engineering Surveying Hydrography Land and Engineering Survey Drafting Surveying Farm Water Supply Materials Testing Structural Engineering
Post-certificate courses are	Administrative Survey Drafting Cartography Engineering Surveying Land and Engineering Survey Drafting Structural Engineering Higher Certificate
Special courses are	Aerial Photograph Interpretation Cartography (full-time)

The School of Building also conducts two related courses:-

Civil Engineering Foremen's and Overseers (Special)
Building Foreman & Clerk of Works (Part-trade)

Klamus* of N.S.W. Water Board has examined a number of these courses and has suggested a scheme for reducing the number of Civil Engineering certificate courses to one, but one with four options - a design option, surveying option, materials option and construction option. By this reduction the problems of equalising standards are more easily overcome, and curricula can more readily be standardised. Whilst this has no direct bearing on course content, nevertheless reducing the number of courses can lead to an increase in the frequency with which courses are reviewed and curricula changes made.

It would be of assistance in establishing courses if the boundary between technician work activity and engineer work activity was more clearly defined. Whilst we gathered ideas about this boundary as this study progressed, nevertheless it was sufficiently ill-defined in our estimation to justify our seeking the views of two authoritative panels. These panels for technicians and engineers respectively were convened on separate occasions and consisted of six carefully selected and representative people from government and industry. An account of these two meetings is given in Appendix 10.

From the two meetings it was difficult to conclude where the delineation lay. A wide range and diversity of sub-professional/technician staff was engaged in the civil engineering industry. At the technical officer end of the spectrum were men, who were claimed to be doing work of a general and broad nature similar to that usually associated with an engineer. At the other end of the spectrum, for example, materials testing, the technician operating the testing equipment was performing specialised work of limited and repetitive nature. Construction supervisors did not fit into this general spectrum and their work was characterised by a high management skills content and clearly defined areas of responsibility, e.g. high for men, but more diffuse for money and policy.

The work of engineers was said to be general in nature and at one

Engineering Surveying
Hydrography
Land and Engineering Survey Drafting
Surveying
Farm Water Supply
Materials Testing
Structural Engineering

Post-certificate courses are
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The work of engineers was said to be general in nature and at one stage of the discussion it was claimed that engineers operating in the civil engineering field were generalists with the ability or potential to exceed a technician's specialised knowledge and repetitive skill in any existing task and the responsibility and skill for the 'breaking in' or the development

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* Klamus, N.G. private communication

of new techniques because of their more lengthy training and/or their innate ability. The importance of management skills was emphasised and the member of the group concerned with construction activities went so far as to say that some project managers were not trained as civil engineers at all.

As mentioned earlier we found it difficult to define the boundary between technician work activity and engineer work activity. The opposite ends of the range of activity were clearly differentiated but we concluded there was no hard and fast boundary, in fact the region of overlap, or 'grey' area, was extensive.

For technicians therefore it is possible to state aims or objectives fairly well but the establishment of course content is more difficult. As for engineers a substantial, although not necessarily the major, component of a vocational training should be related to the job tasks performed later or concurrently by the person under training.

9.5 SEQUENCE

Much has been written on what should be included in courses for engineers and technicians, on how the various subjects should be arranged, how much time each should be allocated, and what subjects should be included. Teller*, of the Cooper Union, New York, U.S.A. claims that "underlying all these changes is an assumption - and the validity of that assumption is open to question. The accepted hypothesis is that the essential format of the curriculum is correct; that science and mathematics should precede fundamentals of engineering behaviour, and the latter should precede application; and that this sequence of formal courses is best for the student. But for what student? Today's generation may not have the same learning psychology and objectives as the preceding generation."

Although the Institute of Engineers specifies content it specifically states that the order may be changed. Few systematic studies on the effect of different subject arrangements on success in vocational courses have been reported in the literature. In one recent study of an electrical engineering certificate+ course the order of the mathematics electrical principles sequence was found to be important.

The effect of various attendance patterns where industrial experience contributes to the learning experience has also been studied overseas.≠

9.6 EVALUATION

Modern curricula are subjected to a thorough evaluation before formal introduction. This evaluation normally proceeds through two stages. Stage one is usually referred to as formative evaluation** where the units of the course are examined for content by experts in the field of study and educationists and for 'teachability' by teachers and potential students. In stage two summative# evaluation, the whole of the course is examined to determine whether the aims and objectives specified are being attained. This proceeds through the application of a series of evaluation instruments where a range of cognitive, affective and psychomotor skills are measured. Although

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* Tailer, A.J., I.E.E.E. Spectrum, 4 March 1967, pp. 124-128

\+ Gilbert, R. private communication

≠ See for example studies of Corgrove, S., Sociology (1972) 6, pp. 59-70 and Jahoda, M., The Education of Technologists, Tavistock Publications, London 1963

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** For an example of formative evaluation of junior science courses see A.S.E.P. Melbourne

\# For an example of summative evaluation see the work of Mackay, L.D., The Australian Physicist (1970) V, p. 103

students are used in the evaluation process the aim is to test the course not the students.

As far as we could determine only the first stage of the formative evaluation process was used for the civil engineering curricula studied. In particular the content was examined by the Institute of Engineering and State Boards (through sub-committees) to determine if the content was 'good engineering'. Amendments to syllabi were frequently made as a result of this process. The industrial evaluation of the performance of graduates before final approval is given to a college course could be interpreted as one aspect of the summative evaluation process. Generally, however, students are examined rather than curricula evaluated and the examination is normally over a narrow range of cognitive skills.

It is also of interest to note that to our knowledge no systematic evaluation by industry has taken place of the relevance or suitability of a particular civil engineering course to the tasks performed by students in industry.

9.7 SUMMARY

We have outlined the basic stages of the curriculum process, objectives, content, and sequence. We have also commented on the evaluation and modification stages although detailed examination falls outside the scope of this report. We hope that the complex nature of curriculum development, and the large amount of work involved in determining the basis for vocational curriculum development, have been made clear. As Vallentine* has said, "The procedure of drafting or revising a professional engineering course by more or less democratic procedures in a community of scholars provides an enlightening, if drawn-out, procedure." The problems are much the same where certificate courses are concerned. It is now necessary to assemble the main features of civil engineering training/education at the engineer and technician level, as we see them, and these together with the findings of the survey outlined in Chapter 8 will show the basis upon which our recommendations are made in Chapter 12.

The objective of curricula in civil engineering courses must be to produce a competent (adaptable) worker with specialised skills for a particular level of the workforce, engineer or technician; either immediately after the completion of the course if it is conducted concurrently with suitable industrial training/experience, or after obtaining such experience in the case of a full-time 'academic' course. The question of adaptability has been discussed briefly in this report; scientific examination of how far a college course can produce adaptability or encourage or discourage a natural ability has rarely been done.

The content of the curricula must be related to the tasks performed in the jobs if minimum time is to elapse between completing the course and performing satisfactorily in the job.

It is therefore necessary to decide whether the traditional collection of subjects studied, some largely for their own intrinsic value, is the correct basis for civil engineering curricula. One must decide:

1) how many separate subjects are necessary?

2) how much of each subject is necessary?

3) when is the best place in the sequence for it to be taught?

4) what is expected to be gained from the subject or body of content?

engineering'. Amendments to syllabi were frequently made as a result of this process. The industrial evaluation of the performance of graduates before final approval is given to a college course could be interpreted as one aspect of the summative evaluation process. Generally, however, students are examined rather than curricula evaluated and the examination is normally over a narrow range of cognitive skills.

It is also of interest to note that to our knowledge no systematic evaluation by industry has taken place of the relevance or suitability of a particular civil engineering course to the tasks performed by students in industry.

9.7 SUMMARY

We have outlined the basic stages of the curriculum process, objectives, content, and sequence. We have also commented on the evaluation and modification stages although detailed examination falls outside the scope of this report. We hope that the complex nature of curriculum development, and the large amount of work involved in determining the basis for vocational curriculum development, have been made clear. As Vallentine* has said, "The procedure of drafting or revising a professional engineering course by more or less democratic procedures in a community of scholars provides an enlightening, if drawn-out, procedure." The problems are much the same where certificate courses are concerned. It is now necessary to assemble the main features of civil engineering training/education at the engineer and technician level, as we see them, and these together with the findings of the survey outlined in Chapter 8 will show the basis upon which our recommendations are made in Chapter 12.

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4) what is expected to be gained from the subject or body of content?

The inclusion of subjects for prestige purposes, for the excessive

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* Vallentine, H.R. "Engineering Education at the University", The Australian University, Vol. 6, No. 2, Aug. 1968, p. 190.

inclusion of subjects which can be administered easily, for example mathematics, or because they appear to have some support value, for example chemistry, for electrical technicians, requires further examination. By adopting more careful selection processes for compulsory subjects the right of tertiary students to choose and study subjects for their own intrinsic interest will be maintained and extended.

It also is necessary to decide whether some of the traditional beliefs about subjects which 'train the mind' and produce in the student critical thinking ability are valid beliefs in the light of modern work in this field, particularly when the discipline is taught by the traditional lecture, textbook, and practical work for verification approach. Furthermore, can a generalised transferable ability be taught at all.

Perhaps the rather more concrete evidence our survey provides will be a more substantial basis on which to make curriculum changes than the basis of what is often, opinion only, and that derived from a basis of vested interest. Many people have a stake in current curricula, and to have one's subject pushed out or reduced in hours is personal defeat, but something must give way if engineering and technician courses are to be of reasonable duration and interest, and be tuned to the needs of today and, hopefully, tomorrow.

Post script.

The additonal content not directly related to employment needs (e.g. additional third year mathematics) and the apparent lack of works exposure as part of the formal course has been referred to in this chapter and will be mentioned again in the following chapter on professionalism. Readers may wish to be reminded of the comments concerning course content made in the Wiltshire Report less than four years ago. There is, intended, to be an emphasis

a. "in treatment of a certain subject or subjects aimed at relating the studies directly to the work situation, thus tending to reduce the more general aspects of such subjects and the course as a whole."

b. "on studies involving the application of knowledge, with a consequent reduced emphasis on studies of a more theoretical nature."

c. "on practical skills to a greater extent in some disciplines than would be found in courses not specifically designed for vocational purposes, such skills being of significance to the occupational needs of the student."

d. "on the planning of the courses so that they are complete in themselves, thus fitting a successful student for his work in industry or commerce." (Wiltshire, 1969, p. 17)

Earlier in this report (Chapter 4.1) we indicated why we decided to use the terms engineer and technician as convenient labels for the two main groups with which this study is concerned. In addition, these terms were defined. For the engineer we adopted the definition of a professional engineer prepared by the Engineering Societies of Western Europe and U.S.A. (E.U.S.E.C.)., which reads as follows:

> "A Professional Engineer is competent by virtue of his fundamental educational and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, construction, manufacturing, superintending and managing and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgement and the ability to supervise the technical and administrative work of others.
>
> "His education will have been such as to make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information and applying it independently. He is thus placed in a position to make contributions to the development of engineering science or its applications.
>
> "His education and training will have been such that he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own branch. In due time he will be able to give authoritative technical advice and to assume responsibility for the direction of important tasks in his branch."

It is important to note that this definition is made mainly in terms of duties of the engineer.

In Chapter 4.1 we commented that use of the adjective professional gave us cause for concern, but there seemed no easy way of avoiding its use. In Australia a person could become or was a "professional engineer" if his qualifications (i.e. examination qualifications plus experience) permitted him or her becoming a member of a recognized engineering institution, e.g. Institution of Engineers, Australia. This latter Institution unequivocally says, with respect to the examination qualifications, +"the only acceptable method of meeting the initial educational requirement of the engineering profession is that of undertaking an ordered course of study in an engineering school accredited for the purpose."

As this project is concerned with civil engineering curricula we believed some time, albeit a little, should be devoted to an examination of professionalism and whether special features existed in civil engineering courses that could be connected in some way with later becoming a "professional engineer".

At the same time the necessary corollary of looking at jobs to determine what did or did not confer on them the accolade of being a professional engineer's job was also very much in mind in analysing the data gathered from the questionnaires returned to us. Also two special meetings with carefully selected authoritative representatives from the civil engineering industry at the engineer and technician levels were convened with the express purpose of attempting to find out what distinguishes a professional engineer's work from that of sub-professional/technician work. These meetings have been discussed in Chapter 9.4.

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* Professor A.S.Hall from U.N.S.W. made the following comment "The term "professional engineer" has unfortunately been more or less forced into frequent use by the vagueness attaching to the term "engineer" standing alone. The quick image in the mind of a member of the public by the word "engineer" is probably that of "garage mechanic". Plumbers, gasfitters, concretors etc. are all "engineers". Ideally, members of the Institution of Engineers should change their label entirely, but this is clearly impractical. If "medicos" called themselves "professional doctors" this would seem to imply that there are some "unprofessional doctors". Unfortunately this is the case with the word "engineer".

\+ Basic Requirements for a Professional Engineering Course - Consolidation of Various Previous Statements, Council of The Institution of Engineers, Australia. 20 March 1971.

Professional status is a sought after label and an increasing number of groups of working people are claiming their jobs are professional in nature. A number of sociologists, philosophers and others have looked at the professions and the distinguishing features of professionalism in modern society. There is reasonable agreement on the main characteristics. Fox* refers to two main criteria - some degree of science or learning connected with practice, such knowledge to include a range and depth of theoretical principles and their bearing on the larger difficulties of practice, and secondly - a code of ethics. Traditionally also a third factor involving independence of judgement and decision has existed, but is today often hard to achieve under modern conditions in large scale enterprises, in teaching, in public works and in other community undertakings governmental or 'private'.

C.E. Moorhouse+ writing on professional education states "The existence of a profession then implies the existence of a body of knowledge which is generally accepted by its members, and which is modified in the light of experience, and also of a professional institution". Moorhouse refers to Whitehead≠ as an authority on the nature of professions. In his chapter entitled "Aspects of Freedom" Whitehead writes "the term Profession means an avocation where activities are subjected to theoretical analysis, and are modified by theoretical conclusions derived from that analysis. - - - - This foresight based upon theory, and theory based upon understanding of the nature of things are essential to a profession". Whitehead claims further "The antithesis to a profession is an avocation based upon customary activities and modified by trial and error of individual practice. Such an avocation is a Craft. - - - Without question the distinction between crafts and professions is not clear cut. In all stages of civilisation crafts are shot through and through with flashes of constructive understanding, and professions are based upon inherited procedures. Nor is it true that the type of men involved are to be ranked higher in proportion to the dominance of abstract mentality in their lives. On the contrary, a due proportion of craftsmanship seems to breed the finer types. The brilliant ability, in proportion to population, of Europe in the fifteenth, sixteenth, and seventeenth centuries suggests that at about that period the best harmony had been reached. Pure mentality easily becomes trivial in its grasp of fact."

* Fox, A.C. "Criteria of a Profession"., Australian Journal of Higher Education.

+ Moorhouse, C.E., Professional Education. Australian Higher Education - Problems of a developing system. Ed. Harman & Selby-Smith, Angus & Robertson, Sydney, 1972.

≠ Whitehead, A.N., "Adventures of Ideas", Cambridge University Press, 1933.

At the time Whitehead was writing, of course, no recognized intermediate category of employment existed between craft and profession. It was not until after World War II that technicians and the role they play in our modern technology-based society came to be more clearly understood.

Whitehead notes the following features of the professions:

a) they were transformed by the advance of scholarship and rational science which culminated in an inversion of the roles of custom and intelligence, older professional practice being rooted upon custom,

b) through this inversion the professional institutions acquired an international life, each institution practising within its own nation, but its sources of life being world-wide. Thus loyalties stretch beyond sovereign states,

c) the most important function of these institutions is the supervision of standards of individual professional competence and of professional practice,

d) the functions of professional institutions constitute a clear cut novelty within modern societies.

Another development, foreshadowed by Whitehead and taken up in recent years by such writers as Galbraith is the growth in size of the business corporation or economic body corporate. Such organizations employ doctors, lawyers, and engineers. Concurrently a growth in size and number of government agencies, departments, and instrumentalities who also employ doctors, lawyers and engineers has occurred. Any consideration of professionalism in the 1970's must take into account the conflict of loyalties and duties that may exist for a professional engineer working for a government department or an international corporation. No conflict exists, of course, if the adjective professional today has a reduced or limited meaning compared to Whitehead's time.

An associated argument applies to a number of groups of people today who are currently seeking professional status. Amongst these are teachers, but it has been argued that in spite of the traditional links of teaching with the church and the ministry the fact that most teachers are employed by institutions or the government under one guise or another makes it difficult to see how the independence associated with professional status can be achieved. Perhaps, however, it is the status that is sought and not the independence and concommitant insecurity.

Goode + observes that "an industrial society is a professionalizing one" and asks why. In his essay "The theoretical limits of Professionalization" he examines the boundary of professionalism and concludes "that many aspiring occupations and semi-professions will never become professions in the usual sense: they will never reach the levels of knowledge and dedication to service that society considers necessary for a profession. Such occupations include school teaching, nursing, librarianship, pharmacy, stockbroking, advertising. business management and others."

"Further, most of the occupations that do rise to such high levels will continue to be viewed as qualitatively different from the four great <u>person</u> professions:- law, medicine, the ministry, and university teaching. This view will correspond to a social reality, for they will be less professional in such traits as cohesion, and rational Science which culminated in an inversion of the roles of custom and intelligence, older professional practice being rooted upon custom,

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• The Higher National Certificates (H.N.C.) in engineering existed in the U.K. in the 1930's but were essentially intended for professionals in training who could not afford full time attendance at university (or who did not hold appropriate entrance qualifications) rather than as technical courses for technicians as they are today.

+ Goode, W.J. "Theoretical limits of professionalization" Chapter 6 of "The semi-professions and their organisation". Editor Etzioni A. Free Press. New York, U.S.A. 1969.

the profession throughout their lifetime, homogeneity of membership, control over professional violation and others. In this narrower sense then, the occupational structure of industrial society is not becoming generally more professionalized, even though a higher percentage of the labour force is in occupations that enjoy higher prestige rankings and income and that call themselves professions."

Later when discussing the generating traits of professionalism Goode lists a number of traits but concludes that the two central generating qualities are:

1) a basic body of abstract knowledge
2) the ideal of service

Goode states further that:

a) professions normally have a monopoly since society has been persuaded it is dangerous to allow others to practice,

b) they have autonomy because others cannot judge their performance and are likely to shape their legislation, the manning of control and examination boards, and determine any standards for licensing,

c) members are likely to remain in the profession, and to assert they would choose the same work if they were to begin again,

d) the service ideal is incorporated in a code.

Towards the end of his essay Goode deals at length with the Person Professions and examines a facet of professionalism - the relationship between the professional and his client. A salient feature of this relationship is trust, the client must allow the professional to know intimate and possibly damaging secrets about his life if the task is to be performed adequately. On occasions there can be intensive interaction between the client and the professional. In contrast, the client can be a corporate one when interaction is much less, and the arrangement takes on the form more of a contract and less of trust. Perhaps as Goode concludes "the core of four great person professions has not expanded much to include many new professions, in contrast with the higher-level managerial and scientific-technical professions and semi-professions. In this much narrower sense then it is not entirely clear that the industrial occupational structure of the society is generally professionalizing. Relatively few professions are arising that require trust and autonomy and that can obtain it through transactions with society."

This view tends to add weight to our own uneasiness about the emphasis on the adjective professional when defining the engineer. However, let us look more closely at the engineer and professionalism, particularly the professional engineer in Australia. In a recent book Lloyd* (who has occupied executive positions with the Association of Professional Engineers, Australia) traces the development of engineering education and the engineering societies. He remarks that "education in the formal sense for the profession of engineering began within the last century or so, but the origins of engineering are lost in antiquity. - - - - "Engineering, as the term is understood today with its organized body of knowledge of both art and science stems from the Industrial Revolution in 18th century Britain". However "provisions for engineering education from the beginnings of industrialization in Europe caused a class of professional engineers to arise in a manner much better defined

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* Lloyd, B.E. "The Education of the Professional Engineer". Association of Professional Engineers, Australia, 1968.

John Smeaton and his colleagues adopted the term "civil engineer" late in the 18th century, to distinguish the civilian practitioner from the military engineer, and grouped together as the "Smeatonians", or the Society of Civil Engineers. Later in 1878 the Institution of Civil Engineers was formed. The American Society of Civil Engineers was founded in 1852.

A feature of the American, British and Australian engineering societies from their beginnings is their independence and self government. They do not operate under any statute as agencies of the State as do the engineering organisations in some European countries. The Royal Charters granted to institutions in the British Commonwealth are charters of recognition which confer powers rather than decrease independence by State regulations.

Three major bodies represent engineers in Australia. Learned society and accreditation functions are provided by the Institution of Engineers, Australia. The professional and economic interests are the province of the Association of Professional Engineers Australia. Consulting Engineers have formed the Association of Consulting Engineers, Australia, to provide similar services for self-employed engineers. Lloyd states, with reference to the formation of the Association of Professional Engineers, Australia "It became evident that employee professional engineers needed a separate identity, and that this could only be achieved through a strong professionally based industrial relations organisation. - - - - The Association has adopted the title "Professional Engineer" to identify those engaged in engineering at the fully professional level. Through the registration under the Commonwealth Conciliation and Arbitration Act of its qualifications for membership together with the definitions in its national awards, it has established legal status for the title and practice of the employee professional engineer as a person engaged on duties, the adequate discharge of any portion of which requires qualifications as (or at least equal) those of a Graduate member of the Institution of Engineers, Australia. - - - - The Institution provides clear and unequivocal criteria for the location of its boundaries, by the accreditation of courses in engineering as suitable qualifications for membership. Such accreditation is directed (vertically) to the level of intellectual attainment and (horizontally) to whether courses are in what are recognized as engineering disciplines. It follows therefore that in Australia persons holding qualifications accepted by The Institution are, ipso facto, Professional Engineers. It also follows that those outside the lateral boundaries are not Professional Engineers, and that those within the lateral boundaries, but whose academic attainments, while substantial, but fall below the plane, are engineering technicians."

There is no statutory control of engineers by registration in Australia similar to that which exists in the U.S.A., (the council of the Institution decided against legal registration on 27 April 1963), the essential component is the possession of qualifications acceptable to the Institution of Engineers, Australia. The Association of Professional Engineers, Australia, concerns itself with raising the status (salary levels, working conditions, etc) of employee professional engineers. These two bodies together with the Association of Consulting Engineers, Australia, are together entirely responsible for defining the boundaries of professionalism as it applies to Engineers, the Government either Federal or State plays no role.

We could conclude therefore that the basis of definition of a professional engineer is in terms of qualification. However, some reference to experience is made by the Institution of Engineers in their bye-laws, under Qualifications of Members, bye-law 14, societies from their beginnings is their independence and self-government. They do not operate under any statute as agencies of the State as do the engineering organisations in some European countries. The Royal Charters granted to institutions in the British Commonwealth are charters of recognition which confer powers rather than decrease independence by State regulations.

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"(A candidate for election or transfer into this grade shall produce evidence to the satisfaction of the Council)
- - - - iv. That having been engaged for at least four years in the practice of the profession of engineering, he shall have gained thereby experience deemed satisfactory by the Council. In the case of a candidate who is a graduate in engineering of a University recognised by the Council for this purpose the term of four years may be reduced to three years".

We know of no check list of the range of preferred skills expected within the specialist field of engineering or the ability to be demonstrated within any skill. The traditional procedure appears to be confirmation of performance by a generalised statement from two or three referees.

The Institution of Engineers has listed Australian Degrees and Diplomas recognized by it for the grade of Graduate (Member) (April 1972). It has also set out the basic requirements for a Professional Engineering course * and states what an acceptable course is expected to include. When referring to practical experience and professional responsibility material it states in items 4 and 5, the course is expected to include

" 4) some practical experience relevant to the course, obtained outside the teaching establishment.

5) professional responsibility material related to the social effects of engineering decisions. "

One must wonder how far various courses do provide any material concerned with the practice of the profession of engineering.

We have referred earlier to the medical profession and registrable qualifications, but it should be recognized that the standard M.B. B.S. programme includes from the second or third year systematic practice in the application of the "applied science of the earlier years", and the degree itself implies that a satisfactory standard of practice is required. Moreover a period of "internship" where further systematic and comprehensive training is provided is required before the graduate can practice as a "professional". Few, if any, engineering courses can lay claim to such vigorous safeguards to protect the public.

The adjective professional may be applied to an engineer by a circular argument of the sort that has been used by interested bodies but one must be quite clear that when used for the engineer it does not imply in most cases that the person has been systematically taught and that his performance has been systematically examined and deemed satisfactory in the practice of the occupation before he receives his basic registrable degree or diploma.

We have mentioned that independence of judgement has been a feature of professionalism, but that this may be difficult to exercise in employment with a government department or large corporation. To what extent are engineers employees of such organisations? A broad summary of the pattern of engineering employment (all types of engineer) is provided by a table compiled by Lloyd from a national survey in 1967. This is reproduced as Table 10.1.

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* Basic Requirements for a Professional Engineering Course, Consolidation of Various Previous Statements, Council of the Institution of Engineers, Australia. 20 March 1971.

TABLE 10.1 PATTERN OF ENGINEERING EMPLOYMENT

Category of Employer	Percentage by Employment	
Private Enterprise	31%	
Public Enterprise		
Commonwealth Public Service	16)	26%
State Public Service	10)	
Commonwealth Instrumentality	3)	27%
State Instrumentality	24)	
Local Government - Civil	6)	10%
Electricity Undertakings (other than above)	4)	
Education, armed forces and others	6%	
Total (12,370 returns)	100%	

In 1971 the Department of Labour and National Service surveyed the employment pattern amongst engineers who were members of the recognised engineering institutions and found the following:

TABLE 10.2 PATTERN OF ENGINEERING EMPLOYMENT (1971)

	All Engineers	Civil Engineers
Private industry (including self-employed and Partnerships)	46.2%	39.1%
Commonwealth Government	14.4%	7.1%
Armed Forces	1.8%	1.2%
State Government	25.1%	34.8%
Local Government	6.7%	13.1%
Educational and others	5.8%	4.7%
	100.0%	100.0%

Our own investigations in the early phases of this project aimed at establishing the pattern of employment of "professional" civil engineers showed:

TABLE 10.3 PATTERN OF ENGINEERING EMPLOYMENT (1972)

Type of employer	Civil Engineers
Consultants	19%
Contractors	13%
General Industry	4%
Commonwealth Government [illegible]	6%

Public Enterprise		
Commonwealth Public Service	16)	26%
State Public Service	10)	
Commonwealth Instrumentality	3)	27%
State Instrumentality	24)	
Local Government - Civil	6)	10%
Electricity Undertakings (other than above)	4)	
Education, armed forces and others		6%
Total (12,370 returns)		100%

In 1971 the Department of Labour and National Service surveyed the employment pattern amongst engineers who were members of the recognised engineering institutions and found the following:

TABLE 10.2 PATTERN OF ENGINEERING EMPLOYMENT (1971)

	All Engineers	Civil Engineers
Private industry (including self-employed and Partnerships)	46.2%	39.1%
Commonwealth Government	14.4%	7.1%
Armed Forces	1.8%	1.2%
State Government	25.1%	34.8%
Local Government	6.7%	13.1%
Educational and others	5.8%	4.7%
	100.0%	100.0%

Our own investigations in the early phases of this project aimed at establishing the pattern of employment of "professional" civil engineers showed:

TABLE 10.3 PATTERN OF ENGINEERING EMPLOYMENT (1972)

Type of employer	Civil Engineers
Consultants	19%
Contractors	13%
General Industry	4%
Commonwealth Government (including Armed Forces)	6%
State Government	48%
Local Government	10%
	100%

Clearly civil engineers are predominantly employees, and 81 per cent, (or more, if one assumes that some of the group labelled consultants will be employees,) appear to face the conflict of loyalties referred to earlier and will not be able to exercise independent judgement.

Returning now to the features which distinguish professionalism. Briefly these are:

(a) a body of science or learning connected with practice and including theoretical principles and their bearing on the larger difficulties of practice,

(b) a code of ethics incorporating the ideal of service,

(c) independence of judgement and decision.

How far does the practice of civil engineering in Australia today incorporate these features?

(a) There is a body of science or learning connected with practice, but we have formed the impression during this study that insufficient emphasis is given to the bearing of this on the larger difficulties of practice. We will refer to this again under recommendation. Chapter 12.

(b) There is a code of ethics * with nineteen items which deals with conduct and behaviours in certain situations, and which states, item 1, headed "Duty to Community - - - An Engineers responsibility to the community shall at all times come before his responsibility to the Profession, to sectional or private interests, or to other engineers".

(c) In view of the employee nature of the status of many civil engineers it would not be possible for them to exercise independence of judgement and decision, and one wonders how far they can obey item 1 of the code of ethics mentioned under 'b' above because of this lack of independence.

Currently the medical profession in Australia is grappling with the Federal Government over a proposed National Health Service. All the doctors arguments reduce to this basic theme of service to the client and that such a service can only be provided, and independence of judgement and decision preserved, if the doctors remain in private practice and do not become government employees.

If this is such an important aspect of professionalism then civil engineers in Australia are not, in the main, professional in the traditional sense of the word. There is little scope for the majority of them to develop and exercise qualities of responsibility to individual clients or even to society at large.

Even if little opportunity exists for them to do so the question must arise as to whether they would freely exercise "professional" responsibility if opportunity did present itself. How far do civil engineers know what traditional professionalism is all about? Do they merely believe that it is concerned with negotiated salary ranges and being a member of the Institution. The

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Even if little opportunity exists for them to do so the question must arise as to whether they would freely exercise "professional" responsibility if opportunity did present itself. How far do civil engineers know what traditional professionalism is all about? Do they merely believe that it is concerned with negotiated salary ranges and being a member of the Institution. The Institution of Engineers, Australia, has stated an acceptable engineering course is expected to include "professional responsibility material related to the social effects of engineering decisions". We said earlier, one must wonder how far various courses do provide any material concerned with the practice of the profession of engineering.

* "Code of Ethics". The Institute of Engineers, Australia, 1966

10.2 VIEWS OF C.A.E.'S AND UNIVERSITIES ON COURSE CONTENT RELATED TO PROFESSIONALISM

In order to determine how far current courses in civil engineering do provide insight into the implications of the label "professional", tertiary institutions in Australia offering such courses were approached for their comments and answers to four questions. The preamble mentioned this present study, our interest in the term professional as applied to engineers, and a request for frank comments.

The four questions were :

1. Does your degree/diploma course set out to produce an embryo professional civil engineer who has had basic experience and exposure to "practice" and needs only a minimum additional period, essentially of <u>maturation</u>, before receiving full "professional" status?

2. In the normal M.B., B.S. programmes in medical schools systematic clinical experience is included as an essential component and the graduates are expected to follow at least a further year of supervision training before independent practice? What comments do you care to make concerning the comparison between the medical "profession" and medical education and the civil engineering "profession" and civil engineering education?

3. Is <u>related</u> industrial experience in civil engineering a compulsory component of your course, and if so

   (a) how many months are required
   (b) when are students expected to acquire this - normal term time or vacation
   (c) is it supervised directly by the staff of the university/college*

4. In the course what components, if any, are included to cover

   "(5) professional responsibility material related to the social effects of engineering decision".

* specific used

Replies were received from all universities with the exception of the University of Newcastle and all C.A.E.'s with the exception of the South Australian Institute of Technology. Our thanks are due to the heads of department concerned for their detailed and helpful comments.

Much of the material that follows has been discussed earlier in the appropriate section of the previous curriculum chapter. The content is expanded however, with respect to its implications for professionalism. Extracts from the replies received have been cited expressing representative viewpoints. This makes the chapter longer, [illegible] in the term professional as applied to engineers, and a request for frank comments.

The four questions were :

1. Does your degree/diploma course set out to produce an embryo professional civil engineer who has had basic experience and exposure to "practice" and needs only a minimum additional period, essentially of maturation, before receiving full "professional" status?

2. In the normal M.B., B.S. programmes in medical schools systematic clinical experience is included as an essential component and the graduates are expected to follow at least a further year of supervision training before independent practice? What comments do you care to make concerning the comparison between the medical "profession" and medical education and the civil engineering "profession" and civil engineering education?

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Their contents are summarized below:-

10.2.1 C.A.E.'s

Most C.A.E.'s gave either a yes or a qualified yes to this question. Qualifications to the answer with respect to training included :

> "they will need to learn the particular techniques and procedures adopted by their employer since it would be impossible in the time available to expose them to those many different aspects of "practice".

and in contrast

> "Yes - at least with regard to the "bread and butter" activities encountered in many civil engineering projects."

The limitations of classroom based teaching were stressed by one head of department. (An alternative approach will be discussed later).

> "By its very nature only certain aspects of Civil Engineering can be taught in a classroom, thus ---- I would suggest that the Civil Engineer not only matures but learns a great deal more ---. In construction management work there is only marginal exposure to practice e.g. site visits and those aspects which are suitable for teaching in the classroom environment."

Effective liaison with industry was stressed by another college.

> We --- "aim to produce an Engineer with the knowledge and skills required so that a graduate can be immediately useful to industry. The department has close liaison with industry and the Civil Engineering work of the course is made to be practical. Visits to industry are common and project work is carried out in a real situation, in most cases taking an actual job from industry (this college does not have a compulsory industrial component)."

The influence of the Institution of Engineers was cited by one board

> "Yes because that is the way the Institution views the process of producing a "professional" civil engineer; and if their yardstick is used our graduate should have the necessary inventory (training, experience) to be, according to this yardstick, called "fully qualified". However, in my personal opinion, this period "maturation" in fact requires a substantial amount of time regardless of the extent of academic training; experience is important"

The lack of systematic training was cited by two other colleges

> "We consider that our products still require a considerable amount of further training before they are full professionals, although our sandwich course has a considerable industrial content and obviously reduces this training period considerably"

"However, a civil engineer is <u>always</u> learning and it would be wrong to say our diplomates only need maturation post graduate ---- they need to develop expertise in

a) applying their knowledge and skills to practical problems

b) fitting into an organisation in the <u>work</u> situation as distinct from the college situation

c) aspects of the profession (such as construction, handling staff, administration practice) that cannot be taught in college

The Arbitration Award has recognised this by defining an "experienced" engineer as a diplomate with 5 years post graduate experience.

This need "to develop expertise in applying their knowledge and skills to practical problems",perhaps the vital component of professionalism, although recognised in theory by the teaching institutions appears in practice to be very much left to chance. Regretably the complete integration of the theoretical college component with the applicational industrial component of what might best be regarded as one overall curriculum has never been achieved. *

One university head made explicit the implicit assumption of the present system

"On graduation he should also have sufficient insight into the processes of design and synthesis to be able to contribute - probably slowly at first - to a design (or other plan) and with a few years of guided activity (and reasonable luck in the choice of superiors) become an efficient professional."

Perhaps the section in parenthesis ought to have been written in block capitals.

Essentially therefore, training for the vital component of civil engineering - ability to apply the theory in practice - is left to an unorganised random type of pseudo apprenticeship, without the safeguards now sought for trade education in many European Countries (particularly Germany).

<u>10.2.2 Universities</u>

With two exceptions the universities gave either a 'yes' or a qualified 'yes' to this question.

Two universities were more emphatic in their yes than most C.A.E.s and both included a substantial experience component as a compulsory part of their degree course.

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* Jahoda, M. The Education of Technologists, Tavistock Publications

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Jahoda discusses theoretical issues in her book using the Tavistock Socio Technical Analysis procedure and argues for the exclusion of industry from the decision making process in course construction. All arrangements in the diploma courses would nevertheless ultimately be subject to final decision within the educational system only. Her argument rests in the assumption that "educational systems, in order to function with optimal efficiency, require an internal organization in order to establish priorities relevant to their central task.

The qualifications to the "yes" were similar to those expressed above, for example,

"A short answer to the question would be "yes" if the practice meant mainly analysis and synthesis, or office work as against field work. ---- If he goes straight into construction or similar fields, he will probably be of less immediate use and be more dependent on 'on the job' training for the maturing process. The 'No' answers both emphasized "the assumption that they will be subject to several years of professional training after graduation". Both universities which answered 'No' had periods of industrial experience as a component of the course greater in duration than most C.A.E.s but the purpose of these was "aimed mainly at showing how the engineering theory is supplied. They are not intended to provide professional experience."

The expectation that most graduates would have

"a sufficient background in science and engineering science to be able to follow new developments for some years after graduation without retraining, and hopefully contribute to them after a relatively short time in practice"

was mentioned by some universities.

10.3 EVALUATION OF THE TRAINING COMPONENT

The integration (with education) and systematic evaluation of the training component was developed further in the first section of Question 2 which then sought opinion concerning similarities and differences between medicine and civil engineering as professions and their associated education - training demands.

10.3.1 The Training Component - C.A.E.s

Again considerable differences were noted among the C.A.E.s rangin from

"a properly designed course of postgraduate or undergraduate training would be of considerable assistance in the rapid development of "professionalism" in engineering students"

to

"there appears to be no advantage in engineering educationalists demanding that students undergo a lengthy supervised "orientation" program prior to the award of a qualification--- it is the responsibility of C.A.E.'s and universities to provide the appropriate engineering education program, that may or may not include a variety of "clinical" programs for educational reasons".

One might here make a Biblical reference *

Most, however, favoured greater training components, one stating explicitly

"Agree provided that we can supervise the work in industry -

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Most, however, favoured greater training components, one stating explicitly

"Agree provided that we can supervise the work in industry - a difficult task. The alternative would be to set up the equivalent of the "teaching hospital".

* Matthew 27 Verse 24

The advantage of this type of "hospital" arrangement followed by a component concerning the shorter duration of most medical "projects" (cases) in comparison with those in civil engineering was reported by some colleges.

"appears to be a practical difficulty in finding engineering establishments which would be prepared to supervise the graduates for minimum terms on a number of varying engineering environments. A hospital tends itself to a concentration of varied assignments, each of them relatively short termed, compared with engineering assignments"

This problem of providing suitable industrial establishments was mentioned by several colleges

"By and large no formal period of this nature is available for Civil Engineers but it has been recognised as desirable by larger employers who have the facilities to establish training programs. Economic feasibility is important since it would mean a government controlled program of at least 1-2 years and is unlikely to be acceptable"

The "sandwich" method of providing supervised training was endorsed by several colleges but again the problems of industrial placement for college based students was stressed.

" I am very much in favour of a sandwich course of the type run by N.S.W.I.T. with supervised and controlled periods in industry preferably with more than one employer ---- employers will have to be persuaded to accept more students for training

At present in X , students are responsible for obtaining themselves related experience; they have difficulty in obtaining employment and often do not obtain it until after completion of full-time studies. They would benefit considerably from a 'sandwich' period in industry part way through the course"

In their handbook Swinburne College of Technology state that

"The industrial training scheme has proved most successful and the Department gratefully acknowledges the assistance and co-operation of the following sponsors"

In the list that followed two private companies are mentioned W.P.Brown and Associates, and Civil and Civic Pty.Ltd., the remaining sixteen employers are either local government or State bodies. Clearly private industry is not accepting its share of training responsibility. In the U.K. private firms are subsidised by the central government and some industrial training boards to cover part of their real costs in training sandwich students: would a similar scheme help in Australia. As an alternative a government controlled and financed program (mentioned earlier) operated essentially by State and National government organisations might be considered.

One college would resist

"any trend to make engineering courses longer than 4 full time years" graduates for minimum terms on a number of varying engineering environments. A hospital tends itself to a concentration of varied assignments, each of them relatively short termed, compared with engineering assignments"

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The effect of outside influences on educational decisions, in this case competition from neighbours, is clear from the following comment

> "While these courses are very popular in the U.K. they are not used much here owing, I believe, to administrative worries
>
> I believe we should insist that our students gain practical experience of 12 months before attempting their final year, but if I do this here at Y , students will go elsewhere to get "qualified" sooner, since they get award salary for "qualified" engineer as soon as they pass their diploma, irrespective of experience".

The implications of this statement need further and serious consideration.

10.3.2 The Training Component - Universities

University comment centred round the similarity in total length of program with medicine if the two year period of additional practice experience is added to the four year period of college education. It was noted, however, that this

> "clinical work of the doctor appears to have been more strictly controlled than in the case of the professional training of the civil engineer"

The most detailed comment is given below

> "The compulsory vacation work training, which is intended to acquaint the students with 'real' engineering and some of its problems, is probably too limited in time to achieve its full potential as an educational technique. There is also little control over the type of work engaged in, and the field is in fact so broad that a student can only hope for a little insight into one or two specific pboelbms in one of the main streams of civil engineering. His first year or two after graduation will normally amount to supervisor-training, but there is no engineering equivalent of a centralised all purpose institute such as a hospital. An arguable case can be made out for spending a sizeable amount of time on 'supervised practice' during the course - say after third year - but this would be difficult to organise, both for the University and the outside offices.

10.3.3 Medicine and Civil Engineering

The most detailed comparison between medicine and civil engineering as professions was provided by the Darling Downs Institute of Advanced Education and it is summarised below along with some other comments :

a) 1) Doctors are trained for <u>direct</u> dealing at the bedside

I believe we should insist that our students gain practical experience of 12 months before attempting their final year, but if I do this here at Y , students will go elsewhere to get "qualified" sooner, since they get award salary for "qualified" engineer as soon as they pass their diploma, irrespective of experience".

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a) 1) Doctors are trained for direct dealing at the bedside

2) Doctors must learn manipulative skills and techniques particularly in surgical work

3) Doctors for private practice must learn to work on their own early in their career (group practice notwithstanding). Some consultation is clearly available in the diagnostic phase.

4) Specialist doctor well recognised but may not be available in emergency situation

b) 1) Most civil engineers' work is done in consulting civil engineers offices, government offices, semi-government offices or on major construction projects - work is rarely done by an isolated civil engineer. Civil engineers do not accept as much responsibility personally as doctors particularly in their early years in practice (nor is this a function of the real nature of civil engineering rather this is a result of the type and extent of training currently given is not clear). Frequent consultation is possible during the working up of a design or planning/implementation of a construction project and emergencies rarely arise (as could, for example, occur with a doctor in his first few months of practice in a country area where he might be required to do an emergency appendectomy)

2) When a civil engineer enters private practice he normally enters as a partner after several years of experience.

3) A medical practitioner in his one year of post basic training is likely to meet something approaching the full range of problems he meets later in practice (excluding specialists) Civil Engineers work on projects of much greater duration.

The essential difference therefore is that medical practitioners are usually "loners" whereas civil engineers are team members. Education and training it is claimed should therefore reflect these essential differences. Clearly the 'professional' civil engineer does not fit into the concept of a professional defined by the authors discussed earlier and has a closer parallel with the teacher.* who is described more frequently as a quasi or semi-professional.

* Footnote

Macquarie University does not provide the common "end on" arrangement for teacher training offered by most other universities where the students first obtain a B.A. or B.Sc. in the normal academic subjects then follow a fourth year of training in the theory and practice of education. Training at Macquaric is a four year integrated programme resulting in the combined award of B.A., Dip.Ed. The training component is the joint responsibility of the university and a series of master teachers in specially selected schools. The amount and content of training is specified but the time arrangement is left to the individual student and his master teacher. The student is not paid for any teaching he does and is always a supernumerary to the staff complement. Clearly this system could have advantages for the training of some civil engineers particularly where projects tend to move slowly. One day each week for two or three years under the direction of two or three carefully selected "master" civil engineers from different branches of civil engineering who report systematically on the work done by the trainee could remedy many of the defects produced by the present

[illegible] civil engineering [illegible]
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10.4 INDUSTRIAL EXPERIENCE REQUIREMENT FOR STUDENTS

The industrial experience required by full-time or sandwich students is shown in Table 10.4

TABLE 10.4

IDENTICAL EXPERIENCE REQUIREMENT - COMPARISON BETWEEN C.A.E.s AND UNIVERSITIES

	C.A.E.s	Universities
A) Length of Experience required* as part of course		
1) Nil	6 **	
2) 6 weeks	1	
3) 7-12 weeks	2	4
4) 13-26 weeks	2	2
5) 26 weeks	3	1
B) When required		
1) During term	3	
2) During vacation	5	6 (one return missing)
C) Supervised directly by staff		
1) Yes	3	
2) No ***	5	7

* Most colleges encourage but do not require experience. College X for example states

> "12 weeks experience required by the Institute of Engineers before the award of the Diploma and this is gained before the conferring ceremony which is held in April each year"

** One college requires 6 weeks for degree students but none for diploma students.

*** A detailed report on what is done during the industrial period is required by all universities and most colleges.

No additional comments are considered necessary: the table shows clearly the extent of any compulsory experience component in the college curriculum.

10.5 COMPONENTS CONCERNING PROFESSIONAL RESPONSIBILITY

This material has been considered extensively in the curriculum chapter and it is sufficient at this stage to list the main points:

a) Despite the claimed influence of the Institution of Engineers on college curricula one C.A.E. was unaware of this requirement and two others made no provision in their diploma course. One university made no provision.

b) The 'subjects' offered ranged from specific courses on 'environment' to courses on sociology, psychology and liberal studies.

c) Many subjects were offered through lecture courses, although student participation in discussion, if not in decision making activity, occurred in others.

d) Several colleges mentioned, and we emphasised, that this type of material is not taught in the usual sense by specific courses but is an attitude inculcated by lecturers throughout a total programme. Teachers, however, traditionally teach "subjects" at the post primary level and it may be difficult in practice to create a teaching situation in which these supplementary aims intended are achieved without deliberate, conscious, continuous effort.

10.6 CONCLUSION

The generally accepted criteria of a profession have been stated, and those criteria relating to real work experience, and professional responsibility have been studied in relation to present day civil engineering and student courses in civil engineering. The background to the use of the adjective professional with the word engineer has also been examined. It is difficult to see how the majority of civil engineers can exercise professional responsibility in the traditional sense of the word. Moreover, it is not possible to conclude from the evidence that students receive sufficient training in practice before receiving their degree or diploma and that they are made fully aware of the traditional implications of the adjective professional.

11. ATTITUDES AND OPINIONS ABOUT CIVIL ENGINEERING TRAINING REVEALED DURING COURSE OF STUDY

11.1. SOURCES OF COMMENT

During the progress of the work many people in industry and academia passed comment on particular aspects of vocational training they were associated with or informed about. Many commented on the products of vocational training, others on some particular aspect of the civil engineering industry. In many instances these comments were recorded, for example, if they occurred during an interview. In other cases respondents commented on some part of the questionnaire or on a subject that concerned them mentioned in the questionnaire. Over the course of two years these comments and remarks became sufficiently large in number to justify some organized reference to them in this report.

11.2. ACADEMIA

Many are concerned with the relevance or lack of relevance of engineering training at all levels, to engineering practice. Many are aware of the problems associated with re-designing curricula and the time and expense involved. Many are concerned about the overall subject of manpower planning. By far the biggest hurdle to overcome is the tremendous inertia inherent in the existence of long established organizations and systems, i.e. traditional attitudes. This is not novel Schon* for example has written at length on the problems associated with innovation in industry. It is apparent that the problems are similar in academia, and in fact innovation in education may be harder to achieve than innovation in industry. This does not deny that many in education see innovation as desirable, the problem, as always, is how can it be brought about? The value of this present study may superficially reside in the report and the quality of its tabulations, but its real value is whether it can be used to bring about even to a minor extent, innovation in the field of civil engineering training.

11.3. INDUSTRY

Some senior men in industry implied it took, say, two years to turn a raw civil engineering graduate into a useful member of their organization. Fact or attitude? It was difficult to decide, but there was sufficient dissatisfaction expressed to raise doubts concerning the relevance of current civil engineering training. As mentioned earlier in this report there was a great deal of interest shown by industry in the project, interest in the civil engineering technician as well as the engineer. However, much of the comment concerned the poorer provision of facilities for training the engineer who wanted to follow a career in construction compared with the provision of facilities for those intending to follow a career in design. One correspondent holding a senior position with a large construction company said "there is a great need in the industry today for men who have been able to combine tertiary education with practical training". He then expressed the view that the N.S.W. Institute of Technology Civil Engineering diploma course fills a gap.**

The subject of mathematics frequently arose, the view being expressed that excessive time was devoted to teaching (and learning!) the more advanced mathematical techniques and that basic maths was all that was needed in practically all civil engineering. It was not possible to determine specifically what basic maths were, as distinct from "advanced technique". [illegible] they were associated with or informed about. Many commented on the products of vocational training, others on some particular aspect of the civil engineering industry. In many instances these comments were recorded, for example, if they occurred during an interview. In other cases respondents commented on some part of the questionnaire or on a subject that concerned them mentioned in the questionnaire. Over the course of two years these comments and remarks became sufficiently large in number to justify some organized reference to them in this report.

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The subject of mathematics frequently arose, the view being expressed that excessive time was devoted to teaching (and learning!) the more advanced mathematical techniques and that basic maths was all that was needed in practically all civil engineering. It was not possible to determine specifically what basic maths were, as distinct from "advanced techniques". The Task Analysis questionnaire subdivided the subject of Mathematics into three items - basic algebra, geometry and trigonometry; calculus; and numerical methods. The results to the

* Schon, D.A. Technology and Change. Pergamon Press, 1967.

** Soon to be phased out!

question on mathematics showed that whilst practically all engineers used basic algebra, geometry and trigonometry only about half used calculus, and rather less than half used numerical methods. The subject of the usefulness of mathematics is a controversial one. To many it is redolent of the cabalistic mysticism of the medieval ages, to others the only subject worth teaching in technological courses. It is a very easy and inexpensive subject to teach compared with the problems of organising meaningful practical work. Perhaps the place of mathematics and the role it plays in the course is due for re-evaluation. As things are at present the view could be taken that the more complete mathematics courses taught at high schools in N.S.W. must provide nearly all the basic algebra, geometry, trigonometry and calculus required for the majority of engineers in practice.

At the other but no less important end of the training spectrum a construction company wrote "one of our continuing problems is to find suitable and experienced foremen capable of controlling projects in the general range $100,000-$500,000. The majority of our foremen have been trained by ourselves, having initially started as labourers, operators, or leading hands. We feel there is a definite need for some form of training scheme for such foremen, as they are always difficult to obtain".

Summarising, it can be said that industry expressed itself freely, but there was more dissatisfaction concerning the training of engineers and foremen for the construction industry than there was about the training for those following a career in design.

11.4. RESPONDENTS

Some dissatisfaction was expressed by respondents in free comment, the general view being that existing courses tended to be biased towards the theory of design, that "design for simplicity, speed and economics" was omitted, and that, in general, attention to construction suffered. For example, one respondent wrote "Modern courses ...... virtually ignore the levels of trade knowledge and detailed construction procedures which are essential knowledge for several years of a construction engineer's life". Another wrote that the Task Analysis Questionnaire itself was biased in the direction of design and insufficient questions about construction had been asked. Another pointed out that we had not allowed for the "work of a contracts engineer (which) does not readily fall into the categories stated" in our questionnaire. We were aware of this problem at the outset, and of the growing importance today of the project engineer or manager. This same respondent concluded "In my opinion a civil engineering degree course should apply equal weight to the following:

1) Training - provide sufficient knowledge in current design and construction methods to be immediately useful to the C.E. industry.

2) Education - to provide trained and inquisitive minds to cope with the inevitable changes that will occur over the lifetime of the student."

If one is tempted to conclude that the two topics, design and construction are separate and unrelated, some respondents would disagree and specifically requested that design instruction become closely integrated with construction methods, implying perhaps that you cannot design well if you are unfamiliar with the restraints imposed by the construction methods available and used on site.

11.5. CONCLUSION

By reporting many views expressing dissatisfaction of one sort or another it can be said that we have over emphasised dissatisfaction. Many people we spoke to, many respondents, and others did not express dissatisfaction. However, one must relate such a broad expression of dissatisfaction about existing courses, with the discussion that has and is still taking place all over the world concerning the defects of engineering training in this latter part of the twentieth century. The inevitable conclusion must be that the ills and doubts about engineering education at all levels that exist outside Australia's boundaries, also exist inside Australia. The next issue must be what is to be done to remedy the situation.

12. RECOMMENDATIONS

OUR OVERALL RECOMMENDATION, WHICH WILL BE EXPANDED FURTHER BELOW, IS THAT MORE SUBSTANTIAL EVIDENCE OUGHT TO BE SOUGHT BEFORE ADDITIONAL COURSES ARE INTRODUCED OR EXISTING COURSES ARE LENGTHENED CONCERNING THE NEED THE COURSE SEEKS TO FILL AND ITS OVERALL AIMS AND OBJECTIVES. AFTER INTRODUCTION EVIDENCE OUGHT TO BE SOUGHT CONCERNING HOW FAR THESE AIMS AND OBJECTIVES ARE ATTAINED.

12.1. SURVEY TECHNIQUE

Few studies of the links between jobs and courses of study relating to those jobs seem to have to taken place. One of the reasons for this may be the length of time it takes to carry out such a study. Even with the benefit of hindsight it would be possible to reduce the time spent on the present study by only a small fraction. Furthermore this present study deals with only that part of the total exercise of re-designing a vocational curriculum based on evidence or information provided by examination of the tasks concerned in the practice of that vocation. Both during and after re-designing, the new curriculum needs to be evaluated, and the feedback used to modify or amend the design. In all therefore, a considerable expenditure of man-hours is involved in the re-design of one vocational curriculum.

Another problem also exists in the nature of the interface between industry and academia. Persons become absorbed in either one or the other, they may change from one to the other, but few attempt to keep a foot in both camps. For those few who have attempted to reconcile both camps the dichotomy appears frequently to produce a sort of hybrid, although perhaps not a dangerous mutant, in danger of rejection by both. Experience throughout this study has shown that this interface is real. In case this is taken as a criticism of industry's attitude to the project it must be emphasised that excellent co-operation and assistance were, in almost every instance, extended without question, and interest was at a high level.

A major hurdle we had to overcome in this project was the lack of data about the civil engineering population. Collecting this data absorbed a large amount of the allocated resources. Apparently this is not an unusual problem, although in this instance the diverse nature of the civil engineering population may have made it larger and more difficult. Where a small homogeneous population exists as we found in the case of the construction foremen, quantifying it and sampling it is considerably easier, and therefore quicker and cheaper.

Two of the instruments designed for probing the population were complex and one was simple. The complex were comprehensive by intention, the view being adopted that if one is mounting a test it is better to collect more data rather than less. We were well and truly in the 'more data' category, (although all of it was important) and this brought in its train the problems associated with examining large quantities of data. It is not possible to merely feed the data to a computer in the expectation that right answers will automatically be produced. The examination of data is more complex, and the computer but one of the tools used. In the case of this study we were able in the time available and without writing our own specific programmes, to carry out only a first broad sweep of the data. Smaller more selective probes of the data could usefully be made.

Our recommendations are:

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Our recommendations are:

1) Further work should be done to determine a <u>model</u> for the establishment or redesign of vocational curricula.* Such a model should include sub components for:

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* Much more attention ought to be paid to defining what the educational institution and particular curricula are attempting to achieve. We found considerable conflict in some cases between stated aim and what appeared to be done to implement that aim.

A) a) Task analysis.

b) Data interpretation.

B) Formative evaluation of the units produced as a result of (A) and such other aspects as are considered important from consideration of general education.

C) Summative evaluation - particularly the development of procedures for determining how effectively the aims of the curricula are being achieved. Objective evidence should be sought. (That students find employment may mean, among other things, that their course was effective or that they were the best alternative available for the job to be done).

2) Where professional institutions may have an influence on curricula the extent of this influence should be determined by obtaining a clear and specific statement of:

a) the depth, breadth and quality of the initial educational requirements;

b) the quantity and quality of the experience component preferably in specific check list items, required before admission to full membership.

Decisions should then be made whether the professional institutions should be allowed to influence what are educational decisions. Meetings of all parties concerned should be held so that each party has a clear and specific knowledge of the various viewpoints.

3) Efforts should be made to compile more substantial data banks conc... ..ng the numbers currently engaged in various fields of employment at the following levels:

A.a) Trade.

b) Technician.

c) Engineer.

Such categorization should preferably be made on two distinct criteria (which may yield different results).

B.a) Qualifications held and eligibility for professional status.

b) Work actually done.

More substantial assistance ought to be forthcoming, as part of their raison d'être from the professional institutions particularly with respect to 2.B(a).

12.2. ENGINEER TRAINING

We believe some thought is being given to extending the length of engineering courses on the basis that there is so much information and knowledge to absorb today that courses must be made longer to cope with this. The view of many students is that three years in general is already long enough, and four years is too much. There seems a problem of maintaining interest. In addition our study has shown that the major deficiencies in past training have been content and skills concerned with management, costing and accounting, communication, and practical work [illegible] procedures for determining how effectively the aims of the curricula are being achieved. Objective evidence should be sought. (That students find employment may mean, among other things, that their course was effective or that they were the best alternative available for the job to be done).

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Our recommendations are:

1) A much more careful analysis be done on the present content of civil engineering to determine the contribution each component makes either to the vocational or general education of the student. Particular attention ought to be paid to the quality rather than the quantity of the learning experience and due cognizance ought to be given to:

a) Those components of theory necessary for the vocation either directly or in the case of mathematics, for example, by their contribution to other theory.

b) What it is possible to teach under any circumstances.

c) Arrangements as specified below for the more systematic integration of theory with practice to develop the practical performance and problem solving skills in real situations of students.

2) Very serious attention be given to devising a course of study which in its later years involves attendance and involvement in real work situations, similar to that existing in medical training. The teaching hospitals of the medical training would be replaced for the engineering training by State Government Departments. In Sydney, for example, there would be no problem in finding three N.S.W. Departments capable of contributing in a meaningful way to the training of civil engineers, and having sufficient resources to devote, with the Universities of Sydney* and N.S.W.*, and The N.S.W. Institute of Technology, to the task of devising a new complete course of study and training. Inasmuch as in N.S.W. 48 per cent of civil engineers are employed by State Government Departments it would not seem improper to consider this direct involvement in the training of civil engineers; it is certainly not impossible. A variation of the suggested pattern could be an association between one or two of the large metropolitan local government civil engineering departments and The Institute of Technology for example, but problems of arranging the financing might arise in this case.

Some observations can be made about the implications of the large differences between the tasks of civil engineers working in jobs labelled 'design' and the tasks of those working in jobs labelled 'construction'. A study of the extent of common needs shows that only basic maths, materials, and soils are common. Outside these topics design engineers are mainly occupied with problems of design - structures and other works. Construction engineers are concerned with a wide variety of topics but design is of minor importance. This suggests perhaps that on the assumption of traditional attendance patterns the first one or two years of the course should be devoted to topics common to both activities followed in the case of those intending to specialize in design by one year of design theory. Ideally, the equivalent of one year's participation in real work situations in the design office of a State Government Department should be incorporated within the course in addition. For those intending to become construction engineers the first two years of basic materials and soils could be followed by (or incorporated with) two years' real work involvement. At the end of the fourth year both streams could spend a period say, of one semester, of intensive education, training and exposure to accounting and costing ideas, management, and communication techniques. These being purposely placed at the end of the course when undergraduates would have acquired a clear notion of why the courses were being conducted for them. Cours [illegible] ought to be given to.

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* It is recognized that these institutions lie outside the scope of the Commission.

For those wishing to follow careers in research or teaching the period of real work involvement would be invaluable experience.

12.3. TECHNICIAN TRAINING

The major need in technician training is for rationalisation. In the U.K. Haslegrave* has made recommendations concerning their training. The U.K. has the benefit of an existing structure of National Certificates to which the newer technician courses can be linked. However, in spite of this already existing national course structure particularly strong recommendations were made by Haslegrave for creation of a new co-ordinating body - a Technician Council. This report is worthy of study since it also deals with other important aspects such as keeping courses under review, and transfer courses or bridging programmes.

The desirability of having a nationally recognized structure of technician courses and awards is referred to in a report from Ireland** dealing with the training of technicians which states "A further serious difficulty in the task of raising the standards of technicians in Ireland is the lack of a nationally recognized technician diploma. The absence of such a diploma deters many parents from considering sub-professional technical careers for their children. This in turn leads to the presence of unsuitable students in university engineering and science classes. Many young people would be more suited to the role of the higher technician than to that of the technologist. Such a re-organization would have the attitional advantage of permitting a higher standard of work in university courses".

In Australia the Snowy Mountains Authority early in its history had to face up to the problem of staffing this huge project and Leech+ who was closely involved with the training and use of sub-professional staff published a number of papers outlining his views and describing the methods he adopted to cope with the situation.

Moran≠ has reviewed the current situation in Australia and makes some international comparisons. However, specific training for the sub-professional level throughout industry in Australia could not be said to be widespread and the practice of up-grading tradesmen is still much used, frequently without additional training. But there does appear to be a growing recognition of the valuable contributions that can be made by trained staff.

Moran states further that "it is considered that training for sub-professional work should ideally be based on terminal-type certificate courses, taken part-time, complemented by in-house training of a more applied type and practical experience in the working environment for which the trainee is being trained".

We have referred to the literature at this stage for two reasons, one to present evidence on the desirability of a central national technician council, and two, to present some views on technician training and the need that may exist for more than one level of technician.

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* Haslegrave, H.L. "Report of the Committee on Technician Courses and Examinations". H.M.S.O. U.K. 1969.

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Leech, T.D.J. "Adult training for sub-professional work" Personnel Practices Bulletin, XVII, June 1961, pp. 29-34.

≠ Moran, P.V. "Engineering Sub-Professional Work". Journal of Institution of Engineers, Australia. 42, June 1970, pp. 57-61.

The work of a central national technician council would be concerned with co-ordination and rationalisation. Some suggestions for reducing the number of certificate courses in civil engineering available in N.S.W. have been made by Klamus* who proposed a single course with four options.

Our main recommendation concerning technician training arising from our study is that:

The present multiplicity of courses for the training of civil engineering technicians ought to be re-examined, in the light of our findings on the work done by technicians, to determine if a simpler structure of a single course with options is possible. Such a course should be established using the guidelines specified earlier for engineers.

We were also convinced by respondents to our questionnaire and by others at selected interviews that serious attention ought to be given to the establishment of a National Co-ordinating body to determine the standards of technician certificates across the country. Parallel with this attempts should be made to stimulate the formation of a Technician Society or Institution on a national basis, which would concern itself with the status of technicians. Interaction between the two bodies would lead to an exchange of ideas on training, certificate course content and standards. Such a body would resolve some of the fears expressed by respondents concerning the relationship between current Certificate courses and the recently established U.G3 (B2) courses. One fear, however, is that such a body would in time become exclusive rather than inclusive. Avenues of progress from technician to engineer should also be established since we were not convinced on the basis of work done that serious barriers exist between the levels. Of value also in such activity would be the eventual clarification of the boundaries between engineer's and technician's work tasks. As we have said an area of overlap exists today and it is not easy to see where the boundary lies.

12.4. FUTURE WORK

Attention has been drawn in the earlier paragraphs to some specific work which needs to be done. Comment will be made in the following paragraphs to more general issues.

Frequent reference has been made in this report to the fact that it has been possible to deal in detail only with Part A of the Research Plan, and this in a slightly incomplete and altered fashion from what was originally planned. Some thought therefore, must be given to rounding off Part A of the Research Plan, and completing Parts B and C.

In addition, as the work has progressed views have formed about some other aspects of the work and ideas about further useful areas of study have arisen. These ideas can be loosely grouped into broad objectives and specific objectives.

12.4.1. Broad Objectives

a) Related to civil engineering study

Present work has concentrated on an analysis of civil engineering tasks at all levels and across all sections of civil engineering practice. Our attempt to survey the curricula in use in the C.A.E.'s across Australia has been limited to material we obtained from handbooks and material sent in response to personal letters. Much information was

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arising from our study is that:

The present multiplicity of courses for the training of civil engineering technicians ought to be re-examined, in the light of our findings on the work done by technicians, to determine if a simpler structure of a single course with options is possible. Such a course should be established using the guidelines specified earlier for engineers.

We were also convinced by respondents to our questionnaire and by others at selected interviews that serious attention ought to be given to the establishment of a National Co-ordinating body to determine the standards of technician certificates across the country. Parallel with this attempts should be made to stimulate the formation of a Technician Society or Institution on a national basis, which would concern itself with the status of technicians. Interaction between the two bodies would lead to an exchange of ideas on training, certificate course content and standards. Such a body would resolve some of the fears expressed by respondents concerning the relationship between current Certificate courses and the recently established U.G3 (B2) courses. One fear, however, is that such a body would in time become exclusive rather than inclusive. Avenues of progress from technician to engineer should also be established since we were not convinced on the basis of work done that serious barriers exist between the levels. Of value also in such activity would be the eventual clarification of the boundaries between engineer's and technician's work tasks. As we have said an area of overlap exists today and it is not easy to see where the boundary lies.

12.4. FUTURE WORK

Attention has been drawn in the earlier paragraphs to some specific work which needs to be done. Comment will be made in the following paragraphs to more general issues.

Frequent reference has been made in this report to the fact that it has been possible to deal in detail only with Part A of the Research Plan, and this in a slightly incomplete and altered fashion from what was originally planned. Some thought therefore, must be given to rounding off Part A of the Research Plan, and completing Parts B and C.

In addition, as the work has progressed views have formed about some other aspects of the work and ideas about further useful areas of study have arisen. These ideas can be loosely grouped into broad objectives and specific objectives.

12.4.1. Broad Objectives

a) Related to civil engineering study

Present work has concentrated on an analysis of civil engineering tasks at all levels and across all sections of civil engineering practice. Our attempt to survey the curricula in use in the C.A.E.'s across Australia has been limited to material we obtained from handbooks and material sent in response to personal letters. Much information was also obtained in this section from the study of Horne and Wise.**

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* Klamus, N.G., loc. cit. Chapter 9.

** Horne, B.C. & Wise, B., "Learning and Teaching in the C.A.E.'s"., 1969.

It is clear, however, that only an imperfect picture can be built from such procedures and a more systematic search for curriculum aims, implementation and evaluation would require personal visits to each institution. We believe that a study for a selected area such as civil engineering would yield considerable benefits. Most institutions we contacted are searching for assistance on systematic curriculum development procedures and such defects as we have noted are due, in part, to lack of effective guidance.

b) Other fields of study.

Apart from civil engineering the experience gained in the current study could be utilised to tackle better another vocation, e.g., chemical engineering, accounting, commerce, or business in general. Of particular relevance today is the subject of business. Courses aimed at preparing students for business are available but one wonders how these courses relate to the tasks the students will later be asked to tackle, how the various curricula were developed, and what the objectives were.

12.4.2. Specific Objectives

a) Connected with civil engineering study generally.

The large number involved in civil engineering (around 25,000 in total for Australia) and the difficulties encountered in obtaining a detailed stratified breakdown of the population on which a sampling procedure could be based, prevented the study from being carried out across Australia. A check should be made when data become (or are made) available to determine if the data collected for N.S.W. are representative of Australia as a whole.

Before collection of statistics about civil engineering started a model was developed which was thought to fit the structure, or most nearly approximate the structure of the industry as a whole. The model was essentially traditional in nature and some defects were expected. As the study progressed some defects were detected. Fortunately these were not so large as to upset markedly the study. The project engineer has been with us a long time but he seems from the data we collected to be increasing in numbers at the present time. Project engineers do not neatly fit into a design or construction or feasibility study category, rather they straddle all three activities and are involved in all three activities. Traffic Engineering, an increasingly important activity was also not specifically included in our model. Some more detailed attempt could be made to verify the accuracy of the model that was used as a basis for investigating the quantitative nature of the civil engineering population.

b) Connected with the instruments.

One of the defects with the current task analysis questionnaire has been our inability to define technical work activities in anything but the jargon of the 'standard' civil engineering curriculum. Some attempt should be made with a small sample, to define work activities in terms of the operational objectives and actions. For example, in panel beating, a tradesman will take a hammer and beat the metal of the mudguard or wing with the intention of hammering out a dent and restoring the curvature of the metal to its original state. There is no [illegible], in part, to [illegible] of [illegible].

b) Other fields of study.

Apart from civil engineering the experience gained in the current study could be utilised to tackle better another vocation, e.g., chemical engineering, accounting, commerce, or business in general. Of particular relevance today is the subject of business. Courses aimed at preparing students for business are available but one wonders how these courses relate to the tasks the students will later be asked to tackle, how the various curricula were developed, and what the objectives were.

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The task analysis questionnaire more nearly approached operational form in the non-technical activities examined, but the weakness lay in these being divorced from the technical activities which were described mainly in non-operational terms. Ideally then one should ask engineers and technicians to nominate lists of skills they use in their jobs. At the same time some attempt should be made to get nearer to the concept of actually observing and detailing the tasks involved in the different jobs: discussion with the task performers would also be necessary. A list of tasks performed and skills used, similar to that produced by Youngman* for workers in an engineering factory could thereby be constructed. This procedure is much easier, of course, if the job involves a high manual skills component.

In the original plan of the study it was intended to use structured interview techniques but these were dropped because of lack of resources. A case could be made for continuing the present study using the structured interview procedure to check the results obtained by use of the mailed questionnaire. Our current knowledge of the industry and its areas of specialisation would enable relatively sophisticated information to be obtained from a comparatively small outlay.

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* Youngman, M.B. A first classification of engineering abilities, Report 1. Industrial Training Research Project, Dept. of Employment, University of Lancaster, U.K., August 1971.

CORRIGENDA

p.14 line 1. "could" should read "would"

p.27 line 3. "retrun" should read "return"

p.31 line 6 of section 5.2.3., "limited" should read "limiting"

p.32)
p.33) both Table 5.2.3.2. and Table 5.2.3.3. have been unnecesarily
p.34) repeated.

p.68 line 1. "eighty" should read "sixty-three"

p.68 line 18 of section 8.1.5.1., "giben" should read "given"

p.68 category 5 of Table 8.1.6. should read "Structural eng. cert. and drafting cert." instead of "Engineering survey cert."

p.69 Table 8.1.7., all figures under columns 6 and 7 should be transposed.

p.70 line 17 of section (4), "pattersn" should read "patterns".

p.102) These two pages are wrongly numbered and should be read in
p.103) the order p.103 first followed by p.102.

p.113 line 6 of postscript, there should be no commas around "intended".

p.124 line 31, "board" should read "head".

p.136 line 14 of section (3), "2.B.(a)" should read "3.B.(a)"

p.138 line 21 of section 12.3., "attitional" should read "additional".

A separate corrigendum dealing with some of the Tables in Appendix 8 is given on p.4. of Appendix 8.

APPENDIX 1. TASK ANALYSIS QUESTIONNAIRE *

- BASIC DATA CONCERNING RESPONDENTS.

The total response to the questionnaire seeking information on the tasks associated with the jobs of engineers and technicians working in civil engineering was 331. The first page of this questionnaire sought information for each subject on where he worked, the type of work, the title of his job, his age, qualifications and years of work in his present job, etc. This information categorised the subjects on the basis of the model of civil engineering developed for the study.

Some salient features of the group of 331 subjects are given in the following tables 1-14.

TABLE A1.1. AGE DISTRIBUTION

Age	All Subjects	%	Engineers	%	Technicians	%
20-25	76	23%	27	13%	49	38%
26-30	93	28	55	28	38	29
31-35	42	13	30	15	13	10
36-40	43	13	32	16	10	8
41-45	33	10	24	12	9	7
46-50	18	5	15	7	3	2
51-55	15	5	10	5	5	4
56-60	8	2	6	3	3	2
> 60	3	1	2	1	--	--
TOTAL	331		201		130	

* Labelled "Survey Schedule" for field work.

TABLE A1.2. DISTRIBUTION OF LEVELS OF ENGINEERS AND TECHNICIANS WITHIN EACH AGE GROUP (AMPLIFICATION OF TABLE 1)

Age	Engineers					Technicians			
	Level 1*	2	3	4	Total	5	6	7	Total
20-25	-	-	9	18	27	7	29	13	49
26-30	-	11	21	23	55	12	26	-	38
31-35	2	9	8	10	29	8	5	-	13
36-40	4	13	8	7	32	6	5	-	11
41-45	2	6	10	6	24	2	7	-	9
46-50	1	3	6	5	15	3	-	-	3
51-55	1	4	2	3	10	4	1	-	5
56-60	1	2	2	1	6	2	-	-	2
> 60	-	1	2	-	3	-	-	-	0
TOTAL	11	49	68	73	201	44	73	13	130

* The various levels 1-7 shown are categories of engineers and technicians ranging from senior engineers in organisations through to recently qualified engineers (levels 1 → 4) and from senior technicians to junior technicians (levels 5 → 7).

TABLE A1.3. DISTRIBUTION OF SUBJECTS OVER TYPE OF EMPLOYER

Employer	Number of Subjects	%
Commonwealth Government	12	3
State Government	119	36
Local Government	85	26
Consultants	73	22
Contractors	38	11
General Industry	4	1
TOTAL	331	100%

TABLE A1.4. AGE DISTRIBUTION OVER EACH TYPE OF EMPLOYER

Age	Employer											
	C'th Govt.		State Govt		Local Govt.		Consultants		Contractors		Gen. Ind.	
20-25	2	17%	26	22%	16	19%	24	33%	8	21%	-	
26-30	5	42%	39	33%	20	24%	20	26%	10	26%	-	
31-35	3	25%	9	8%	8	9%	10	13%	9	23%	3	75%
36-40	-	-	15	13%	17	20%	7	10%	4	11%	-	
41-45	-	-	10	8%	13	15%	7	10%	2	5%	1	25%
46-50	1	8%	10	8%	4	5%	2	3%	1	3%	-	
51-55	-	-	6	5%	4	5%	2	3%	3	8%	-	
56-60	-	-	4	3%	2	2%	1	1%	1	3%	-	
> 60	1	8%	-	-	1	1%	-		-		-	
Sub-Total Total	12	100%	119	100%	85	100%	73	100%	38	100%	4	100% 331

On the evidence provided by the above table General Industry was excluded from all further considerations in the analysis of the data.

TABLE A1.5. TYPE OF WORK DISTRIBUTION (MAIN ACTIVITY)

Type of Work	Number of Subjects	%
1. Design	158	47%
2. Construction	90	27
3. Maintenance	10	3
4. Feasibility Studies	13	4
5. R & D/Investigational	25	8
6. Sales	3	1
7. Design and feasibility	1	-
8. Construction and Maintenance	9	3
9. 7 & 8	22	7
TOTAL	331	100%

TABLE A1.6. AGE DISTRIBUTION OVER EACH CATEGORY/TYPE OF WORK

	Category/Type of Work								
	1	2	3	4	5	6	7	8	9
Age	Design	Constr.	Maint.	Feasib.	R & D	Sales	Des/feas.	Const/ Maint.	7 & 8
20-25	45	15	3	2	4	-	-	3	3
26-30	46	30	3	6	3	-	-	1	5
31-35	18	13	-	2	4	3	-	1	3
36-40	20	14	-	-	3	-	1	-	5
41-45	14	8	2	1	4	-	-	2	2
46-50	8	2	-	1	2	-	-	1	4
51-55	3	7	-	1	2	-	-	1	1
56-60	3	1	1	-	3	-	-	-	-
> 60	1	-	1	-	-	-	-	-	1
Sub-Totals	158	90	10	13	25	3	1	9	24
Totals									331

TABLE A1.7. TYPE OF QUALIFICATION

Qualification	Number of Subjects
B.E. (Civil)	81
Diploma-engineering	37
B.Sc. (Civil Engineering)	20
Degree - other	13
Professional Inst. qualification	5
Local Government certificate	14
Diploma - other	5
Structural engineering certificate	21
Engineering surveying certificate	28
Drafting certificate	14
Materials testing certificate	4
Certificate - other	36
No qualification	45
No answer	8
TOTAL	331

20-25	45	15	3	2	4	-	-	3	3
26-30	46	30	3	6	3	-	-	1	5
31-35	18	13	-	2	4	3	-	1	3
36-40	20	14	-	-	3	-	1	-	5
41-45	14	8	2	1	4	-	-	2	2
46-50	8	2	-	1	2	-	-	1	4
51-55	3	7	-	1	2	-	-	1	1
56-60	3	1	1	-	3	-	-	-	-
> 60	1	-	1	-	-	-	-	-	1
Sub-Totals	158	90	10	13	25	3	1	9	24
Totals									331

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Diploma - other	5
Structural engineering certificate	21
Engineering surveying certificate	28
Drafting certificate	14
Materials testing certificate	4
Certificate - other	36
No qualification	45
No answer	8
TOTAL	331

TABLE A1.8. TYPE OF QUALIFICATION OVER CLASSIFICATION AS ENGINEER (LEVELS 1-4) AND TECHNICIAN (LEVELS 5-7)

Qualification	Engineer				Technician			
	Level 1	2	3	4	5	6	7	Total
B.E. (Civil)	2	18	28	33	-	-	-	81
Diploma-Engineering	2	9	12	10	3	1	-	37
B.Sc. (Civil Engineering)	1	3	10	6	-	-	-	20
Degree - other	-	3	7	2	1	-	-	13
Prof. qualification	-	1	2	2	-	-	-	5
Local Govt. Certificate	6	4	3	1	-	-	-	14
Diploma - other	-	1	2	2	-	-	-	5
Struct. Eng. Certificate	-	-	-	-	8	11	2	21
Eng. Survey Certificate	-	-	1	3	5	19	-	28
Draft Certificate	-	-	-	1	3	9	1	14
Mats. test. Certificate	-	-	-	-	-	4	-	4
Certificate - other	-	2	5	10	10	9	-	36
No qualification	-	2	-	3	13	18	9	45
No answer	-	-	-	-	-	-	-	8
TOTAL		201				130		331

TABLE A1.9. EMPLOYER CATEGORIES SPLIT OVER ENGINEER AND TECHNICIAN CLASSIFICATIONS

Employer	Engineer				Technician			
	Level 1	2	3	4	5	6	7	Total
C'wealth Government			7	3	2	-		12
State Government		10	26	27	19	25	2	119
Local Government	7	25	12	13	12	15	1	85
Consultants	2	7	14	12	8	20	10	73
Contractors	2	6	9	15	3	3	-	38
General Industry	1	-	-	3	-	-	-	4
	12	48	68	73	44	73	13	
			201			130		331

TABLE A1.10. TYPE OF WORK SPLIT OVER ENGINEER AND TECHNICIAN CLASSIFICATIONS

Type of Work	Engineer				Technician			
	Level 1	2	3	4	5	6	7	Total
1. Design	1	15	23	21	25	61	12	158
2. Construction	3	18	29	26	8	6	-	90
3. Maintenance	-	3	3	2	1	-	1	10
4. Feasibility studies	-	-	5	5	2	1	-	13
5. R & D/Investigational	-	4	5	7	6	3	-	25
6. Sales	1	-	-	2	-	-	-	3
7. Design & feasibility	1	-	-	-	-	-	-	1
8. Constr. & Maint.	1	3	-	4	-	1	-	9
9. 7 & 8	5	5	3	6	2	1	-	22
	12	48	68	73	44	73	13	
	201				130			331

TABLE A1.11. COMPOSITE TABLE SHOWING ENGINEERS AND TECHNICIANS OVER TYPES OF WORK AND EMPLOYERS

Type of Work		Employer						Total	
		C'wealth Govt.	State Govt.	Local Govt.	Consul-tants.	Contra-ctors.	General Indu.		
1. Design -	Engrs.	2	17	15	24	1	1	60	
	Techns	-	41	20	37	-	-	98	158
2. Construction	Engrs.	2	23	18	4	29	-	76	
	Techns	-	6	3	-	5	-	14	90
3. Maintenance	Engrs.	-	6	2	-	-	-	8	
	Techns	-	1	1	-	-	-	2	10
4. Feasibility Studies	Engrs.	1	2	-	5	2	-	10	
	Techns	-	1	-	1	1	-	3	13
5. R & D	Engrs.	2	10	3	1	-	-	16	
	Techns	2	7	-	-	-	-	9	25
6. Sales	Engrs.	-	-	-	-	-	3	3	
	Techns	-	-	-	-	-	-	-	3

2. Construction	3	18	29	26	8	6	-	90
3. Maintenance	-	3	3	2	1	-	1	10
4. Feasibility studies	-	-	5	5	2	1	-	13
5. R & D/Investigational	-	4	5	7	6	3	-	25
6. Sales	1	-	-	2	-	-	-	3
7. Design & feasibility	1	-	-	-	-	-	-	1
8. Constr. & Maint.	1	3	-	4	-	1	-	9
9. 7 & 8	5	5	3	6	2	1	-	22
	12	48	68	73	44	73	13	
		201				130		331

TABLE A1.11. COMPOSITE TABLE SHOWING ENGINEERS AND TECHNICIANS OVER TYPES OF WORK AND EMPLOYERS

Type of Work		Employer						Totals	
		C'wealth Govt.	State Govt.	Local Govt.	Consul-tants.	Contra-ctors.	General Indu.		
1. Design -	Engrs.	2	17	15	24	1	1	60	
	Techns	-	41	20	37	-	-	98	158
2. Construction	Engrs.	2	23	18	4	29	-	76	
	Techns	-	6	3	-	5	-	14	90
3. Maintenance	Engrs.	-	6	2	-	-	-	8	
	Techns	-	1	1	-	-	-	2	10
4. Feasibility Studies	Engrs.	1	2	-	5	2	-	10	
	Techns	-	1	-	1	1	-	3	13
5. R & D	Engrs.	2	10	3	1	-	-	16	
	Techns	2	7	-	-	-	-	9	25
6. Sales	Engrs.	-	-	-	-	-	3	3	
	Techns	-	-	-	-	-	-	-	3
7. Design, Feasibility	Engrs.	-	-	-	1	-	-	1	
	Techns	-	-	-	-	-	-	-	1
8. Construction & Maintenance	Engrs.	-	3	5	-	-	-	8	
	Techns	-	-	1	-	-	-	1	9

TABLE A1.11. (Cont.)

Type of Work		C'wealth Govt.	State Govt.	Local Govt.	Consultants.	Contractors.	General Indu.	Totals	
		Employer							
9. 7 & 8	Engnrs.	3	2	14	-	-	-	19	
	Techns	-	-	3	-	-	-	3	22
Total Engineers		10	63	57	35	32	4	201	
Total Technicians		2	56	28	38	6	-	130	
TOTAL		12	119	85	73	38	4		331

TABLE A1.12 METHOD OF ACHIEVING QUALIFICATIONS

Method	Engineers	Technicians	Total
Full-Time	85	6	91
Part-Time	79	74	153
Full-Time/Part-Time			11
Correspondence			7
Sandwich			3
T.W.I.			1
Self-Learning			3
No-Answer			62
TOTAL			331

TABLE A1.13. LENGTH OF TIME IN PRESENT JOB (YEARS)

	< 1yr.	2 yr.	3 yr.	4 yr.	5 yr.	6-7 yr.	8-10 yr.	> 10 yr.	Total
Number of Subjects	37	59	56	28	30	35	31	55	331
%	11%	18	17	8	9	11	9	17	100%

TABLE A1.14 LENGTH OF TIME IN CIVIL ENGINEERING (YEARS)

						16-20	21-30	> 30	No

9. 7 & 8	Engnrs.	3	2	14	-	-	-	19	
	Techns	-	-	3	-	-	-	3	22
Total Engineers		10	63	57	35	32	4	201	
Total Technicians		2	56	28	38	6	-	130	
TOTAL		12	119	85	73	38	4		331

TABLE A1.12 METHOD OF ACHIEVING QUALIFICATIONS

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Full-Time/Part-Time			11
Correspondence			7
Sandwich			3
T.W.I.			[illegible]
Self-Learning			3
No-Answer			62
TOTAL			331

TABLE A1.13. LENGTH OF TIME IN PRESENT JOB (YEARS)

	< 1yr	2 yr.	3 yr.	4 yr.	5 yr.	6-7 yr.	8-10 yr.	> 10 yr.	Total
Number of Subjects	37	59	56	28	30	35	31	55	331
%	11%	18	17	8	9	11	9	17	100%

TABLE A1.14 LENGTH OF TIME IN CIVIL ENGINEERING (YEARS)

	< 1yr	2 yr.	3-4yr.	5-7 yr	8-10yr.	11-15yr	16-20 yr.	21-30 yr.	> 30 yr.	No Answer
Number of Subjects	4	9	37	52	53	65	33	55	18	5
									TOTAL	331
%	1	3	11	16	16	20	10	17	5	1
									TOTAL	100%

N.B. In tables A1.13., and A1.14., the increments chosen for the time scales are unequal. The questions were inserted in order to see if an unduly large number of respondents were new to civil engineering and/or new to their job.

APPENDIX 2

TASK ANALYSIS QUESTIONNAIRE - BROAD TASK ANALYSIS, FREQUENCY OF TASK

On the second page of the questionnaire seeking information on tasks and training etc., respondents were asked to allocate their work time over certain types of task. These tasks were classified as Technical matters, Manual skills, Economic and financial matters, Communication matters/exchange of information, and Management and Personnel matters. The analysis of the data relating to this has been dealt with in Chapter 8 of this report.

The instructions to respondents dealing with this task analysis or Broad Task Analysis as it has been called in this report, also asked them to indicate the frequency with which they were involved in each particular task over the previous twelve months. The instructions read as follows:

> "On this page we would like you to show how your working time is split-up over some broad categories of tasks. In order to do this with some accuracy we suggest you note down day by day for a period of two working weeks the approximate hours spent on each of the broad categories of task. At the end of the time the hours can be summed and a percentage calculated for each category. We are only interested in the percentage of the hours worked, and these should be indicated in the column headed "% or nil". Percentages to be given to the nearest 5%. In the next column headed "Frequency" please indicate how frequently you were engaged on the category of task over the last year, since the fortnight chosen may not have been typical of your working year. Your answer to be selected from the following list of code numbers with their meanings:-
>
> 1 = Regularly, frequently, i.e. every day or every other day
> 2 = Frequently, i.e. about once a week
> 3 = Not frequently, i.e. about once a month
> 4 = Infrequently, less than 10 times a year.
>
> Please write the selected code number in its relevant column in your answers below.
>
> We suggest you read all the pages of the Task Analysis section in order to gain an idea of what is meant by Technical Matters, Manual Skills, Economic & Financial Matters etc."

This appendix presents in detail the information concerning frequency of use provided by the respondents. In this presentation the total response has been split a variety of ways, e.g. between all engineers, and all technicians, split over employer, type of work, and age etc.

TABLES A2.1. 1 & 2   FREQUENCY OF USE OF TASK
(SPLIT OVER ALL ENGINEERS AND ALL TECHNICIANS)

1. ENGINEERS   n = 201

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Answer
Technical	8	193	96%	139	37	11	2	12
Manual	84	117	58	35	41	21	23	81
Economic	29	172	86	57	71	36	9	28
Communication	11	190	95	130	41	12	2	16
Management	32	169	84	101	39	19	7	35

N.B. In the above table, as in all the tables in this appendix the first and last columns roughly agree, the figures in the last column always being numerically greater than those in the first column. This is because in some cases a respondent indicating use or involvement in a category of task did not report the frequency of use. Therefore the number of "no answer" replies for frequency was slightly larger than the number of "do not use" replies for the tasks.

2. TECHNICIANS   n = 130

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Answer
Technical	21	109	83.8	70	17	10	3	30
Manual	19	111	85.4	71	21	7	2	29
Economic	76	54	41.5	8	14	16	12	80
Communication	43	87	66.9	35	27	15	2	51
Management	80	50	38.5	21	11	6	5	87

TABLES A2. 2. 1.2.3. 4.5. & 6.

FREQUENCY OF USE OF TASK (FOR ENGINEERS AND TECHNICIANS ENGAGED ON DESIGN, CONSTRUCTION AND OTHER WORK)

1. ENGINEERS - DESIGN

n = 60

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	1	59	98	50	8	2	0	0
Manual	25	35	58	13	13	4	7	23
Economic	12	48	80	11	22	13	4	10
Communication	2	58	95	33	19	5	1	2
Management	14	46	76	25	9	8	5	13

2. ENGINEERS - CONSTRUCTION

n = 92

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	5	87	95	57	18	7	2	8
Manual	32	60	65	16	23	12	9	32
Economic	11	81	88	34	30	15	0	13
Communication	4	88	96	64	15	5	1	7
Management	6	86	93	50	23	8	1	10

3. ENG..NEERS - OTHER WORK

n = 49

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	2	47	96	32	11	2	0	4
Manual	27	22	45	6	3	7	6	27
Economic	6	43	88	11	18	8	5	7
Communication	5	44	90	33	7	2	0	7
Management	12	37	75	25	6	4	1	13

TABLES A2. 2. 1.2.3.
4.5. & 6. (continued)

4. TECHNICIANS - DESIGN n = 98

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	16	82	84	52	12	9	3	22
Manual	11	87	89	54	18	5	1	20
Economic	56	42	43	6	12	14	9	57
Communication	32	66	67	27	22	13	1	35
Management	62	36	37	15	8	6	4	65

5. TECHNICIANS - CONSTRUCTION n = 17

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	1	16	94	9	4	1	0	3
Manual	5	12	71	8	2	1	0	6
Economic	11	6	35	1	1	2	1	12
Communication	5	12	71	4	5	0	1	7
Management	10	7	41	3	1	0	1	12

6. TECHNICIANS - OTHER WORK n = 15.

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	4	11	73	9	1	0	0	5
Manual	3	12	30	8	0	2	1	4
Economic	9	6	40	1	3	0	2	9
Communication	6	9	60	5	1	2	0	7
Management	8	7	47	4	2	0	0	9

TABLES A2 4. 1.2.3. 4.5. & 6.

FREQUENCY OF USE OF TASK (SPLIT OVER TYPE OF EMPLOYER)

1. COMMONWEALTH GOVERNMENT n = 12.

TASK	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	1	11	92	8	1	2	0	1
Manual	5	7	58	4	0	1	2	5
Economic	3	9	75	1	3	4	2	2
Communication	1	11	92	10	1	0	0	1
Management	3	9	75	3	7	1	1	0

2. STATE GOVERNMENT n = 119

TASK	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	10	109	92	83	15	8	1	12
Manual	35	84	71	35	28	11	11	34
Economic	37	82	69	20	32	22	9	36
Communication	19	100	84	55	27	11	2	24
Management	51	68	57	43	12	8	4	52

3. LOCAL GOVERNMENT n = 85

TASK	DO NOT USE	USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	3	82	96	57	16	5	3	4
Manual	20	65	76	32	15	12	6	20
Economic	16	69	81	23	28	14	4	16
Communication	8	77	91	50	17	0	9	9
Management	21	64	27	40	10	5	8	22

TABLES A2. 4. 1.2.3.
4.5. & 6. (continued)

4. CONSULTANTS n = 73

TASK	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	11	62	85	39	10	3	1	20
Manual	24	49	67	29	10	1	1	32
Economic	43	40	41	4	10	8	4	47
Communication	22	51	70	28	16	2	2	25
Management	27	46	63	18	14	8	0	33

5. CONTRACTORS n = 38

TASK	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	4	34	90	20	10	3	0	5
Manual	16	22	58	5	6	5	4	18
Economic	6	32	84	16	12	2	1	7
Communication	4	34	90	20	7	5	0	6
Management	9	29	76	12	12	3	0	11

6. GENERAL INDUSTRY n = 4

TASK	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	-	4	100	2	2	0	0	0
Manual	2	2	50	0	0	1	0	3
Economic	-	4	100	0	1	2	1	0
Communication	-	4	100	3	2	0	0	0
Management	1	3	75	2	0	1	0	1

A2. f.6.

TABLES A2. 5. 1.2.3.
4. & 5.

FREQUENCY OF USE OF TASK (SPLIT OVER AGE AND AGAIN OVER ENGINEERS AND TECHNICIANS)

1. ENGINEERS 20-30 yrs. n = 83

TASKS	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	6	77	93	59	12	3	1	8
Manual	24	59	71	16	24	11	10	22
Economic	12	71	85	21	33	14	3	12
Communication	6	77	93	56	13	6	1	7
Management	18	65	78	36	18	9	2	18

2. ENGINEERS 31-40 yrs. n = 61

TASKS	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	2	59	96	43	11	4	1	2
Manual	29	32	52	10	6	7	8	30
Economic	9	52	85	18	19	11	3	10
Communication	2	59	96	36	16	4	0	5
Management	5	56	92	30	13	6	4	8

3. ENGINEERS 41 yrs. and older n = 57

TASKS	DO NOT USE	DO USE	%	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	0	57	100	37	14	4	0	2
Manual	31	26	46	9	9	5	4	30
Economic	8	49	86	17	18	11	3	8
Communication	3	54	95	38	12	2	1	4
Management	9	48	84	34	7	5	1	10

TABLES A2. 5. 1.2.3.
4. & 5. (continued)

4. TECHNICIANS 20-30 yrs. n = 87

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	15	72	83	40	14	9	2	22
Manual	11	76	87	54	9	4	0	20
Economic	52	35	40	5	11	8	9	54
Communication	34	53	61	21	19	10	2	35
Management	59	28	32	11	7	3	3	63

5. TECHNICIANS 31 yrs & older n = 43

TASK	DO NOT USE	DO USE	% USE	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.
Technical	6	37	86	30	3	1	1	8
Manual	8	35	81	16	11	4	2	10
Economic	24	19	44	3	5	8	3	24
Communication	9	34	79	15	9	5	0	14
Management	21	22	51	11	4	3	2	23

APPENDIX 3. TASK ANALYSIS QUESTIONNAIRE-

ANALYSIS OF "MANUAL SKILLS" CATEGORY OF TASK.

In the questionnaire each category of task was sub-divided into a number of sub-categories of task in order to determine whether some particular skills or parts of a task were used more frequently than others, particularly with respect to one of the independent variables e.g. type of work. Questions concerning the importance of the sub-category of task were also raised.

This appendix, and the next three, are similar in format and all relate to sub-categories of task. It may be of use therefore at this point to repeat those instructions in the questionnaire relating to these sub-categories of task as this could assist in comprehending the tables that appear in Appendices 3,4,5, and 6.

The instructions were:-

"Please indicate in the sections that follow viz. Manual skills, Economic, Communication, and Personnel matters.

a) what percentage of the total time spent on the activities connected with that particular section can be allocated to the sub-categories of task listed in that section. Answers to nearest 10%. Percentage column to total 100%.

b) against those tasks where you have put a % figure indicate the frequency with which you perform the task. Use one of the code numbers 1,2,3 or 4 according to the notes below.

c) against those tasks where you have put a % figure indicate the importance of that task using one of the code numbers 1,2,3,4 or 5; according to the notes below.

d) against all sub category tasks put either 1 or 0 (used, or not used) depending on whether you have performed the task in the past 12 months.

FREQUENCY of use, select one of the following code numbers with their meanings as given:-

1 = Regularly, frequently, i.e. every day or every other day

2 = Frequently, i.e. about once a week

3 = Not frequently, i.e. about once a month

4 = Infrequently, i.e. less than 10 times a year

IMPORTANCE - i.e. whether knowledge of the particular element is important in your job. Your answer to be selected from the following code numbers with their meanings as given:-

1 = Very important, easy to acquire

2 = Very important, difficult to acquire

3 = Important, easy to acquire

4 = Important, difficult to acquire

5 = Not important "

The category "Manual skills" was sub-divided into

i) drawing and drafting

ii) using survey instruments

iii) using laboratory or testing apparatus

iv) other (specify)

After the usual adjustments for no response and imperfect response the following tables for engineers and technicians were prepared.

TABLE A3.1. PERCENTAGE USE OF VARIOUS MANUAL SKILLS BY ALL ENGINEERS AND TECHNICIANS INDICATING USE OF MANUAL SKILLS AT SOME TIME IN THEIR JOB

SUB-CATEGORY OF TASK	ENGINEERS - % n = 147	TECHNICIANS - % n = 124
Drawing & Drafting	54%	73%
Using survey instruments	32	13
Using lab. apparatus	7	8
Others (miscellaneous)	6	5
"rounding off" error	1	1

TABLE A3.2. 1 & 2. FREQUENCY OF USE AND IMPORTANCE OF VARIOUS MANUAL SKILLS

1 - Engineers n = 147

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	28	37	32	37	13	37	3	62	18	14	13	125
Using survey insts.	27	19	28	31	42	41	4	45	8	5	42	90
Using lab. apparatus	1	7	18	23	98	3	1	35	1	6	98	43

2 - Technicians n = 124

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	88	15	10	5	6	74	15	24	3	2	6	114
Using survey insts.	19	11	13	14	67	23	4	24	6	-	67	54
Using lab. apparatus	9	2	1	1	111	6	1	6	-	-	111	13

The next table consists of six parts, and refers to technicians split into the three types of work category, viz. design, construction, and other work (feasibility studies, R & D/ investigational, etc.)

TABLE A3.3. PERCENTAGE USE OF VARIOUS MANUAL SKILLS BY ENGINEERS AND TECHNICIANS ACCORDING TO TYPE OF WORK, AND WHO INDICATED USE OF MANUAL SKILLS AT SOME TIME IN THEIR JOB.

DESIGN WORK	n = 44	n = 93
SUB-CATEGORY OF TASK	ENGINEERS %	TECHNICIANS %
Drawing & Drafting	70%	84%
Using survey instruments	14	11
Using lab. apparatus	5	1
Other (miscellaneous)	10	3
rounding off 'error'	1	1

CONSTRUCTION WORK	n = 68	n = 16
Drawing & Drafting	44%	32%
Using survey instruments	48	17
Using lab. apparatus	7	39
Other (miscellaneous)	1	11
rounding off 'error'	0	1

OTHER WORK	n = 35	n = 15
Drawing & Drafting	52%	41%
Using survey instruments	26	19
Using lab. apparatus	12	28
Other (miscellaneous)	9	11
rounding off 'error'	1	1

The following six tables deal with the frequency of use and importance for each of the six groups referred to in the previous t. bles.

TABLE A3.4. FREQUENCY AND IMPORTANCE OF MANUAL SKILLS FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK, AND WHO USED SUCH SKILLS AT SOME TIME IN THEIR JOB.

ENGINEERS - DESIGN n = 44

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	12.	15.	6.	7.	4	16.	2.	15.	5.	4.	2	42
Using survey insts.	5.	3.	3.	4.	29	9.	0.	3.	3.	0.	29	16
Using lab. apparatus	0.	0.	3.	6.	35	1.	1.	6.	0.	0.	36	9

ENGINEERS - CONSTRUCTION n = 68

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	12.	12.	20.	21.	3	17.	1.	32.	4.	8.	6	58
Using survey insts.	18.	12.	21.	15.	0	26.	2.	31.	4.	3.	2	58
Using lab. apparatus	0.	7.	11.	10.	40	0.	0.	22.	1.	4.	39	25

ENGINEERS - OTHER WORK n = 35

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	4.	9.	7.	9.	6	5.	0.	19.	0.	5.	6	26
Using survey insts.	4.	4.	8.	5.	14	5.	1.	13.	0.	2.	14	31
Using lab. apparatus	1.	0.	4.	7.	23	2.	0.	7.	0.	2.	24	10

TECHNICIANS - DESIGN n = 93

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	80.	10.	2.	1.	0	67.	15.	9.	2.	0.	0	92
Using survey insts.	13.	9.	13.	11.	47	18.	4.	17.	6.	1.	47	43
Using lab. apparatus	1.	0.	1.	0.	91	1.	1.	0.	0.	0.	91	2

TECHNICIANS - CONSTRUCTION n = 16

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	4.	2.	3.	3.	4	4.	0.	7.	1.	0.	4	12
Using survey insts.	3.	1.	1.	1.	10	3.	0.	3.	0.	0.	0	6
Using lab. apparatus	5.	1.	0.	1.	9	4.	0.	3.	0.	0.	0	7

TECHNICIANS - OTHER WORK n = 15

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	NO ANS.	IMPORTANCE 1.	2.	3.	4.	5.	NO ANS.	USE IN YEAR
Drawing & Drafting	3.	3.	5.	1.	3	3.	0.	6.	0.	2.	4	10
Using survey insts.	2.	2.	2.	0.	9	2.	0.	4.	0.	0.	9	5
Using lab. apparatus	3.	1.	0.	0.	11	2.	0.	3.	0.	0.	10	4

APPENDIX 4. TASK ANALYSIS QUESTIONNAIRE-ANALYSIS OF "ECONOMIC/FINANCIAL MATTERS" CATEGORY OF TASK.

The category "Economic/financial matters" was sub-divided into:-

i) Feasibility studies
ii) Cost benefit analyses
iii) Market studies
iv) Costing of, costs of projects
v) Other (specify)

After the usual adjustments for no response and imperfect response had been made the following combined table for engineers and technicians in design work, construction work and other work (feasibility studies, R & D/Investigational etc.) was prepared:

TABLE A4.1. PERCENTAGE USE OF VARIOUS "ECONOMIC/FINANCIAL MATTERS" BY ENGINEERS AND TECHNICIANS ACCORDING TO TYPE OF WORK, AND WHO INDICATED USE OF "ECONOMIC/FINANCIAL MATTERS" AT SOME TIME IN THEIR JOB.

DESIGN WORK	n = 44	n = 45
SUB-CATEGORY OF TASK	ENGINEERS %	TECHNICIANS %
Feasibility Studies	18%	12%
Cost benefit analyses	10	2
Market studies	3	1
Costings, costs	65	80
Other (miscellaneous)	3	4
Rounding off 'error'	1	0

CONSTRUCTION WORK	n = 86	n = 7
Feasibility Studies	11%	4%
Cost benefit analyses	9	3
Market studies	7	0
Costings, costs	70	92
Other (miscellaneous)	3	1
Rounding off 'error'	0	0

OTHER WORK	n = 46	n = 6
Feasibility Studies	19%	22%
Cost benefit analyses	10	12
Market studies	4	0
Costings, costs	60	49
Other (miscellaneous)	7	4
Rounding off 'error'	0	3

The following combined table shows the frequency of use, and importance of the various economic/financial matters for each of the

iii) Market studies
iv) Costing of, costs of projects
v) Other (specify)

After the usual adjustments for no response and imperfect response had been made the following combined table for engineers and technicians in design work, construction work and other work (feasibility studies, R & D/Investigational etc.) was prepared:

TABLE A4.1. PERCENTAGE USE OF VARIOUS "ECONOMIC/FINANCIAL MATTERS" BY ENGINEERS AND TECHNICIANS ACCORDING TO TYPE OF WORK, AND WHO INDICATED USE OF "ECONOMIC/FINANCIAL MATTERS" AT SOME TIME IN THEIR JOB.

DESIGN WORK	n = 44	n = 45
SUB-CATEGORY OF TASK	ENGINEERS %	TECHNICIANS %
Feasibility Studies	18%	12%
Cost benefit analyses	10	2
Market studies	3	1
Costings, costs	65	80
Other (miscellaneous)	3	4
Rounding off 'error'	1	0

CONSTRUCTION WORK	n = 86	n = 7
Feasibility Studies	11%	4%
Cost benefit analyses	9	3
Market studies	7	0
Costings, costs	70	92
Other (miscellaneous)	3	1
Rounding off 'error'	0	0

OTHER WORK	n = 46	n = 6
Feasibility Studies	19%	22%
Cost benefit analyses	10	12
Market studies	4	0
Costings, costs	60	49
Other (miscellaneous)	7	4
Rounding off 'error'	0	3

The following combined table shows the frequency of use, and importance of the various economic/financial matters for each of the six groups referred to in the previous table.

* See pre-amble to Appendix 3.

TABLE A4.2. FREQUENCY AND IMPORTANCE OF VARIOUS ECONOMIC/FINANCIAL MATTERS FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK, AND WHO USED THEM AT SOME TIME IN THEIR JOB.

ENGINEERS - DESIGN n = 44

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1. 2. 3. 4. NO ANS.	IMPORTANCE 1. 2. 3. 4. 5. NO ANS.	USE IN YEAR
Feasibility studies	4. 5. 8.15. 12	8. 7. 9. 6. 1. 13	28
Cost benefit analyses	3. 4. 6. 9. 22	5. 4. 7. 4. 2. 22	19
Market studies	1. 1. 1. 2. 39	3. 0. 1. 1. 0. 39	5
Costings, costs	11.13.14. 6. 0	15. 8.15. 4. 2. 0	44

ENGINEERS - CONSTRUCTION n = 86

Feasibility studies	9.10.19.13. 35	12. 4.21. 9. 3. 37	43
Cost benefit analyses	7. 6.14.11. 48	7. 2.18. 8. 1. 50	31
Market studies	2. 1. 1. 1. 81	0. 1. 2. 1. 1. 81	4
Costings, costs	34.34.12. 2. 4	37.15.26. 2. 1. 5	76

ENGINEERS - OTHER WORK n = 46

Feasibility studies	7. 8. 8. 5. 18	4.11. 9. 4. 0. 18	27
Cost benefit analyses	3. 5. 8. 8. 22	3. 8. 7. 4. 1. 23	23
Market studies	0. 0. 2. 2. 42	0. 0. 4. 1. 0. 41	4
Costings, costs	13.21. 5. 2. 5	12. 5.22. 2. 0. 5	38

TECHNICIANS - DESIGN n = 45

Feasibility studies	4. 2. 6. 4. 29	5. 3. 2. 4. 2. 29	15
Cost benefit analyses	0. 1. 3. 1. 40	0. 2. 2. 1. 0. 40	5
Market studies	0. 0. 0. 1. 44	0. 0. 1. 0. 0. 44	1
Costings, costs	8.18. 9. 6. 4	16. 5.12. 6. 2. 4	39

TECHNICIANS - CONSTRUCTION n = 7

Feasibility studies	0. 0. 2. 0. 5	0. 2. 0. 0. 0. 5	2
Cost benefit analyses	0. 0. 1. 2. 4	0. 2. 0. 1. 0. 4	3
Market studies	0. 0. 0. 0. 0	0. 0. 0. 0. 0. 7	0
Costings, costs	3. 1. 2. 1. 0	1. 3. 2. 1. 0. 0	7

TECHNICIANS - OTHER WORK n = 6

Feasibility studies	0. 3. 0. 0. 3	2. 0. 0. 1. 0. 3	1
Cost benefit analyses	1. 1. 0. 1. 3	0. 0. 1. 1. 1. 3	2
Market studies	0. 0. 0. 0. 6	0. 0. 0. 0. 0. 6	0
Costings, costs	1. 3. 1. 1. 0	2. 0. 2. 1. 1. 0	4

APPENDIX 5 •

TASK ANALYSIS QUESTIONNAIRE - ANALYSIS OF "COMMUNICATION OR EXCHANGE OF INFORMATION MATTERS" CATEGORY OF TASK

The category "Communication or exchange of information matters" was sub-divided into:-

(1) W.iting letters, reports or filling in forms

(2) Sketching

(3) Talking on telephone, in groups, lecturing, attending meetings as a participant

(4) Reading letters, reports, drawings or forms. Keeps up-to-date reading journals.

The usual adjustments were made for no response, and imperfect response, and the following combined table for engineers and technicians engaged in design work, construction work and other work (feasibility studies, R & D/Investigational etc.) was prepared.

TABLE A5. 1. PERCENTAGE USE OF VARIOUS "COMMUNICATION OR EXCHANGE OF INFORMATION MATTERS" BY ENGINEERS AND TECHNICIANS ACCORDING TO TYPE OF WORK, AND WHO INDICATED USE OF COMMUNICATION OR EXCHANGE OF INFORMATION MATTERS AT SOME TIME IN THEIR JOB.

DESIGN WORK	n = 57	n = 74
SUB-CATEGORY OF TASK	ENGINEERS %	TECHNICIANS %
Writing letters etc.	31%	33%
Sketching	15	21
Talking	25	18
Reading reports etc.	27	26
Other (miscellaneous)	2	2
Rounding off 'error'	0	0
CONSTRUCTION WORK	n = 88	n = 15
Writing letters etc.	38%	44%
Sketching	9	9
Talking	30	19
Reading reports etc.	22	24
Other (miscellaneous)	1	4
Rounding off 'error'	0	0
OTHER WORK	n = 46	n = 11
Writing letters etc.	43%	38%
Sketching	7	10
Talking	26	21
Reading reports etc.	22	27
Other (miscellaneous)	1	2
Rounding off 'error'	1	2

(1) Writing letters, reports or filling in forms

(2) Sketching

(3) Talking on telephone, in groups, lecturing, attending meetings as a participant

(4) Reading letters, reports, drawings or forms. Keeps up-to-date reading journals.

The usual adjustments were made for no response, and imperfect response, and the following combined table for engineers and technicians engaged in design work, construction work and other work (feasibility studies, R & D/Investigational etc.) was prepared.

TABLE A5. 1. PERCENTAGE USE OF VARIOUS "COMMUNICATION OR EXCHANGE OF INFORMATION MATTERS" BY ENGINEERS AND TECHNICIANS ACCORDING TO TYPE OF WORK, AND WHO INDICATED USE OF COMMUNICATION OR EXCHANGE OF INFORMATION MATTERS AT SOME TIME IN THEIR JOB.

DESIGN WORK	n = 57	n = 74
SUB-CATEGORY OF TASK	ENGINEERS %	TECHNICIANS %
Writing letters etc.	31%	33% *
Sketching	15	21
Talking	25	18
Reading reports etc.	27	26
Other (miscellaneous)	2	2
Rounding off 'error'	0	0
CONSTRUCTION WORK	n = 88	n = 15
Writing letters etc.	38%	44%
Sketching	9	9
Talking	30	19
Reading reports etc.	22	24
Other (miscellaneous)	1	4
Rounding off 'error'	0	0
OTHER WORK	n = 46	n = 11
Writing letters etc.	43%	38%
Sketching	7	10
Talking	26	21
Reading reports etc.	22	27
Other (miscellaneous)	1	2
Rounding off 'error'	1	2

* See preamble to Appendix 3.

The following combined table shows the frequency of use and importance of the various communication or exchange of information matters for each of the six groups referred to in the previous table.

TABLE A5. 2. FREQUENCY AND IMPORTANCE OF VARIOUS COMMUNICATION MATTERS FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK, AND WHO USED THEM AT SOME TIME IN THEIR JOB.

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No Ans.	1.	2.	3.	4.	5.	No Ans.	
ENGINEERS - DESIGN n = 57												
Writing letters etc.	33	14	4	1	5	24	10	11	4	1	7	45
Sketching	17	14	7	2	17	21	4	13	0	2	17	35
Talking	39	6	3	3	6	23	4	17	4	1	8	45
Reading reports etc.	32	17	2	1	5	25	1	17	5	2	7	46
ENGINEERS - CONSTRUCTION n = 88												
Writing letters etc.	63	18	4	0	3	29	20	27	6	0	6	75
Sketching	17	17	15	2	37	9	1	26	5	4	43	46
Talking	72	10	3	0	3	32	8	38	4	2	4	76
Reading reports etc.	60	19	5	0	4	30	10	35	3	3	7	75
ENGINEERS - OTHER WORK n = 46												
Writing letters etc.	30	12	1	1	2	18	8	10	3	0	7	31
Sketching	7	13	5	1	20	7	2	13	1	1	22	18
Talking	31	9	3	0	3	19	2	15	3	1	6	31
Reading reports etc.	30	12	1	0	3	23	4	11	1		6	32
TECHNICIANS - DESIGN n = 74												
Writing letters etc.	17	18	17	5	17	15	10	25	1	4	19	52
Sketching	13	19	12	9	21	15	3	25	3	5	23	46
Talking	18	17	11	4	24	18	3	21	1	5	26	44
Reading reports etc.	26	16	15	2	15	16	4	31	2	4	17	50
TECHNICIANS - CONSTRUCTION n = 15												
Writing letters etc.	9	3	3	0	0	4	3	6	2	0	0	15
Sketching	2	2	4	2	5	2	0	7	0	0	6	9
Talking	7	4	0	2	2	3	3	5	1	0	3	11
Reading reports etc.	8	2	1	1	3	5	0	6	0	0	4	11
TECHNICIANS - OTHER WORK n = 11												

TABLE A5. 2. **FREQUENCY AND IMPORTANCE OF VARIOUS COMMUNICATION MATTERS FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK, AND WHO USED THEM AT SOME TIME IN THEIR JOB.**

SUB-CATEGORY OF TASK	FREQUENCY OF USE 1.	2.	3.	4.	No Ans.	IMPORTANCE 1.	2.	3.	4.	5.	No Ans.	USE IN YEAR
ENGINEERS - DESIGN n = 57												
Writing letters etc.	33	14	4	1	5	24	10	11	4	1	7	45
Sketching	17	14	7	2	17	21	4	13	0	2	17	35
Talking	39	6	3	3	6	23	4	17	4	1	8	45
Reading reports etc.	32	17	2	1	5	25	1	17	5	2	7	46
ENGINEERS - CONSTRUCTION n = 88												
Writing letters etc.	63	18	4	0	3	29	20	27	6	0	6	75
Sketching	17	17	15	2	37	9	1	26	5	4	43	46
Talking	72	10	3	0	3	32	8	38	4	2	4	76
Reading reports etc.	[illegible]	19	5	0	4	30	10	35	3	3	7	75
ENGINEERS - OTHER WORK n = 46												
Writing letters etc.	30	12	1	1	2	18	8	10	3	0	7	31
Sketching	7	13	5	1	20	7	2	13	1	1	22	18
Talking	31	9	3	0	3	19	2	15	3	1	6	31
Reading reports etc.	30	12	1	0	3	23	4	11	1	.	6	32
TECHNICIANS - DESIGN n = 74												
Writing letters etc.	17	18	17	5	17	15	10	25	1	4	19	52
Sketching	13	19	12	9	21	15	3	25	3	5	23	46
Talking	18	17	11	4	24	18	3	21	1	5	26	44
Reading reports etc.	26	16	15	2	15	16	4	31	2	4	17	50
TECHNICIANS - CONSTRUCTION n = 15												
Writing letters etc.	9	3	3	0	0	4	3	6	2	0	0	15
Sketching	2	2	4	2	5	2	0	7	0	0	6	9
Talking	7	4	0	2	2	3	3	5	1	0	3	11
Reading reports etc.	8	2	1	1	3	5	0	6	0	0	4	11
TECHNICIANS - OTHER WORK n = 11												
Writing letters etc.	8	1	1	0	1	3	0	5	0	1	2	6
Sketching	2	2	2	1	4	1	0	3	1	1	5	5
Talking	9	0	0	0	2	3	0	4	1	0	4	5
Reading reports etc.	7	2	0	0	2	2	0	5	1	1	2	5

APPENDIX 6 *

TASK ANALYSIS QUESTIONNAIRE - ANALYSIS OF "MANAGEMENT AND PERSONNEL MATTERS" CATEGORY OF TASK

The category "Management and personnel matters" was divided into eleven sub-categories of task as follows:-

1) Planning - annual plans, budgets, P.E.R.T. critical path work, network analysis, classification and statement of objectives.

2) Organising - adapting resources to meet needs of jobs defining procedures, assigning activities.

3) Directing - talking to staff in reporting sessions, following progress of work, motivating, leading, preserving morale.

4) Controlling - comparing with accepted or nominated modes of performance, budgetary control, time control, production control.

5) Co-ordinating - arranging inter-departmental, inter-company etc. discussions, smoothing out obstacles.

6) Interviewing - engaging staff, promoting, firing, staff counselling, staff appraisal sessions, filling in reports on staff.

7) Labour relations - arbitrating etc., discussions with bodies representing groups of staff or labour, salary and wage discussions.

8) General personnel matters - absenteeism, health matters, arguments, worries, anxieties, frustrations of staff and labour.

9) Statistics - on labour and staff, compiling returns for accountants, government departments etc.

10) Safety matters - dealing with safety regulations, policing safety precautions etc.

11) Other (please specify).

The usual adjustments were made for no response, and imperfect response and the following combined table for engineers and technicians engaged in design work, construction work and other work was prepared.

* See preamble to Appendix 3.

TABLE A6. 1. PERCENTAGE USE OF VARIOUS "MANAGEMENT AND PERSONNEL MATTERS" BY ENGINEERS AND TECHNICIANS ACCORDING TO TYPE OF WORK, AND WHO INDICATED USE OF MANAGEMENT AND PERSONNEL MATTERS AT SOME TIME IN THEIR JOB.

DESIGN WORK

SUB-CATEGORY OF TASK	ENGINEERS % (n = 55)		TECHNICIANS % (n = 43)	
Planning	11		6	
Organising	19		24	
Directing	31		34	
Controlling	11		8	
Co-ordinating	18	90%	4	76%
Interviewing	2		5	
Labour relations	1		1	
General personnel	4		5	
Statistics	1		5	
Safety matters	1		2	
Other (miscellaneous)	1	10%	5	23%
Rounding off 'error'	0		1	

CONSTRUCTION WORK

SUB-CATEGORY OF TASK	ENGINEERS % (n = 86)		TECHNICIANS % (n = 9)	
Planning	15		16	
Organising	23		25	
Directing	20		20	
Controlling	14		5	
Co-ordinating	10	82%	5	71%
Interviewing	3		1	
Labour relations	3		2	
General personnel	5		18	
Statistics	2		3	
Safety matters	5		2	
Other(miscellaneous)	0	18%	0	26%
Rounding off 'error'	0		3	

At P.2.

TABLE A6. 1. (Continued)

OTHER WORK n = 40 n = 8

SUB-CATEGORY OF TASK	ENGINEERS %		TECHNICIANS %	
Planning	18		10	
Organising	21		26	
Directing	21		17	
Controlling	10		8	
Co-ordinating	9	79%	13	74%
Interviewing	4		0	
Labour relations	2		4	
General personnel	5		8	
Statistics	2		5	
Safety matters	6		8	
Other (miscellaneous)	1	20%	0	25%
Rounding off 'error'	1		1	

Next follows the combined table showing the frequency of use and importance attached to the various management and personnel matters for each of the six groups of respondents referred to in the previous table.

TABLE A6. 2. FREQUENCY AND IMPORTANCE OF VARIOUS MANAGEMENT AND PERSONNEL MATTER FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK, AND WHO USED THEM AT SOME TIME IN THEIR JOB.

ENGINEERS - DESIGN n = 55

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No. Ans.	1.	2.	3.	4.	5.	No. Ans.	
Planning	6	9	10	6	24	8	8	9	5	1	24	27
Organising	19	15	7	4	10	16	9	13	4	2	11	40
Directing	36	4	5	2	8	19	8	12	5	2	9	42
Controlling	10	9	13	1	22	9	3	10	8	0	25	30
Co-ordinating	16	16	6	4	13	14	6	14	6	2	13	37
Interviewing	2	0	11	5	37	3	0	9	3	2	38	15
Labour relations	3	0	0	3	49	1	0	1	2	0	51	5
General personnel	4	5	8	4	34	5	3	6	4	2	35	18
Statistics	3	2	4	1	45	2	0	6	1	0	46	8
Safety matters	2	0	2	2	49	4	1	1	0	0	49	5

ENGINEERS - CONSTRUCTION n = 86

Planning	13	26	26	5	16	22	15	20	12	1	16	66
Organising	49	21	8	1	7	32	17	23	7	1	6	76
Directing	53	20	7	0	6	31	20	18	10	1	6	75
Controlling	24	34	11	2	15	23	17	20	12	0	14	67
Co-ordinating	17	21	14	2	32	16	7	21	10	2	30	53
Interviewing	6	6	11	4	59	8	2	9	5	2	60	27
Labour relations	6	7	11	5	57	8	8	8	6	0	56	30
General personnel	13	13	12	8	40	9	11	10	11	4	41	44
Statistics	5	6	10	4	51	4	1	13	3	3	62	25
Safety matters	10	14	18	2	42	12	11	16	4	1	41	44

TABLE A6. 2. (Continued)

ENGINEERS - OTHER WORKS n = 40

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No. Ans.	1.	2.	3.	4.	5.	No. Ans.	
Planning	12	6	9	4	9	13	4	7	3	2	11	25
Organising	19	12	2	3	4	14	6	11	2	0	7	31
Directing	19	11	5	1	4	10	10	10	4	0	6	31
Controlling	10	8	7	2	13	7	6	7	5	1	14	24
Co-ordinating	11	8	4	1	16	7	4	10	2	0	17	22
Intervewing	5	4	7	8	16	4	1	12	4	2	17	21
Labour relations	3	5	2	2	28	2	2	3	2	2	29	11
General personnel	4	9	4	3	20	4	2	6	4	3	21	18
Statistics	4	2	5	5	24	3	1	8	1	2	25	14
Safety matters	6	3	5	4	22	7	3	5	2	0	25	16

TECHNICIANS - DESIGN n = 43

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No. Ans.	1.	2.	3.	4.	5.	No. Ans.	
Planning	6	2	3	3	29	2	3	8	1	0	29	13
Organising	15	8	5	2	13	7	7	12	3	0	14	29
Directing	20	8	4	1	10	14	7	9	3	0	10	33
Controlling	6	7	4	1	25	3	4	7	3	0	26	17
Co-ordinating	5	4	2	0	32	3	0	8	0	0	32	10
Interviewing	4	1	2	4	32	4	2	3	0	1	33	9
Labour relations	0	2	2	1	38	2	0	2	0	1	38	3
General personnel	4	3	5	5	26	1	2	8	2	2	28	14
Statistics	4	2	0	5	32	1	0	6	0	3	33	10

ENGINEERS - OTHER WORKS n = 40

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No. Ans.	1.	2.	3.	4.	5.	No. Ans.	
Planning	12	6	9	4	9	13	4	7	3	2	11	25
Organising	19	12	2	3	4	14	6	11	2	0	7	31
Directing	19	11	5	1	4	10	10	10	4	0	6	31
Controlling	10	8	7	2	13	7	6	7	5	1	14	24
Co-ordinating	11	8	4	1	16	7	4	10	2	0	17	22
Intervewing	5	4	7	8	16	4	1	12	4	2	17	21
Labour relations	3	5	2	2	28	2	2	3	2	2	29	11
General personnel	4	9	4	3	20	4	2	6	4	3	21	18
Statistics	4	2	5	5	24	3	1	8	1	2	25	14
Safety matters	6	3	5	4	22	7	3	5	2	0	25	16

TECHNICIANS - DESIGN n = 43

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No. Ans.	1.	2.	3.	4.	5.	No. Ans.	
Planning	6	2	3	3	29	2	3	8	1	0	29	13
Organising	15	8	5	2	13	7	7	12	3	0	14	29
Directing	20	8	4	1	10	14	7	9	3	0	10	33
Controlling	6	7	4	1	25	3	4	7	3	0	26	17
Co-ordinating	5	4	2	0	32	3	0	8	0	0	32	10
Interviewing	4	1	2	4	32	4	2	3	0	1	33	9
Labour relations	0	2	2	1	38	2	0	2	0	1	38	3
General personnel	4	3	5	5	26	1	2	8	2	2	28	14
Statistics	4	2	0	5	32	1	0	6	0	3	33	10
Safety matters	1	0	2	1	39	1	0	2	0	0	40	4

TABLE A6. 2. (Continued)

TECHNICIANS - CONSTRUCTION n = 9

SUB-CATEGORY OF TASK	FREQUENCY OF USE					IMPORTANCE						USE IN YEAR
	1.	2.	3.	4.	No. Ans.	1.	2.	3.	4.	5.	No. Ans.	
Planning	1	0	2	1	5	0	2	0	2	0	5	4
Organising	5	1	0	1	2	1	2	2	2	0	2	7
Directing	4	1	0	0	4	2	2	0	1	0	4	5
Controlling	3	0	0	0	6	0	1	2	0	0	6	3
Co-ordinating	1	2	0	1	5	1	1	0	2	0	5	4
Interviewing	2	0	1	0	6	1	2	0	0	0	6	3
Labour relations	1	1	0	0	7	0	1	1	0	0	7	2
General personnel	5	0	0	0	4	0	2	2	0	1	4	5
Statistics	1	0	2	0	6	0	1	2	0	0	6	3
Safety matters	1	1	0	1	6	0	1	2	0	0	6	3

TECHNICIANS - OTHER WORK n = 8

Planning	2	1	3	0	2	1	1	1	2	0	3	4
Organising	5	1	2	0	0	3	0	2	1	0	2	5
Directing	4	0	1	0	3	2	1	1	1	0	3	4
Controlling	2	1	2	0	3	3	0	1	1	0	3	4
Co-ordinating	5	0	0	0	3	3	0	1	0	0	4	3
Interviewing	0	0	0	1	7	0	1	0	0	0	7	1
Labour relations	1	0	0	2	5	1	1	0	0	1	5	2
General personnel	2	1	0	1	4	1	0	2	1	0	4	4
Statistics	1	1	0	2	4	2	0	1	1	0	4	3
Safety matters	1	0	0	4	3	2	0	1	0	1	4	3

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for:-

ENGINEERS — DESIGN n = 60

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialized	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	61	9	14	33	3	1	24	5	13	9	22	6	16	4	3	1	7	22	21	47	13
Frame Analysis																					
using manual methods	44	16	12	24	2	1	11	13	9	10	11	8	17	5	2	2	10	15	16	36	24
using computers																					
a) via terminal to large installation	19	41	0	14	5	0	2	2	6	9	2	6	9	2	0	1	2	7	8	15	45
b) on site small computer	11	49	1	9	1	0	1	2	6	2	5	0	5	1	0	0	3	3	5	11	49
c) desk top programmable calculator	8	52	2	5	1	0	1	2	1	4	2	1	2	0	3	0	2	5	1	6	54
using handbooks	40	20	6	33	1	0	13	7	10	10	14	4	16	3	1	0	4	17	17	36	24
elasticity (stress, strain etc.)	35	25	8	24	2	1	10	9	6	8	8	6	12	3	1	1	5	17	11	33	27
statics (i e virtual work)	28	32	9	16	3	0	7	5	6	8	8	3	11	2	1	1	0	9	10	22	38
Design																					
metal structures, inc. steel	53	7	11	35	6	1	16	9	12	15	24	9	19	4	4	4	11	19	19	48	12
concrete structures	53	7	13	34	5	1	21	5	16	10	23	9	15	3	3	4	8	23	18	48	12
timber	42	18	14	32	5	1	5	3	12	2	10	8	15	7	4	0	5	16	20	35	25
code of practice	45	15	10	30	4	1	19	7	7	10	17	8	12	3	4	0	8	17	20	40	20
safety factors and load factors	44	16	9	32	3	1	16	4	10	12	21	6	11	4	2	1	4	19	21	40	20
Other (please specify)	6	54	1	4	1	0	2	0	3	1	4	1	1	0	0	1	0	1	4	5	55
ditto	1	59	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	59
MATERIALS:-																					
Mechanical Testing	15	45	0	14	0	1	1	2	7	5	1	0	8	5	1	0	1	8	6	14	46
Quality control	15	45	0	12	3	0	2	1	6	6	1	1	7	3	3	0	1	6	8	13	47
Selection & specifications	42	18	3	32	5	2	8	8	15	11	6	10	19	5	2	2	6	20	14	36	24
Metallic	25	35	4	16	5	0	7	6	9	3	8	1	14	2	0	0	3	6	16	23	37
Organic (including timber)	24	36	1	20	3	0	3	0	8	10	3	1	6	2	3	0	3	6	16	23	37
Concrete	45	15	8	33	4	0	14	10	9	12	12	4	20	5	4	1	6	[illegible]	17	41	19
Ceramic	4	56	1	3	0	0	1	0	1	2	1	0	2	0	1	0	1	1	2	2	58
Silicate	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Road Materials	27	33	[illegible]	24	2	0	2	10	6	9	3	3	14	5	3	3	2	12	9	22	38
Rheology	2	58	0	1	1	0	0	0	1	1	0	0	1	0	1	0	0	2	0	1	59
Other (please specify)	4	56	1	2	1	0	0	1	3	0	0	1	0	2	0	0	2	1	0	3	57
ditto	3	57	0	1	2	0	0	1	2	0	0	1	0	2	0	1	0	1	1	3	57
WATER:-																					
Solution of hydraulic problems from first principles	20	40	1	16	2	1	1	2	6	11	2	4	6	5	3	3	5	6	6	15	45
using empirical formulae	21	39	0	26	5	0	1	5	13	12	6	1	15	7	2	0	7	15	9	27	33
using computer packages	4	56	0	4	0	0	0	0	0	4	1	0	2	1	0	0	1	2	1	2	58
using handbooks	30	30	3	22	5	0	3	6	15	6	9	2	14	3	2	0	5	10	15	27	33
using models	3	57	0	1	1	1	0	1	0	2	0	2	0	1	0	2	1	0	0	2	58
Solution of hydrology problems																					
using raw data & first principles	9	51	0	7	2	0	0	2	2	5	1	1	3	3	1	1	1	5	1	7	53
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	27	33	2	20	5	0	3	6	13	5	9	1	10	5	2	0	4	10	13	27	33
using computer package	2	58	0	2	0	0	0	0	1	1	1	0	1	0	0	0	0	0	2	1	59
using models	1	59	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	60
using systems analysis	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Hydrostatics	16	44	0	16	0	0	0	0	6	9	0	1	10	3	2	0	2	6	8	13	47
Hydrodynamics	12	48	0	11	0	1	1	0	3	7	1	0	7	4	0	0	2	7	3	10	50
Water engineering	13	47	1	10	2	0	2	1	4	6	1	1	7	2	2	0	2	7	4	10	50

the table below for:-

ENGINEERS — DESIGN

n = 60

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	51	9	14	33	3	1	24	5	13	9	22	6	16	4	3	1	7	22	21	47	13
Frame Analysis																					
using manual methods	44	16	12	29	2	1	11	13	4	10	11	8	17	5	2	2	10	15	16	36	24
using computers																					
a) via terminal to large installation	19	41	0	14	5	0	2	2	6	9	2	6	9	2	0	1	2	7	8	15	45
b) on site small computer	11	49	1	9	1	0	1	2	6	2	5	0	5	1	0	0	3	3	5	11	49
c) desk top programmable calculator	8	52	2	5	1	0	1	2	1	4	2	1	2	0	3	0	2	5	1	6	54
using handbooks	40	20	6	33	1	0	13	7	10	10	14	4	16	3	1	0	4	17	17	36	24
elasticity (stress, strain etc.)	35	25	8	24	2	1	10	9	6	8	8	6	12	3	1	1	5	17	11	33	27
statics (i e virtual work)	28	32	9	16	3	0	7	5	6	8	8	3	11	2	1	1	6	9	10	22	38
Design																					
metal structures, inc. steel	53	7	11	35	6	1	16	9	12	15	21	9	19	4	4	4	8	19	19	48	12
concrete structures	53	7	13	34	5	1	21	5	16	10	23	9	15	3	3	4	8	23	18	48	12
timber	42	18	14	32	5	1	5	3	12	21	10	8	15	7	4	0	5	16	20	35	25
code of practice	45	15	10	30	4	1	19	7	7	10	17	8	12	3	4	0	8	17	20	40	20
safety factors and load factors	44	16	8	32	3	1	16	4	10	12	21	6	11	4	2	1	4	18	21	40	20
Other (please specify)	6	54	1	4	1	0	2	0	3	1	4	1	1	0	0	1	0	1	4	5	55
ditto	1	59	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	59
MATERIALS:-																					
Mechanical Testing	15	45	0	14	0	1	1	2	7	5	1	0	8	5	1	0	1	8	6	14	46
Quality control	15	45	0	12	3	0	2	1	6	6	1	1	7	3	3	0	1	6	8	13	47
Selection & specifications	42	18	3	32	5	2	8	8	15	11	6	10	19	5	2	2	6	20	14	36	24
Metallic	25	35	4	16	5	0	7	6	9	3	8	1	14	2	0	0	3	6	16	23	37
Organic (including timber)	24	36	1	20	3	0	3	0	11	10	3	1	16	2	3	0	3	6	16	23	37
Concrete	45	15	8	33	4	0	14	10	9	12	12	4	20	5	4	1	6	21	17	41	19
Ceramic	4	56	1	3	0	0	1	0	1	2	1	0	2	0	1	0	1	1	2	2	58
Silicate	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Road Materials	27	33	1	24	2	0	2	10	6	9	2	3	14	5	3	3	2	12	9	22	38
Rheology	2	57	0	1	1	0	0	0	1	1	0	0	1	0	1	0	0	2	0	1	59
Other (please specify)	4	56	1	2	1	0	0	1	3	0	0	1	0	2	0	0	2	1	0	3	57
ditto	3	57	0	1	2	0	0	1	2	0	0	1	0	2	0	1	0	1	1	3	57
WATER:-																					
Solution of hydraulic problems																					
from first principles	20	40	1	16	2	1	1	2	6	11	2	4	6	5	3	3	5	6	6	15	45
using empirical formulae	31	29	[illegible]	26	5	0	1	5	13	12	6	1	15	7	2	0	7	15	9	27	33
using computer packages	4	56	0	4	0	0	0	0	0	4	1	0	2	1	0	0	1	2	1	2	58
using handbooks	30	30	3	22	5	0	3	6	15	6	9	2	14	3	2	0	5	10	15	27	33
using models	3	57	0	1	1	[illegible]	0	1	0	2	0	2	0	1	0	2	1	0	0	2	58
Solution of hydrology problems																					
using raw data & first principles	9	51	0	7	2	0	0	2	2	5	1	1	3	3	1	1	1	5	1	7	53
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	27	33	2	20	5	0	3	6	13	5	9	1	10	5	2	0	4	10	13	27	33
using computer package	2	58	0	2	0	0	0	0	1	1	1	0	1	0	0	0	0	0	2	1	59
using models	1	59	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	60
using systems analysis	0	60	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Hydrostatics	16	44	0	16	0	0	0	0	6	9	0	1	10	3	2	0	2	6	8	13	47
Hydrodynamics	12	48	0	11	0	1	1	0	3	7	1	0	7	4	0	0	2	7	3	10	50
Water engineering	13	47	1	10	2	0	2	1	4	6	1	1	7	2	2	0	2	7	4	10	50
Other (please specify)	2	58	1	0	1	0	1	0	0	1	1	0	1	0	0	0	1	1	0	2	58
ditto	1	59	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	59

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

ENGINEERS – DESIGN n = 60

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	20	40	0	18	2	0	0	0	10	10	1	0	10	7	2	1	3	13	3	17	43
Field investigations	27	33	2	24	1	0	1	3	14	10	4	1	15	6	0	0	5	13	8	23	37
Laboratory investigations	15	45	0	12	2	1	0	2	8	5	0	0	10	3	2	0	2	7	6	11	49
Foundation design or assessment	48	12	4	37	5	2	1	15	19	14	12	10	11	9	5	2	13	23	9	41	19
Earth structures design (e.g. embankments dams, road bases)	35	25	1	27	6	1	2	6	16	10	8	7	9	7	2	2	5	18	8	24	36
Mechanics	21	34	2	16	3	0	0	1	12	8	2	5	6	6	1	2	7	9	2	17	43
Engineering	23	37	1	20	2	0	0	3	13	6	4	4	9	5	0	1	5	14	2	17	43
Other (please specify)	2	58	0	1	0	1	1	0	0	1	1	1	0	0	0	1	0	1	0	1	59
ditto	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
CONSTRUCTION:-																					
Critical Path Methods	17	43	3	14	0	0	0	1	6	10	1	0	8	6	1	0	0	8	8	12	48
Explosives	8	52	1	5	2	0	0	1	4	3	1	0	3	3	1	1	0	2	4	4	56
Drilling	11	49	0	8	2	1	0	1	4	6	0	1	5	3	2	1	1	3	5	6	54
ELECTRICAL ENGINEERING:-																					
Network analysis	1	59	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	60
Equipment specification	6	54	0	4	0	2	0	1	2	3	0	1	1	1	3	2	1	1	2	5	55
Other (please specify)	2	58	0	2	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	2	58
ditto	2	58	0	2	0	0	0	1	1	0	1	0	1	0	0	0	0	0	2	2	58
MATHEMATICS																					
Basic algebra, geometry and trigonometry	56	4	11	41	3	1	20	18	14	4	11	6	23	8	1	2	3	21	27	51	9
Calculus	38	22	7	28	2	1	3	9	14	12	11	7	10	5	4	0	11	11	14	31	29
Numerical Methods	32	28	3	24	4	1	4	6	14	8	8	4	14	3	2	0	8	13	12	27	33
Other (please specify)	4	56	3	0	0	1	1	3	0	0	2	1	1	0	0	0	0	0	4	3	57
ditto	1	59	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	59
COMPUTERS																					
System Analysis	2	58	0	1	0	1	0	0	1	1	0	1	1	0	0	0	0	1	1	0	60
Writing programs	20	40	1	13	5	1	1	3	8	8	1	3	12	2	1	1	3	12	3	12	48
Using programs	33	27	1	24	6	2	3	8	17	6	11	2	15	4	0	0	2	14	17	32	28
Other (please specify)	2	57	0	2	0	0	0	1	1	0	0	0	2	0	0	0	0	1	1	2	58
ditto	1	54	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	60
EQUIPMENT & PLANT	10	50	2	8	0	0	1	1	5	3	1	0	2	4	3	0	0	6	4	8	52
SURVEYING																					
Levelling	33	27	8	23	2	0	10	6	8	9	13	1	14	2	1	2	1	8	20	22	38
Setting out	30	30	8	19	3	0	9	6	6	9	10	3	11	2	2	2	2	11	13	18	42
Traversing	19	41	5	13	1	0	3	3	3	10	4	3	8	2	2	2	3	7	6	10	50
Photogrammetry	11	49	0	11	0	0	0	1	3	7	1	0	4	2	4	0	2	3	5	8	52
Other (please specify)	1	59	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	59
ditto	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
[illegible]MISTRY – ENGINEERING																					

ENGINEERS — DESIGN n = 60

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	20	40	0	18	2	0	0	0	10	10	1	0	10	7	2	1	3	13	3	17	43
Field investigations	27	33	2	24	1	0	1	3	14	10	4	1	15	6	0	0	5	13	8	23	37
Laboratory investigations	15	45	0	12	2	1	0	2	8	5	0	0	10	3	2	0	2	7	6	11	49
Foundation design or assessment	48	12	4	37	5	2	1	15	19	14	12	10	11	9	5	2	13	23	9	41	19
Earth structures design (e.g. embankments dams, road bases)	35	25	1	27	6	1	2	6	16	10	8	7	9	7	2	2	5	18	8	24	36
Mechanics	21	39	2	16	3	0	0	1	12	8	2	5	6	6	1	2	7	9	2	17	43
Engineering	23	37	1	20	2	0	0	3	13	6	4	4	9	5	0	1	5	14	2	17	43
Other (please specify)	2	[illegible]	0	1	0	1	1	0	0	1	1	1	0	0	0	1	0	1	0	1	59
ditto	[illegible]	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
CONSTRUCTION:-																					
Critical Path Methods	[illegible]	43	3	14	0	0	0	1	6	10	1	0	8	6	1	0	0	8	8	12	48
Explosives	8	52	1	5	2	0	0	1	4	3	1	0	3	3	1	1	0	2	4	4	56
Drilling	11	49	0	8	2	1	0	1	4	6	0	1	5	3	2	1	1	3	5	6	54
ELECTRICAL ENGINEERING:-																					
Network analysis	1	59	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	60
Equipment specification	6	54	0	4	0	2	0	1	2	3	0	1	1	1	3	2	1	1	2	5	55
Other (please specify)	2	58	0	2	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	2	58
ditto	2	58	0	2	0	0	0	1	1	0	1	0	1		0	0	0	0	2	2	58
MATHEMATICS																					
Basic algebra, geometry and trigonometry	56	4	11	41	3	1	20	18	14	4	22	6	23	8	1	2	3	21	27	51	9
Calculus	38	22	7	28	2	1	3	9	14	12	11	7	10	5	4	0	11	11	14	31	29
Numerical Methods	32	28	3	24	4	1	4	6	14	8	8	4	14	3	2	0	8	13	12	27	33
Other (please specify)	4	56	3	0	0	1	1	3	0	0	2	1	1	0	0	0	0	0	4	3	57
ditto	1	59	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	59
COMPUTERS																					
System Analysis	2	58	0	1	0	1	0	0	1	1	0	1	1	0	0	0	0	1	1	0	60
Writing programs	20	40	1	13	5	1	1	3	8	8	1	3	12	2	1	1	3	12	3	12	48
Using programs	33	27	1	24	6	2	3	8	17	6	11	2	15	4	0	0	2	14	17	32	28
Other (please specify)	2	58	0	2	0	0	0	1	1	0	0	0	2	0	0	0	0	1	1	2	58
ditto	1	59	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	60
EQUIPMENT & PLANT	10	50	2	8	0	0	1	1	5	3	1	0	2	4	3	0	0	6	4	8	52
SURVEYING																					
Levelling	33	27	8	23	2	0	10	6	8	9	13	1	14	2	1	2	1	8	10	22	38
Setting out	30	30	8	19	3	0	9	6	6	9	10	3	11	2	3	2	2	11	13	18	42
Traversing	19	41	5	13	1	0	3	3	3	10	4	3	8	2	2	2	3	7	6	10	50
Photogrammetry	11	49	0	11	0	0	0	1	3	7	1	0	4	2	4	0	2	3	5	8	52
Other (please specify)	1	59	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	59
ditto	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
CHEMISTRY – ENGINEERING (e.g. corrosion)	18	42	0	16	0	2	0	1	7	3	1	3	5	5	1	0	1	8	5	13	47
PHYSICS – ENGINEERING (e.g. thermodynamics)	10	50	0	9	1	0	0	0		7	0	0	4	2	2	0	3	2	3	6	54
GEOLOGY – ENGINEERING (e.g. stability of rocks)	13	47	0	12	1	0	0	1	[illegible]	7	1	1	1	7	1	1	3	5	2	10	50
BIOLOGY – ENGINEERING (e.g. water & sewerage, environment, public health)	15	45	0	13	2	0	0	3	7	4	0	2	6	5	0	0	3	6	3	10	50
OTHER (please specify)	3	57	0	2	1	0	0	[illegible]	1	1	0	0	2	1	0	0	1	1	1	3	59

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

ENGINEERS – CONSTRUCTION n = 91

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use: Do use	Use: Do not use	Level of Knowledge: Advanced	Level of Knowledge: General	Level of Knowledge: Specialised	Level of Knowledge: V. Specialised	Frequency: Regularly	Frequency: Frequently	Frequency: Not Frequently	Frequency: Infrequently	Importance: V. Important-easy	Importance: V. Important-diff.	Importance: Important-easy	Importance: Important-diff.	Importance: Not Important	Difficulty: Very difficult	Difficulty: Difficult	Difficulty: Mod. difficult	Difficulty: Easy	Use in Year: Used	Use in Year: Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	50	41	3	46	0	1	0	9	18	23	4	2	30	4	10	0	5	19	17	45	46
Frame Analysis																					
using manual methods	30	61	3	26	1	0	0	5	11	15	3	1	17	3	6	0	2	15	13	27	66
using computers																					
a) via terminal to large installation	2	89	1	1	0	0	0	0	0	2	1	0	0	1	0	0	1	0	1	1	90
b) on site small computer	4	87	1	3	0	0	0	0	4	0	0	0	2	2	0	0	0	2	2	4	87
c) desk top programmable calculator	6	85	1	4	0	1	0	4	1	1	0	1	4	1	0	0	2	1	3	5	86
using handbooks	27	64	1	26	0	0	2	6	11	8	3	1	16	3	3	1	1	7	17	25	66
elasticity (stress, strain etc.)	25	66	1	23	1	0	0	4	10	12	2	2	12	3	6	0	6	12	7	26	66
statics (i e virtual work)	19	72	1	17	1	0	0	4	8	6	2	1	7	5	3	0	4	8	6	16	75
Design																					
metal structures, inc. steel	41	50	1	39	1	0	1	5	15	21	3	3	28	0	7	0	5	22	13	36	55
concrete structures	[illegible]	40	5	44	2	0	6	5	20	21	9	3	25	7	7	2	7	25	16	44	47
timber	39	52	2	35	1	1	5	7	13	15	3	3	22	4	7	0	5	20	13	30	61
code of practice	43	48	5	35	5	0	5	12	14	12	9	3	23	1	6	1	5	16	19	37	54
safety factors and load factors	44	47	2	39	2	1	1	8	21	14	5	4	28	4	2	3	3	19	17	34	57
Other (please specify)	4	87	1	3	0	0	1	0	2	1	0	1	3	0	0	1	0	2	1	4	87
ditto	1	90	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	99
MATERIALS:-																					
Mechanical Testing	42	49	3	34	4	1	5	10	10	17	6	7	23	1	0	1	2	13	24	34	57
Quality control	52	39	5	40	6	1	12	12	17	11	13	6	23	3	6	0	4	21	24	47	44
Selection & specifications	63	27	6	50	8	0	13	17	20	14	12	7	33	5	6	1	7	28	25	61	30
Metallic	32	59	0	27	5	0	3	6	6	17	3	1	16	2	10	0	4	15	12	30	61
Organic (including timber)	35	56	0	33	2	0	3	8	11	14	3	2	18	0	12	0	1	18	16	30	61
Concrete	74	17	12	56	6	1	29	19	15	12	23	7	35	5	4	0	9	33	31	75	18
Ceramic	4	87	0	4	0	0	2	0	2	0	1	0	2	0	1	0	0	0	4	4	87
Silicate	2	89	0	2	0	0	2	0	0	0	1	0	1	0	0	0	0	1	1	2	89
Road Materials	69	22	9	48	11	1	19	19	16	16	25	8	26	3	7	1	8	25	34	64	27
Rheology	2	89	0	1	1	0	0	0	1	1	0	0	1	1	0	0	0	2	0	2	89
Other (please specify)	3	88	1	1	1	0	1	2	0	0	0	1	1	1	0	1	0	1	1	3	88
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90
WATER.-																					
Solution of hydraulic problems																					
from first principles	21	70	1	17	3	0	2	3	5	11	3	2	12	1	2	0	2	13	4	18	73
using empirical formulae	34	57	2	30	2	0	3	4	9	18	3	2	20	4	3	1	4	16	10	27	64
using computer packages	1	90	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	1	90
using handbooks	37	54	0	35	2	0	4	7	10	16	6	2	18	6	4	1	5	14	15	34	57
using models	2	89	0	1	1	0	0	0	1	1	0	1	0	0	1	0	1	0	1	2	89
Solution of hydrology problems																					
using raw data & first principles	10	81	2	8	0	0	2	0	3	5	2	0	6	1	1	0	2	6	1	7	84
using standard design procedures	38	53	3	37	3	0	5	2	19	12	9	3	24	2	2	0	5	16	14	32	59
(e.g. Australia Rainfall & Runoff Handbook)																					
using computer package	1	[illegible]	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	90
using models	1	90	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	90
using systems analysis	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
Hydrostatics	11	80	0	11	0	0	0	3	3	5	0	1	9	1	0	0	1	5	4	9	82
Hydrodynamics	10	81	0	9	1	0	0	3	2	5	0	1	7	2	0	0	1	6	2	8	83
Water engineering																					

ENGINEERS – CONSTRUCTION n = 91

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	50	41	3	46	0	1	0	9	18	23	4	2	30	4	10	0	5	29	17	45	46
Frame Analysis																					
using manual methods	30	61	3	26	1	0	0	5	11	15	3	1	17	3	6	0	2	15	13	27	64
using computers																					
a) via terminal to large installation	2	89	1	1	0	0	0	0	0	2	1	0	0	1	0	0	1	0	1	1	90
b) on site small computer	4	87	1	3	0	0	0	0	4	0	0	0	2	2	0	0	0	2	2	4	87
c) desk top programmable calculator	6	85	1	4	0	1	0	4	1	1	0	1	4	1	0	0	2	1	3	5	86
using handbooks	27	64	1	26	0	0	2	6	11	8	3	1	16	3	3	1	1	7	17	25	66
elasticity (stress, strain etc.)	25	66	1	23	1	0	0	4	10	12	2	2	12	3	6	0	6	12	7	25	66
statics (i.e. virtual work)	19	72	1	17	1	0	0	4	8	6	2	1	7	5	3	0	4	8	6	16	75
Design																					
metal structures, inc. steel	41	50	1	34	1	0	1	5	15	21	3	3	28	0	7	0	5	22	13	36	55
concrete structures	51	40	5	44	2	0	6	5	20	21	9	3	25	7	7	2	7	25	16	44	47
timber	39	52	2	35	1	1	5	7	15	15	3	3	22	4	7	0	5	20	13	30	61
code of practice	43	48	5	35	5	0	5	12	14	12	9	3	23	1	6	1	5	16	19	37	54
safety factors and load factors	44	47	2	39	2	1	1	8	21	14	5	4	28	4	2	3	3	19	17	34	57
Other (please specify)	4	87	1	3	0	0	1	0	2	1	0	1	3	0	0	1	0	2	1	4	87
ditto	1	90	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	1	90
MATERIALS:-																					
Mechanical Testing	42	49	3	34	4	1	5	10	10	17	6	3	23	1	0	1	2	13	24	34	57
Quality control	52	39	5	40	6	1	12	12	17	11	13	6	23	3	6	0	4	21	24	47	44
Selection & specifications	63	27	6	50	8	0	13	17	20	14	12	7	33	5	6	1	7	28	25	61	30
Metallic	32	59	0	27	5	0	3	6	6	17	3	1	15	2	10	0	4	15	12	30	61
Organic (including timber)	35	56	0	33	2	0	3	8	11	14	3	2	18	0	12	0	1	18	16	30	61
Concrete	74	17	12	5	6	1	29	19	15	12	23	7	35	5	4	0	8	33	31	75	18
Ceramic	4	87	0	4	0	0	2	0	2	0	1	0	2	0	1	0	0	0	4	4	87
Silicate	2	89	0	2	0	0	2	0	0	0	1	0	1	0	0	0	0	1	1	2	89
Road Materials	69	22	9	48	11	1	19	19	16	16	25	8	26	3	7	1	8	25	34	64	27
Rheology	2	89	0	1	1	0	0	0	1	1	0	0	1	1	0	0	0	2	0	2	89
Other (please specify)	3	88	1	1	1	0	1	2	0	0	0	1	1	1	0	1	0	1	1	3	88
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90
WATER:-																					
Solution of hydraulic problems																					
from first principles	21	70	1	17	2	0	2	3	5	11	3	2	12	1	2	0	2	13	4	18	73
using empirical formulae	34	57	2	30	2	0	3	4	9	18	5	2	20	4	3	1	4	16	10	27	64
using computer packages	1	90	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	1	90
using handbooks	37	54	0	35	2	0	4	7	10	16	6	2	18	6	4	1	5	14	15	34	57
using models	2	89	0	1	1	0	0	0	1	1	0	1	0	0	1	0	1	0	1	2	89
Solution of hydrology problems																					
using raw data & first principles	10	81	2	8	0	0	2	0	3	5	2	0	6	1	1	0	2	6	1	7	84
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	38	53	3	32	3	0	5	2	19	12	5	3	24	2	2	0	5	16	14	32	59
using computer package	1	90	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	90
using models	1	90	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	40
using systems analysis	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
Hydrostatics	11	80	0	11	0	0	0	3	3	5	0	1	9	1	0	0	1	5	4	9	82
Hydrodynamics	10	81	0	9	1	0	0	3	2	5	0	1	7	2	0	0	1	6	2	8	83
Water engineering	21	70	2	14	4	1	1	3	8	9	2	1	15	2	0	1	2	13	3	20	71
Other (please specify)	2	89	0	2	0	0	0	1	0	1	0	2	0	0	0	1	0	1	0	2	89
ditto	1	90	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	90

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

ENGINEERS - CONSTRUCTION n= 91

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	37	54	1	33	3	0	4	10	15	8	7	4	16	6	2	0	8	20	7	30	61
Field investigations	49	42	2	43	4	0	6	10	21	8	7	3	30	3	4	0	8	24	14	41	50
Laboratory investigations	31	60	2	20	9	0	1	11	8	19	3	4	13	5	2	0	7	14	5	21	70
Foundation design or assessment	49	42	3	42	4	0	4	12	17	16	6	10	21	9	1	0	16	21	9	40	57
Earth structures design (e.g. embankments dams, road bases)	49	42	4	40	5	0	5	11	13	19	8	7	19	9	2	2	10	22	9	41	50
Mechanics	28	63	2	24	1	1	0	4	12	11	3	4	12	3	4	1	7	14	3	21	70
Engineering	30	61	1	27	1	1	1	7	9	12	3	5	14	3	3	1	6	17	2	23	68
Other (please specify)	1	90	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	90
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
CONSTRUCTION:-																					
Critical Path Methods	59	32	13	41	4	1	4	21	16	16	12	5	24	12	4	2	8	22	22	49	42
Explosives	54	37	10	38	5	1	3	15	16	19	11	4	25	9	4	1	4	23	22	43	48
Drilling	52	39	8	35	5	1	6	14	18	15	3	1	27	10	5	0	6	20	22	41	50
ELECTRICAL ENGINEERING:-																					
Network analysis	1	90	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	91
Equipment specification	8	83	0	5	2	1	0	2	0	6	0	1	1	3	3	0	3	3	1	6	85
Other (please specify)	1	90	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	90
ditto	1	90	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	90
MATHEMATICS																					
Basic algebra, geometry and trigonometry	71	20	20	50	1	0	19	24	19	8	17	0	34	9	9	2	6	16	43	61	30
Calculus	31	60	6	23	2	0	2	10	7	12	5	2	14	6	3	1	6	8	14	22	69
Numerical Methods	29	62	6	21	1	1	7	10	4	8	4	0	15	7	2	2	3	11	10	23	68
Other (please specify)	1	90	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	90
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
COMPUTERS																					
System Analysis	6	85	3	3	0	0	0	0	5	1	0	0	3	2	1	0	1	4	1	6	85
Writing programs	11	80	3	7	1	0	0	2	3	6	0	0	2	4	5	2	1	6	2	9	92
Using programs	22	69	1	15	3	3	2	3	7	10	2	0	12	4	4	2	2	13	5	16	75
Other (please specify)	2	89	0	2	0	0	0	1	0	1	1	0	1	0	0	0	0	0	2	2	89
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
EQUIPMENT & PLANT	54	37	12	33	8	1	30	15	3	5	14	8	18	3	2	0	4	23	21	44	47
SURVEYING																					
Levelling	70	21	26	43	1	0	23	19	16	13	28	1	35	2	3	0	3	13	48	58	33
Setting out	68	23	22	45	1	0	13	23	18	15	25	5	32	2	3	0	5	18	40	54	37
Traversing	37	54	10	25	1	1	3	11	11	11	15	2	15	2	2	0	3	12	19	26	65
Photogrammetry	11	80	1	10	0	0	0	3	4	3	2	0	5	1	3	0	0	3	6	6	85
Other (please specify)	4	87	1	3	0	0	1	1	2	0	0	3	0	1	0	0	1	2	0	1	90
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
CHEMISTRY – ENGINEERING																					

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	37	54	1	31	5	0	4	10	15	8	7	4	16	6	2	0	8	20	7	30	61
Field investigations	49	42	2	43	4	0	6	10	21	8	7	3	10	3	4	0	8	24	14	41	50
Laboratory investigations	31	60	2	20	9	0	1	11	8	11	3	4	13	5	2	0	7	14	5	21	70
Foundation design or assessment	49	42	3	42	4	0	4	12	17	16	6	10	21	9	1	0	16	21	9	40	57
Earth structures design (e.g. embankments dams, road bases)	49	42	4	40	5	0	5	11	13	19	8	7	19	9	2	2	10	22	9	41	50
Mechanics	28	63	2	24	1	1	0	4	12	11	3	4	12	3	4	1	7	14	3	21	70
Engineering	30	61	1	27	1	1	1	7	9	12	3	5	14	3	3	1	6	17	2	23	68
Other (please specify)	1	90	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	90
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
CONSTRUCTION:-																					
Critical Path Methods	59	32	13	41	4	1	4	21	16	16	12	5	24	12	4	2	8	22	22	49	42
Explosives	54	37	10	38	5	1	5	15	16	19	11	4	25	9	4	1	4	23	22	43	48
Drilling	52	39	8	35	5	1	6	14	18	15	3	1	27	10	5	0	6	20	22	41	50
ELECTRICAL ENGINEERING:-																					
Network analysis	1	90	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	91
Equipment specification	9	83	0	5	2	1	0	2	0	6	0	1	1	3	3	0	3	3	1	6	85
Other (please specify)	1	90	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	90
ditto	1	90	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	90
MATHEMATICS																					
Basic algebra, geometry and trigonometry	71	20	20	50	1	0	19	24	19	8	17	0	34	9	9	2	6	16	43	61	30
Calculus	31	60	6	23	2	0	2	10	7	12	5	2	14	6	3	1	6	8	14	22	69
Numerical Methods	29	62	6	21	1	1	7	10	4	8	4	0	15	7	2	2	3	11	10	23	68
Other (please specify)	1	90	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	90
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
COMPUTERS																					
System Analysis	6	85	3	3	0	0	0	0	5	1	0	0	3	2	1	0	1	4	1	6	85
Writing programs	11	80	3	7	1	0	0	2	3	6	0	0	2	4	5	2	1	6	2	9	82
Using programs	22	69	1	15	3	3	2	3	7	10	2	0	12	4	4	2	2	13	5	16	75
Other (please specify)	2	89	0	2	0	0	0	1	0	1	1	0	1	0	0	0	0	0	2	2	89
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
EQUIPMENT & PLANT	54	37	12	33	8	1	30	15	3	5	19	8	18	3	2	0	4	23	21	44	47
SURVEYING																					
Levelling	70	21	20	43	1	0	23	19	16	13	28	1	35	2	3	0	3	13	46	58	33
Setting out	68	23	22	45	1	0	13	23	18	15	25	5	32	2	3	0	5	18	40	54	37
Traversing	37	54	10	25	1	1	3	11	11	11	15	2	15	2	2	0	3	12	19	26	65
Photogrammetry	11	80	1	10	0	0	0	3	4	3	2	0	5	1	3	0	0	3	6	6	85
Other (please specify)	4	87	1	3	0	0	1	1	2	0	0	3	0	1	0	0	1	2	0	1	90
ditto	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91
CHEMISTRY - ENGINEERING (e.g. corrosion)	16	75	0	13	2	1	0	1	6	9	1	0	8	2	3	1	1	6	5	10	81
PHYSICS - ENGINEERING (e.g. thermodynamics)	10	81	0	9	0	1	2	2	3	4	0	1	7	2	0	0	2	6	1	6	85
GEOLOGY - ENGINEERING (e.g. stability of rocks)	31	60	2	21	2	0	2	7	14	9	2	4	13	6	5	0	5	19	5	23	68
BIOLOGY - ENGINEERING (e.g. water & sewerage, environment, public	22	69	4	17	1	0	1	6	10	4	3	4	10	1	2	1	1	13	4	17	74
OTHER (please specify)	3	88	2	1	0	0	2	0	1	0	0	1	2	0	0	0	1	2	0	3	88

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

ENGINEERS - OTHER WORK n = 50

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not Important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	21	29	2	18	1	0	2	2	9	9	3	0	8	4	1	1	5	10	4	19	32
Frame Analysis																					
using manual methods	11	39	2	8	1	0	0	1	3	7	1	1	5	3	1	1	3	5	2	6	44
using computers																					
a) via terminal to large installation	4	46	0	4	0	0	0	1	1	2	1	0	1	1	0	0	0	3	0	1	49
b) on site small computer	2	49	0	2	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	50
c) desk top programmable calculator	4	46	1	3	0	0	1	0	0	3	1	0	0	2	0	0	1	3	0	1	49
using handbooks	9	41	9	0	0	0	0	3	2	5	1	0	4	3	1	0	3	4	2	5	45
elasticity (stress, strain etc)	6	44	1	5	0	0	0	2	1	3	1	0	1	3	0	0	0	4	1	1	49
statics (i e virtual work)	5	45	1	4	0	0	0	2	0	3	1	0	1	2	1	0	0	3	1	2	4[illegible]
Design																					
metal structures, inc. steel	19	31	2	14	3	0	1	3	4	11	2	1	5	7	1	0	4	10	2	16	34
concrete structures	26	24	2	22	2	0	1	2	10	13	3	2	8	8	3	0	4	13	6	23	27
timber	18	32	2	16	0	0	1	1	8	11	2	0	5	7	2	0	3	7	8	13	37
code of practice	18	32	1	15	1	1	1	1	9	7	2	0	6	6	1	0	0	8	7	15	36
safety factors and load factors	19	31	1	15	2	1	1	2	9	7	3	0	5	8	1	0	0	11	5	18	32
Other (please specify)	4	46	0	2	2	0	1	0	3	1	0	0	0	2	0	0	1	2	1	4	46
ditto	3	47	0	1	2	0	0	2	0	1	0	1	0	1	0	0	0	3	0	3	47
MATERIALS:-																					
Mechanical Testing	18	32	1	15	1	1	2	1	6	9	2	1	10	2	1	1	0	10	5	13	37
Quality control	17	33	3	12	0	2	4	2	5	6	3	2	6	5	0	0	3	9	3	16	34
Selection & specifications	26	24	2	17	7	0	1	7	13	5	3	2	15	3	1	0	4	13	7	22	28
Metallic	13	37	1	11	0	1	2	2	3	6	2	0	7	2	1	0	1	5	5	7	43
Organic (including timber)	14	36	0	11	3	0	2	2	4	6	1	1	8	1	2	0	1	7	4	9	41
Concrete	27	23	4	18	4	1	2	9	11	6	2	1	17	3	3	0	3	15	8	20	30
Ceramic	4	46	0	3	1	0	1	1	1	1	0	0	1	3	0	0	1	1	1	3	47
Silicate	1	49	0	1	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	0	50
Road Materials	23	27	4	15	4	0	3	11	6	3	5	1	12	3	1	1	3	9	9	19	31
Rheology	3	47	0	2	1	0	0	0	3	0	0	1	2	0	0	0	1	1	1	3	47
Other (please specify)	2	48	1	0	1	0	0	0	2	0	1	0	1	0	0	0	0	1	1	2	48
ditto	1	49	1	0	0	0	1	0	0	0	1	0	1	0	0	0	1	1	0	2	48
WATER:-																					
Solution of hydraulic problems																					
from first principles	14	36	1	11	1	1	1	3	2	7	5	1	1	4	2	0	2	8	3	13	37
using empirical formulae	26	24	2	19	4	1	2	7	7	9	6	2	10	4	3	2	2	10	11	23	27
using computer packages	6	44	0	4	2	0	0	2	0	3	0	2	2	0	0	0	0	2	2	4	49
using handbooks	23	27	1	18	4	0	2	5	10	6	5	2	9	4	2	1	3	10	7	20	30
using models	3	47	0	3	0	0	0	0	1	2	0	1	0	1	1	0	2	1	0	1	49
Solution of hydrology problems																					
using raw data & first principles	9	41	2	7	0	0	0	1	4	4	2	1	2	1	2	0	2	4	2	8	42
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	23	27	2	20	0	1	2	6	7	8	5	1	10	4	3	0	1	11	10	19	31
using computer package	3	47	0	3	0	0	0	0	2	1	1	0	1	0	1	0	1	2	0	2	49
using models	1	49	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	49
using systems analysis	2	49	0	2	0	0	0	0	0	2	0	0	0	1	1	1	1	0	0	1	49
Hydrostatics	6	44	1	5	0	0	0	1	1	4	0	2	1	0	2	1	1	2	1	3	47
Hydrodynamics	6	44	1	4	1	0	0	1	3	2	0	3	0	3	0	2	3	1	0	5	45
Water engineering	12	38	2	6	4	0	0	5	5	2	2	3	2	4	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ENGINEERS - OTHER WORK n=50

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not Important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	21	29	2	18	1	0	2	2	8	9	3	0	11	4	1	1	5	10	4	19	32
Frame Analysis																					
using manual methods	11	39	2	8	1	0	0	1	3	7	1	1	5	3	1	1	3	5	2	6	44
using computers																					
a) via terminal to large installation	4	46	0	4	0	0	0	1	1	2	1	0	1	1	0	0	0	3	0	1	49
b) on site small computer	2	48	0	2	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	50
c) desk top programmable calculator	4	46	1	3	0	0	1	0	0	3	1	0	0	2	0	0	1	3	0	1	49
using handbooks	9	41	9	0	0	0	0	3	2	5	1	0	4	3	1	0	3	4	2	5	45
elasticity (stress, strain etc.)	6	44	1	5	0	0	0	2	1	3	1	0	1	3	0	0	0	4	1	1	49
statics (i.e. virtual work)	5	45	1	4	0	0	0	2	0	3	1	0	1	2	1	0	0	3	1	2	4
Design																					
metal structures, inc. steel	19	31	2	14	3	0	1	3	4	11	2	1	5	7	1	0	4	10	2	16	34
concrete structures	26	24	2	22	2	0	1	2	10	13	3	2	8	8	3	0	4	13	6	23	27
timber	18	32	2	16	0	0	1	1	5	11	2	0	5	7	2	0	3	7	5	13	37
code of practice	18	32	1	15	1	1	1	1	9	7	2	0	6	6	1	0	0	8	7	15	35
safety factors and load factors	19	31	1	15	2	1	1	2	9	7	2	0	5	8	1	0	0	11	5	19	32
Other (please specify)	4	46	0	2	2	0	1	0	2	1	0	0	0	2	0	0	1	2	1	4	46
ditto	3	47	0	1	2	0	0	2	0	1	0	1	0	1	0	0	0	3	0	3	47
MATERIALS:-																					
Mechanical Testing	18	32	1	15	1	1	2	1	6	9	2	1	10	2	1	1	0	10	5	13	37
Quality control	17	33	3	12	0	2	4	2	5	6	3	2	6	5	0	0	3	9	3	16	34
Selection & specifications	26	24	2	17	7	0	1	7	13	5	3	2	15	3	1	0	4	13	7	22	28
Metallic	13	37	1	11	0	1	2	2	3	6	2	0	7	2	1	0	1	5	5	7	43
Organic (including timber)	14	36	0	11	3	0	2	2	4	6	1	1	8	1	2	0	1	7	4	9	41
Concrete	27	23	4	18	4	1	2	9	11	6	2	1	17	3	3	0	3	15	8	20	30
Ceramic	4	46	0	3	1	0	1	1	1	1	0	0	1	3	0	0	1	1	1	3	47
Silicate	1	49	0	1	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	0	50
Road Materials	23	27	4	15	4	0	3	11	6	3	5	1	12	3	1	1	3	9	9	19	31
Rheology	3	47	0	2	1	0	0	0	3	0	0	1	2	0	0	0	1	1	1	3	47
Other (please specify)	2	48	1	0	1	0	0	0	2	0	1	0	1	0	0	0	0	1	1	2	48
ditto	1	49	1	0	0	0	1	0	0	0	1	0	1	0	0	0	1	1	0	2	48
WATER:-																					
Solution of hydraulic problems																					
from first principles	14	36	1	11	1	1	1	3	2	7	5	1	1	4	2	0	2	9	3	13	37
using empirical formulae	26	24	2	19	4	1	2	7	7	9	6	2	10	4	3	2	2	10	11	25	27
using computer packages	6	64	0	4	2	0	0	2	0	3	0	2	2	0	0	0	0	2	2	4	49
using handbooks	23	27	1	18	4	0	2	5	10	6	5	-	9	4	2	1	3	10	7	20	30
using models	3	47	0	3	0	0	0	0	1	2	0	1	0	1	1	0	2	1	0	1	49
Solution of hydrology problems																					
using raw data & first principles	9	41	2	7	0	0	0	1	4	4	2	1	2	1	2	0	2	4	2	8	42
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	23	27	2	20	0	1	2	6	7	8	5	1	10	4	2	0	1	11	10	19	31
using computer package	3	47	0	3	0	0	0	0	2	1	1	0	1	0	1	0	1	2	0	2	49
using models	1	49	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	49
using systems analysis	2	49	0	2	0	0	0	0	0	2	0	0	0	1	1	1	1	0	0	1	49
Hydrostatics	6	44	1	5	0	0	0	1	1	4	0	2	1	0	2	1	1	2	1	3	47
Hydrodynamics	6	44	1	4	1	0	0	1	3	2	0	3	0	3	0	2	3	1	0	5	45
Water engineering	12	38	2	6	4	0	0	5	5	2	2	3	2	4	1	1	4	5	2	10	40
Other (please specify)	2	48	0	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	2	2	48
ditto	1	49	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	49

APPENDIX "

TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

ENGINEERS - OTHER WORK n = 50

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	11	39	2	9	0	1	0	2	3	6	1	3	5	1	1	0	2	6	2	11	39
Field investigations	25	25	2	21	7	0	1	4	9	12	3	1	15	6	0	0	3	15	6	24	26
Laboratory investigations	13	37	2	9	2	0	2	1	4	7	2	1	4	4	1	0	3	7	2	10	40
Foundation design or assessment	24	26	2	21	0	1	1	2	8	14	3	1	8	10	1	0	4	13	6	21	29
Earth structures design (e.g. embankments dams, road bases)	25	25	3	22	0	0	1	5	10	4	1	3	14	5	1	0	2	16	5	24	26
Mechanics	13	37	0	13	0	0	1	0	3	9	1	1	3	3	4	1	2	8	0	6	44
Engineering	12	38	0	11	1	0	1	0	5	6	1	1	4	4	1	1	3	5	1	8	42
Other (please specify)	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
CONSTRUCTION:-																					
Critical Path Methods	20	30	3	15	1	1	1	4	5	11	5	0	6	7	2	0	2	10	7	15	35
Explosives	15	35	3	11	1	0	1	3	2	9	2	2	8	2	1	0	2	5	7	12	38
Drilling	12	38	1	10	1	0	1	3	1	7	1	2	5	2	2	0	1	8	9	11	39
ELECTRICAL ENGINEERING:-																					
Network analysis	1	49	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	49
Equipment specification	7	43	0	5	2	0	0	2	2	3	0	3	0	0	3	0	4	1	1	6	44
Other (please specify)	1	49	0	1	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	50
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MATHEMATICS																					
Basic algebra, geometry and trigonometry	43	7	11	32	0	0	11	13	14	5	12	2	19	4	4	0	1	17	23	39	11
Calculus	23	27	5	17	1	0	5	2	10	6	6	1	8	5	1	0	4	8	9	16	34
Numerical Methods	23	27	5	18	0	0	4	4	10	6	5	1	10	4	2	0	2	7	12	19	31
Other (please specify)	2	48	0	1	1	0	0	2	0	0	0	1	0	0	0	1	0	0	0	1	49
ditto	1	49	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	49
COMPUTERS																					
System Analysis	7	43	1	3	3	0	1	0	1	5	0	3	1	3	1	1	3	2	1	2	48
Writing programs	11	39	2	7	2	0	0	1	5	5	2	1	3	4	1	0	4	3	2	7	43
Using programs	19	31	2	14	3	0	2	4	4	9	1	1	4	6	2	0	2	6	10	15	35
Other (please specify)	1	49	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	49
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
EQUIPMENT & PLANT	15	35	3	6	5	1	6	6	3	0	4	5	4	2	0	1	2	6	4	15	35
SURVEYING																					
Levelling	28	22	6	21	1	0	4	7	7	10	10	1	9	1	5	1	0	7	18	22	28
Setting out	23	27	4	16	2	1	3	7	7	1	9	1	8	2	3	2	0	5	14	18	32
Traversing	20	30	4	15	1	0	3	4	8	5	6	2	9	1	1	1	1	6	11	15	35
Photogrammetry	11	39	2	7	2	0	0	1	3	6	0	1	3	3	2	0	0	5	3	6	44
Other (please specify)	5	45	0	5	0	0	0	1	2	2	2	0	2	0	0	0	0	1	3	4	46
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
CHEMISTRY – ENGINEERING																					

ENGINEERS - OTHER WORK n=50

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	U
SOILS:-																					
Geological assessment	11	39	2	9	0	1	0	2	3	6	1	3	5	1	1	0	2	6	2	11	39
Field investigations	25	25	2	21	2	0	1	4	9	12	3	1	15	6	0	0	3	15	6	24	26
Laboratory investigations	13	37	2	9	2	0	2	1	4	7	2	1	4	4	1	0	3	7	2	10	40
Foundation design or assessment	24	26	2	21	0	1	1	2	8	14	3	1	9	10	1	0	4	13	6	21	29
Earth structures design (e.g. embankments dams, road bases)	25	25	3	22	0	0	1	5	10	4	1	3	14	5	1	0	2	16	5	24	26
Mechanics	13	37	0	13	0	0	1	0	3	9	1	1	3	3	4	1	2	8	0	6	44
Engineering	12	38	0	11	1	0	1	0	5	6	1	1	4	4	1	1	3	5	1	8	42
Other (please specify)	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
CONSTRUCTION:-																					
Critical Path Methods	20	30	3	15	1	1	1	4	5	11	5	0	6	7	2	0	2	10	7	15	35
Explosives	15	35	3	11	1	0	1	3	2	9	2	2	9	2	1	0	2	5	7	12	38
Drilling	12	38	1	10	1	0	1	3	1	7	1	2	5	2	2	0	1	5	5	11	39
ELECTRICAL ENGINEERING:-																					
Network analysis	1	49	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	49
Equipment specification	7	43	0	5	2	0	0	2	2	3	0	3	0	0	3	0	4	1	1	6	44
Other (please specify)	1	49	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	50
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MATHEMATICS																					
Basic algebra, geometry and trigonometry	43	7	11	32	0	0	11	13	14	5	12	2	19	4	4	0	1	11	23	39	11
Calculus	23	27	5	17	1	0	5	2	10	6	6	1	8	5	1	0	4	8	9	16	34
Numerical Methods	23	27	5	18	0	0	4	4	10	6	5	1	10	4	2	0	2	7	12	19	31
Other (please specify)	2	48	0	1	1	0	0	2	0	0	0	1	0	0	0	1	0	0	0	1	49
ditto	1	49	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	49
COMPUTERS																					
System Analysis	7	43	1	3	3	0	1	0	1	5	0	3	1	3	1	1	3	2	1	2	48
Writing programs	11	39	2	7	2	0	0	1	5	5	2	1	3	4	1	0	4	5	2	7	43
Using programs	19	31	2	14	3	0	2	4	4	9	1	1	4	6	2	0	2	6	10	15	35
Other (please specify)	1	49	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	49
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
EQUIPMENT & PLANT	15	35	3	6	5	1	6	6	3	0	4	5	4	2	0	1	2	6	4	15	35
SURVEYING																					
Levelling	28	22	6	21	1	0	4	7	7	10	10	1	9	1	5	1	0	1	18	22	28
Setting out	23	27	4	16	2	1	3	7	7	1	8	1	8	2	3	2	0	5	14	18	32
Traversing	20	30	4	15	1	0	3	4	8	5	6	2	9	1	1	1	1	6	11	15	35
Photogrammetry	11	39	2	7	2	0	0	1	3	6	0	1	3	3	2	0	0	5	3	6	44
Other (please specify)	5	45	0	5	0	0	0	1	2	2	2	0	2	0	0	0	0	1	3	4	46
ditto	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
CHEMISTRY – ENGINEERING (e.g. corrosion)	7	43	1	6	0	0	1	1	2	3	1	1	0	4	1	0	2	5	0	6	44
PHYSICS – ENGINEERING (e.g. thermodynamics)	5	45	0	3	2	0	0	0	2	3	0	0	2	3	0	1	2	2	0	4	46
GEOLOGY – ENGINEERING (e.g. stability of rocks)	7	43	1	6	0	0	0	0	2	5	0	1	2	3	1	0	2	4	1	7	43
BIOLOGY – ENGINEERING (e.g. water & sewerage, environment, public health)	21	29	2	17	2	0	1	5	6	9	3	3	5	10	0	1	4	11	4	7	33
OTHER (please specify)	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50

APPENDIX 7   TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

TECHNICIANS - DESIGN   n = 98

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	11	87	1	9	1	0	1	2	4	4	1	0	7	1	2	0	2	6	2	10	88
Frame Analysis																					
using manual methods	4	94	1	2	1	0	1	2	1	0	1	0	1	2	0	2	0	1	0	4	98
using computers																					
a) via terminal to large installation	1	97	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	97
b) on site small computer	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
c) desk top programmable calculator	5	93	0	5	0	0	1	2	0	2	0	0	3	2	0	1	1	1	1	4	94
using handbooks	4	94	0	3	1	0	0	1	3	0	0	1	1	0	1	1	1	0	2	4	94
elasticity (stress, strain etc)	5	93	1	4	0	0	0	2	1	2	1	0	2	1	1	0	0	4	0	5	93
statics (i e virtual work)	3	95	0	3	0	0	0	0	1	2	0	0	1	1	0	0	1	2	0	3	95
Design																					
metal structures, inc. steel	21	77	1	16	3	1	2	7	6	6	3	4	7	4	2	1	3	11	4	20	78
concrete structures	40	58	1	35	5	1	3	11	12	14	5	5	21	8	2	0	6	20	12	35	63
timber	23	75	0	20	3	0	0	3	9	11	1	3	11	5	1	0	3	10	7	17	81
code of practice	21	77	1	18	1	1	1	6	7	7	3	2	9	4	2	0	3	8	9	20	78
safety factors and load factors	18	80	0	16	1	1	1	6	4	7	2	1	8	4	2	0	3	6	7	17	81
Other (please specify)	3	95	0	2	1	0	1	2	0	0	1	0	1	1	0	0	3	0	0	3	95
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
MATERIALS:-																					
Mechanical Testing	2	96	0	1	1	0	0	0	0	2	0	1	0	0	0	0	0	2	0	2	96
Quality control	3	95	0	2	1	0	0	0	2	1	1	1	0	1	0	0	0	3	0	3	95
Selection & specifications	9	89	0	7	2	0	0	3	6	9	0	1	8	1	0	0	0	6	4	10	88
Metallic	10	88	0	8	1	1	0	7	2	2	0	1	8	1	1	0	1	7	3	9	89
Organic (including timber)	9	89	0	8	1	0	0	4	3	2	0	1	7	1	0	0	1	5	3	9	89
Concrete	23	75	0	21	2	0	2	9	9	4	4	1	14	5	0	0	3	11	10	20	78
Ceramic	2	96	0	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0	2	2	96
Silicate	2	96	0	2	0	0	0	1	1	0	0	0	2	0	0	0	0	1	1	2	96
Road Materials	19	79	1	16	1	1	2	8	4	6	3	2	9	4	1	0	2	9	9	20	78
Rheology	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Other (please specify)	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
WATER:-																					
Solution of hydraulic problems																					
from first principles	11	87	0	6	4	1	0	2	7	2	2	3	4	2	0	0	4	5	2	10	88
using empirical formulae	21	77	0	12	8	1	2	6	10	3	6	1	8	6	0	0	5	9	6	19	79
using computer packages	2	96	0	2	0	0	0	0	1	1	0	0	0	1	1	0	1	1	0	2	96
using handbooks	27	71	0	16	10	1	2	11	9	6	8	2	13	5	0	0	5	11	11	24	74
using models	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Solution of hydrology problems																					
using raw data & first principles	6	92	0	5	0	1	0	2	2	2	1	0	3	2	0	0	0	3	3	5	93
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	31	67	2	20	8	1	3	5	16	7	9	4	10	8	0	0	4	15	12	29	69
using computer package	3	95	0	3	0	0	0	1	1	1	0	1	1	1	0	0	1	0	2	3	95
using models	1	97	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	97
using systems analysis	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Hydrostatics	1	97	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	97
Hydrodynamics	1	97	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	97
Water engineering	3	95	0	1	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TECHNICIANS - DESIGN   n = 98

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use: Do use	Use: Do not use	Level of Knowledge: Advanced	Level of Knowledge: General	Level of Knowledge: Specialised	Level of Knowledge: V. Specialised	Frequency: Regularly	Frequency: Frequently	Frequency: Not Frequently	Frequency: Infrequently	Importance: V. important-easy	Importance: V. important-diff.	Importance: Important-easy	Importance: Important-diff.	Importance: Not important	Difficulty: Very difficult	Difficulty: Difficult	Difficulty: Mod. difficult	Difficulty: Easy	Use in Year: Used	Use in Year: Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	11	87	1	9	1	0	1	2	4	4	1	0	7	1	2	0	2	6	2	10	89
Frame Analysis																					
using manual methods	4	94	1	2	1	0	1	2	1	0	1	0	1	2	0	2	0	1	0	4	98
using computers																					
a) via terminal to large installation	1	97	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	97
b) on site small computer	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
c) desk top programmable calculator	5	93	0	5	0	0	1	2	0	2	0	0	3	2	0	1	1	1	1	4	94
using handbooks	4	94	0	3	1	0	0	1	3	0	0	1	1	0	1	1	1	0	2	4	94
elasticity (stress, strain etc.)	5	93	1	4	0	0	0	2	1	2	1	0	2	1	1	0	0	4	0	5	93
statics (i.e. virtual work)	3	95	0	3	0	0	0	0	1	2	0	0	1	1	0	0	1	2	0	3	95
Design																					
metal structures, inc. steel	21	77	1	16	3	1	2	7	6	6	3	4	7	4	2	1	3	11	4	20	78
concrete structures	40	58	1	33	5	1	3	11	12	14	5	5	21	8	2	0	6	20	13	35	63
timber	23	75	0	20	3	0	0	3	9	11	1	3	11	5	1	0	3	10	7	17	81
code of practice	21	77	1	18	1	1	1	6	7	7	5	2	9	4	2	0	3	8	9	20	78
safety factors and load factors	18	80	0	16	1	1	1	6	4	7	2	1	8	4	2	0	3	6	7	17	81
Other (please specify)	3	95	0	2	1	0	1	2	0	0	1	0	1	1	0	0	3	0	0	3	95
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
MATERIALS:-																					
Mechanical Testing	2	96	0	1	1	0	0	0	0	2	0	1	0	0	0	0	0	2	0	2	96
Quality control	3	95	0	2	1	0	0	0	2	1	1	1	0	1	0	0	0	3	0	3	95
Selection & specifications	9	89	0	7	2	0	0	3	6	9	0	1	8	1	0	0	0	6	4	10	88
Metallic	10	88	0	8	1	1	0	7	2	2	0	1	8	1	1	0	1	7	3	9	89
Organic (including timber)	9	89	0	8	1	0	0	4	3	2	0	1	7	1	0	0	1	5	3	9	89
Concrete	23	75	0	21	2	0	2	9	9	4	4	1	14	5	0	0	3	11	10	20	78
Ceramic	2	96	0	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0	2	2	96
Silicate	2	96	0	2	0	0	0	1	1	0	0	0	2	0	0	0	0	1	1	2	96
Road Materials	19	79	1	16	1	1	2	8	4	6	3	2	9	4	1	0	2	9	9	20	78
Rheology	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Other (please specify)	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
WATER:-																					
Solution of hydraulic problems																					
from first principles	11	87	0	6	4	1	0	2	7	2	2	3	4	2	0	0	4	5	2	10	88
using empirical formulae	21	77	0	12	8	1	2	6	10	3	6	1	8	6	0	0	5	9	6	19	79
using computer packages	2	96	0	2	0	0	0	0	1	1	0	0	0	1	1	0	1	1	0	2	96
using handbooks	27	71	0	16	10	1	2	11	9	6	8	2	13	5	0	0	5	11	11	24	74
using models	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Solution of hydrology problems																					
using raw data & first principles	6	92	0	5	0	1	0	2	2	2	1	0	3	2	0	0	0	3	3	5	93
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	31	67	2	20	8	1	3	5	16	7	9	4	16	6	0	0	4	15	12	29	69
using computer package	3	95	0	3	0	0	0	1	1	1	0	1	1	1	0	0	1	0	2	3	95
using models	1	97	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	97
using systems analysis	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Hydrostatics	1	97	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	97
Hydrodynamics	1	97	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	97
Water engineering	3	95	0	3	0	0	0	1	1	1	1	0	0	0	1	0	0	1	2	3	95
Other (please specify)	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

TECHNICIANS - DESIGN n = 98

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. important-easy	V. important-diff	Important-easy	Important diff	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	5	93	0	5	2	0	2	0	0	3	2	0	0	2	1	0	1	2	2	4	94
Field investigations	8	90	0	7	1	0	2	1	2	3	2	1	3	2		0	1	3	4	6	92
Laboratory investigations	4	94	0	3	1	0	2	0	0	2	2	0	0	2		1	0	2	1	3	95
Foundation design or assessment	11	87	0	10	1	0	2	1	3	5	2	0	3	4		1	1	6	3	6	92
Earth structures design (e.g. embankments dams, road bases)	18	80	1	13	3	1	4	6	4	4	3	1	9	3		1	0	11	6	15	83
Mechanics	4	94	0	3	1	0	1	0	1	2	1	0	0	3	0	1	1	2	0	3	95
Engineering	6	92	0	5	1	0	0	1	1	4	1	0	0	4	1	1	3	2	0	4	94
Other (please specify)	1	97	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	97
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
CONSTRUCTION.-																					
Critical Path Methods	9	89	0	9	0	0	1	2	3	3	3	0	0	5	1	0	1	5	2	9	89
Explosives	3	95	0	3	0	0	1	0	0	2	1	0	0	1	1	0	1	1	1	2	96
Drilling	3	95	0	3	0	0	1	0	0	1	1	0	0	1	1	0	1	1	1	2	96
ELECTRICAL ENGINEERING:-																					
Network analysis	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Equipment specification	1	97	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	98
Other (please specify)	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
MATHEMATICS																					
Basic algebra, geometry and trigonometry	90	8	15	70	5	0	35	34	13	7	25	9	48	4	2	1	7	31	49	79	19
Calculus	22	76	2	20	0	0	1	6	9	6	1	3	8	6	4	2	2	11	6	18	80
Numerical Methods	21	77	1	20	0	0	9	7	2	3	6	3	10	2	0	1	2	8	13	18	80
Other (please specify)	1	97	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	97
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
COMPUTERS																					
System Analysis	1	97	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	97
Writing programs	11	87	0	7	4	0	0	1	1	9	0	3	2	3	3	0	5	4	2	10	88
Using programs	20	78	0	14	4	2	4	7	5	5	3	4	9	4	1	0	4	8	9	20	78
Other (please specify)	4	94	0	4	0	0	0	1	0	3	0	1	1	1	1	0	0	2	2	3	95
ditto	1	97	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	97
EQUIPMENT & PLANT	6	92	0	3	3	0	2	0	3	1	1	0	3	1	1	0	0	4	2	5	93
SURVEYING																					
Levelling	61	37	5	46	8	2	11	6	21	22	15	3	35	3	3	0	3	19	36	47	51
Setting out	38	60	3	29	3	3	11	4	8	15	9	6	14	4	4	1	5	16	12	24	74
Traversing	38	60	2	30	5	1	6	4	9	19	9	2	16	2	7	1	2	17	15	24	74
Photogrammetry	30	68	3	23	4	0	2	6	11	12	3	3	13	8	3	0	5	12	13	26	72
Other (please specify)	2	96	0	2	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	97
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
CHEMISTRY - ENGINEERING																					

TECHNICIANS – DESIGN n = 98

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use: Do use	Use: Do not use	Level of Knowledge: Advanced	General	Specialised	V. Specialised	Frequency: Regularly	Frequently	Not Frequently	Infrequently	Importance: V. Important-easy	V. Important-diff	Important-easy	Important-diff	Not important	Difficulty: Very difficult	Difficult	Mod. difficult	Easy	Use in Year: Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	5	93	0	3	2	0	2	0	0	3		0	0	2	1	0	1	2	2	4	94
Field investigations	8	90	0	7	1	0	2	1	2	3		1	3	2	0	0	1	3	4	6	92
Laboratory investigations	4	94	0	3	1	0	2	0	0	2	2	0	0	2	0	1	0	2	1	3	95
Foundation design or assessment	11	87	0	10	1	0	2	1	3	5	2	0	3	4	2	1	1	6	3	6	92
Earth structures design (e.g. embankments dams, road bases)	18	80	1	13	3	1	4	6	4	4	3	1	9	3	2	1	0	11	6	15	83
Mechanics	4	94	0	3	1	0	1	0	1	2	1	0	0	3	0	1	1	2	0	3	95
Engineering	6	92	0	5	1	0	0	1	1	4		0	0	4	1	1	3	2	0	4	94
Other (please specify)	1	97	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	97
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
CONSTRUCTION:-																					
Critical Path Methods	9	89	0	9	0	0	1	2	3	3	3	0	0	5	1	0	1	5	2	9	89
Explosives	3	95	0	3	0	0	1	0	0	2	1	0	0	1	1	0	1	1	1	2	96
Drilling	3	95	0	3	0	0	1	0	0	1	1	0	0	1	1	0	1	1	1	2	96
ELECTRICAL ENGINEERING:-																					
Network analysis	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
Equipment specification	1	97	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	98
Other (please specify)	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
MATHEMATICS																					
Basic algebra, geometry and trigonometry	90	8	15	70	5	0	35	34	13	7	25	9	48	4	2	1	7	31	48	79	19
Calculus	22	76	2	20	0	0	1	6	9	6	1	3	8	6	4	2	2	11	6	18	80
Numerical Methods	21	77	1	20	0	0	9	7	2	3	6	3	10	2	0	1	2	7	13	18	80
Other (please specify)	1	97	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	97
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
COMPUTERS																					
System Analysis	1	97	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	97
Writing programs	11	87	0	7	4	0	0	1	1	9	0	3	2	3	3	0	5	4	2	10	88
Using programs	20	78	0	14	4	2	4	7	5	5	3	4	9	4	1	0	4	8	9	20	78
Other (please specify)	4	94	0	4	0	0	0	1	0	3	0	1	1	1	1	0	0	2	2	3	95
ditto	1	97	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	97
EQUIPMENT & PLANT	6	92	0	3	3	0	2	0	3	1	1	0	3	1	1	0	0	4	2	5	93
SURVEYING																					
Levelling	61	37	5	46	8	2	11	6	21	22	15	3	35	3	3	0	3	19	36	47	51
Setting out	38	60	3	29	3	3	11	4	8	15	9	6	14	4	4	1	5	15	12	24	74
Traversing	36	60	2	20	5	1	6	4	9	17	9	2	16	2	7	1	2	17	15	24	74
Photogrammetry	30	68	3	23	4	0	2	6	11	12	3	3	13	8	3	0	5	12	13	26	72
Other (please specify)	2	96	0	2	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	97
ditto	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
CHEMISTRY – ENGINEERING (e.g. corrosion)	2	96	0	1	1	0	0	0	1	1	1	0	1	0	0	0	0	1	0	1	97
PHYSICS – ENGINEERING (e.g. thermodynamics)	6	92	0	1	1	4	0	3	2	1	3	0	3	0	0	0	0	3	3	6	92
GEOLOGY – ENGINEERING (e.g. stability of rocks)	4	94	0	3	1	0	1	0	2	1	2	0	1	1	0	0	1	2	1	4	94
BIOLOGY – ENGINEERING (e.g. water & sewerage, environment, public health)	2	96	0	2	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	2	96
OTHER (please specify)	1	97	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	98

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

TECHNICIANS - CONSTRUCTION n = 17

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regular	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	1	16	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	16
Frame Analysis																					
using manual methods	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using computers																					
a) via terminal to large installation	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
b) on site small computer	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0		4	0	0	17
c) desk top programmable calculator	2	15	0	2	0	0	1	0	0	1	0	0	2	0	0				1	2	15
using handbooks	1	16	0	1	0	0	0	1	0	0	0	0	1	0	0	0		0	1	1	16
elasticity (stress, strain etc.)	1	16	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	16
statics (i.e. virtual work)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Design																					
metal structures, inc. steel	1	16	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	16
concrete structures	1	16	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	16
timber	1	16	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	16
code of practice	2	15	0	2	0	0	0	1	1	0	1	0	0	0	1	0	0	1	1	1	16
safety factors and load factors	2	15	0	2	0	0	0	1	1	0	1	0	0	0	1	0	0	1	1	1	16
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
MATERIALS:-																					
Mechanical Testing	11	6	1	9	1	0	4	3	3	1	1	0	8	1	1	0		6	3	8	9
Quality control	10	7	1	8	1	0	2	3	4	1	1	0	5	2	1	0	1	7	2	9	8
Selection & specifications	8	9	0	8	0	0	1	2	3	2	0	0	4	2	1	0	1	5	2	6	11
Metallic	4	13	0	4	0	0	1	0	2	1	0	0	1	1	2	0	1	2	0	2	15
Organic (including timber)	5	12	0	5	0	0	1	1	2	2	1	0	1	0	3	0	1	3	2	4	13
Concrete	8	9	1	7	0	0	2	2	4	0	3	0	3	0	1	0	1	3	2	7	10
Ceramic	2	15	0	2	0	0	2	0	0	0	0	1	0	0	1	0	0	2	0	2	15
Silicate	2	15	0	2	0	0	1	0	0	1	0	0	0	0	1	0	0	2	0	0	17
Road Materials	10	7	1	8	1	0	4	2	4	0	4	0	4	1	1	0	0	0	2	9	8
Rheology	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Other (please specify)	1	16	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	16
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
WATER:-																					
Solution of hydraulic problems																					
from first principles	1	16	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	16
using empirical formulae	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using computer packages	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using handbooks	2	15	0	2	0	0	0	0	0	2	1	0	0	0	0	0	0	1	1	1	16
using models	1	16	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	17
Solution of hydrology problems																					
using raw data & first principles	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using standard design procedures	2	15	0	1	1	0	1	0	1	0	1	0	1	0	0	0	1	0	1	2	15
(e.g. Australia Rainfall & Runoff Handbook)																					
using computer package	1	16	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	17
using models	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using systems analysis	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Hydrostatics	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Hydrodynamics	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17

TECHNICIANS – CONSTRUCTION n = 17

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not Important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	1	16	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	16
Frame Analysis																					
using manual methods	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using computers																					
a) via terminal to large installation	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
b) on site small computer	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	[illegible]	0	0	17
c) desk top programmable calculator	2	15	0	2	0	0	1	0	0	1	0	0	2	0	0	[illegible]	[illegible]	[illegible]	1	2	15
using handbooks	1	16	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	16
elasticity (stress, strain etc.)	1	16	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	16
statics (i.e. virtual work)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Design																					
metal structures inc. steel	1	16	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	16
concrete structures	1	16	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	16
timber	1	16	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	16
code of practice	2	15	0	2	0	0	0	1	1	0	1	0	0	0	1	0	0	1	1	1	16
safety factors and load factors	2	15	0	2	0	0	0	1	1	0	1	0	0	0	1	0	0	1	1	1	16
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
MATERIALS:-																					
Mechanical Testing	11	6	1	9	1	0	4	3	3	1	1	0	8	1	1	0		6	3	8	9
Quality control	10	7	1	8	1	0	2	3	4	1	1	0	5	2	1	0	1	7	2	9	8
Selection & specifications	8	9	0	8	0	0	1	2	3	2	0	0	4	2	1	0	1	5	2	6	11
Metallic	4	13	0	4	0	0	1	0	2	1	0	0	1	1	2	0	1	2	0	2	15
Organic (including timber)	5	12	0	5	0	0	1	1	2	2	1	0	1	0	3	0	1	3	2	4	13
Concrete	8	9	1	7	0	0	2	2	4	0	3	0	3	0	1	0	1	3	2	7	10
Ceramic	2	15	0	2	0	0	2	0	0	0	0	1	0	0	1	0	0	2	0	2	15
Silicate	2	15	0	2	0	0	1	0	0	1	0	0	0	0	1	0	0	2	0	0	17
Road Materials	10	7	1	8	1	0	4	2	4	0	4	0	4	1	1	0	0	0	2	9	8
Rheology	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Other (please specify)	1	16	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	16
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
WATER:-																					
Solution of hydraulic problems																					
from first principles	1	16	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	16
using empirical formulae	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using computer packages	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using handbooks	2	15	0	2	0	0	0	0	0	2	1	0	0	0	0	0	0	1	1	1	16
using models	1	16	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	17
Solution of hydrology problems																					
using raw data & first principles	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	2	15	0	1	1	0	1	0	1	0	1	0	1	0	0	0	1	0	1	2	15
using computer package	1	16	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	17
using models	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
using systems analysis	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Hydrostatics	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Hydrodynamics	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Water engineering	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17

TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

TECHNICIANS — CONSTRUCTION n = 17

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	7	10	0	7	0	0	0	2	0	4	0	1	1	1	3	1	0	3	2	4	13
Field investigations	12	5	1	11	0	0	3	3	1	4	2	1	4	3	1	1	0	4	5	11	6
Laboratory investigations	7	10	0	6	1	0	3	1	2	1	1	1	4	0	1	0	2	2	2	6	11
Foundation design or assessment	6	11	0	6	0	0	0	1	2	2	1	0	2	1	1	0	1	1	2	4	13
Earth structures design (e.g. embankments dams, road bases)	7	10	1	3	2	1	1	1	2	2	2	0	1	2	1	0	2	3	1	6	11
Mechanics	1	16	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	2	15
Engineering	1	16	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	16
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
CONSTRUCTION:-																					
Critical Path Methods	3	14	1	2	0	0	2	0	0	0	2	0	0	0	0	0	0	2	[illegible]	2	15
Explosives	4	13	1	3	0	0	1	0	1	1	0	1	0	2	0	0	1	2	0	3	14
Drilling	4	13	1	3	0	0	1	0	1	2	0	1	1	2	0	0	1	2	0	3	14
ELECTRICAL ENGINEERING:-																					
Network analysis	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Equipment specification	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
MATHEMATICS																					
Basic algebra, geometry and trigonometry	13	4	2	10	1	0	6	3	3	0	2	1	9	0	0	0	0	4	7	12	5
Calculus	2	15	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	2	0	2	15
Numerical Methods	4	13	0	4	0	0	2	1	0	1	0	0	3	0	1	0	0	0	4	3	14
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
COMPUTERS																					
System Analysis	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Writing programs	2	15	0	2	0	0	0	0	0	2	0	0	0	1	1	1	1	0	0	1	16
Using programs	3	14	0	3	0	0	0	0	0	3	0	0	1	2	0	1	0	2	0	3	14
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
EQUIPMENT & PLANT	5	12	1	3	1	0	2	2	2	0	2	0	2	2	0	0	1	2	3	6	11
SURVEYING																					
Levelling	8	9	2	6	0	0	3	2	1	1	4	0	3	0	0	0	0	1	6	7	10
Setting out	6	11	2	4	0	0	3	1	0	2	2	0	4	0	0	0	0	1	5	6	11
Traversing	6	11	1	5	0	0	2	1	0	3	2	0	3	0	1	0	0	1	5	5	12
Photogrammetry	1	16	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	16
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
MISTRY — ENGINEERING (e.g. corrosion)	2	15	0	1	1	0	0	2	0	0	0	0	2	0	0	0	0	1	1	2	15

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Y5hr	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	7	10	0	7	0	0	0	2	0	4	0	1	1	1	3	1	0	3	2	4	13
Field investigations	12	5	1	11	0	0	3	3	1	4	2	1	4	3	1	1	0	4	5	11	6
Laboratory investigations	7	10	0	6	1	0	3	1	2	1	1	1	4	0	1	0	2	2	2	6	11
Foundation design or assessment	6	11	0	6	0	0	0	1	2	2	1	0	2	1	1	0	1	1	2	4	13
Earth structures design (e.g. embankments dams, road bases)	7	10	1	3	2	1	1	1	2	2	2	0	1	2	1	0	2	3	1	6	11
Mechanics	1	16	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	2	15
Engineering	1	16	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	16
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
CONSTRUCTION:-																					
Critical Path Methods	3	14	1	2	0	0	2	0	0	0	2	0	0	0	0	0	0	2	0	2	15
Explosives	4	13	1	3	0	0	1	0	1	1	0	1	0	2	0	0	1	2	0	3	14
Drilling	4	13	1	3	0	0	1	0	1	2	0	1	1	2	0	0	1	2	0	3	14
ELECTRICAL ENGINEERING:-																					
Network analysis	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Equipment specification	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
MATHEMATICS																					
Basic algebra, geometry and trigonometry	13	4	2	10	1	0	6	3	3	0	2	1	4	0	0	0	0	4	7	12	5
Calculus	2	15	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	2	0	2	15
Numerical Methods	4	13	0	4	0	0	2	1	0	1	0	0	3	0	1	0	0	0	4	3	14
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
COMPUTERS																					
System Analysis	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Writing programs	2	15	0	2	0	0	0	0	0	2	0	0	0	1	1	1	1	0	0	1	16
Using programs	3	14	0	3	0	0	0	0	0	3	0	0	1	2	0	1	0	2	0	3	14
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
EQUIPMENT & PLANT	5	12	1	3	1	0	2	2	2	0	2	0	2	2	0	0	1	2	3	6	11
SURVEYING																					
Levelling	8	9	2	6	0	0	3	2	1	1	4	0	3	0	0	0	0	1	6	7	10
Setting out	6	11	2	4	0	0	3	1	0	2	2	0	4	0	0	0	0	1	5	6	11
Traversing	6	11	1	5	0	0	2	1	0	3	2	0	3	0	1	0	0	1	5	5	12
Photogrammetry	1	16	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	16
Other (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
ditto	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
CHEMISTRY – ENGINEERING (e.g. corrosion)	2	15	0	1	1	0	0	2	0	0	0	0	2	0	0	0	0	1	1	2	15
PHYSICS – ENGINEERING (e.g. thermodynamics)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
GEOLOGY – ENGINEERING (e.g. stability of rocks)	1	16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
BIOLOGY – ENGINEERING (e.g. water & sewerage, environment, public health)	1	16	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	16
OTHER (please specify)	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

TECHNICIANS - OTHER WORK n = 15

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	2	13	0	1	1	0	0	0	0	2	0	0	1	1	0	0	0	2	0	1	14
Frame Analysis																					
using manual methods	2	13	0	2	0	0	0	0	0	2	0	0	1	1	0	0	0	1	1	1	14
using computers																					
a) via terminal to large installation	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
b) on site small computer	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
c) desk top programmable calculator	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
using handbooks	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
elasticity (stress, strain etc.)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
statics (i.e. virtual work)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Design																					
metal structures, inc. steel	4	11	0	3	1	0	0	0	1	3	0	0	2	1	1	0	0	4	0	2	13
concrete structures	4	11	0	3	1	0	0	1	2	1	0	0	3	1	0	0	0	3	1	3	12
timber	3	12	0	2	1	0	0	1	1	1	0	0	2	0	1	0	0	2	1	3	12
code of practice	3	12	0	3	0	0	0	0	1	1	0	0	1	1	0	0	0	1	1	1	14
safety factors and load factors	2	13	0	2	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	1	14
Other (please specify)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
ditto	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
MATERIALS:-																					
Mechanical Testing	2	13	0	1	1	0	1	1	0	0	1	0	1	0	0	0	0	0	2	2	13
Quality control	3	12	0	2	1	0	1	2	0	0	1	0	2	0	0	0	0	2	1	3	12
Selection & specifications	3	12	0	2	0	1	0	2	1	0	0	0	2	1	0	0	0	1	2	3	12
Metallic	2	13	0	2	0	0	0	1	0	1	0	0	1	0	1	0	0	1	1	1	14
Organic (including timber)	3	12	0	3	0	0	0	1	2	0	0	0	2	0	1	0	1	0	2	2	13
Concrete	5	10	1	3	1	0	2	1	2	0	0	0	4	1	0	0	0	1	4	5	10
Ceramic	1	14	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	14
Silicate	1	14	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	14
Road Materials	4	11	0	2	1	0	2	1	0	1	1	0	2	0	0	0	0	1	3	3	12
Rheology	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Other (please specify)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
ditto	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
WATER:-																					
Solution of hydraulic problems																					
from first principles	2	13	0	2	0	0	0	0	0	2	0	1	1	0	0	0	0	2	0	2	13
using empirical formulae	3	12	0	2	1	0	0	1	0	2	1	0	1	0	1	0	0	3	0	3	12
using computer packages	1	14	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	14
using handbooks	3	12	0	2	1	0	0	2	0	1	1	0	2	0	0	0	0	2	1	3	12
using models	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Solution of hydrology problems																					
using raw data & first principles	2	13	0	2	0	0	0	0	0	2	0	1	0	0	1	0	0	2	0	0	15
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	2	13	0	2	0	0	0	1	1	0	0	0	2	0	0	0	0	0	1	2	13
using computer package	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15

TECHNICIANS - OTHER WORK n = 15

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)	2	13	0	1	1	0	0	0	0	2	0	0	1	1	0	0	0	2	0	1	14
Frame Analysis																					
using manual methods	2	13	0	2	0	0	0	0	0	2	0	0	1	1	0	0	0	1	1	1	14
using computers																					
a) via terminal to large installation	0	15	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0	0	0	15
b) on site small computer	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
c) desk top programmable calculator	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
using handbooks	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
elasticity (stress, strain etc.)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
statics (i e virtual work)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Design																					
metal structures, inc. steel	4	11	0	3	1	0	0	0	1	3	0	0	2	1	1	0	0	4	0	2	13
concrete structures	4	11	0	3	1	0	0	1	2	1	0	0	3	1	0	0	0	3	1	3	12
timber	3	12	0	2	1	0	0	1	1	1	0	0	2	0	1	0	0	2	1	3	12
code of practice	3	12	0	3	0	0	0	0	1	1	0	0	1	1	0	0	0	1	1	1	14
safety factors and load factors	2	13	0	2	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	1	14
Other (please specify)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
ditto	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
MATERIALS:-																					
Mechanical Testing	2	13	0	1	1	0	1	1	0	0	1	0	1	0	0	0	0	0	2	2	13
Quality control	3	12	0	2	1	0	1	2	0	0	1	0	2	0	0	0	0	2	1	3	12
Selection & specifications	3	12	0	2	0	1	0	2	1	0	0	0	2	1	0	0	0	1	2	3	12
Metallic	2	13	0	2	0	0	0	1	0	1	0	0	1	0	1	0	0	1	1	1	14
Organic (including timber)	3	12	0	3	0	0	0	1	2	0	0	0	2	0	1	0	1	0	2	2	13
Concrete	5	10	1	3	1	0	2	1	2	0	0	0	4	1	0	0	0	1	4	5	10
Ceramic	1	14	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	14
Silicate	1	14	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	14
Road Materials	4	11	0	3	1	0	2	1	0	1	1	0	3	0	0	0	0	1	3	3	12
Rheology	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Other (please specify)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
ditto	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
WATER:-																					
Solution of hydraulic problems																					
from first principles	2	13	0	2	0	0	0	0	0	2	0	1	1	0	0	0	0	2	0	2	13
using empirical formulae	3	12	0	2	1	0	0	1	0	2	1	0	1	0	1	0	0	3	0	3	12
using computer packages	1	14	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	14
using handbooks	3	12	0	2	1	0	0	2	0	1	1	0	2	0	0	0	0	2	1	3	12
using models	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Solution of hydrology problems																					
using raw data & first principles	2	13	0	2	0	0	0	0	0	2	0	1	0	0	1	0	0	2	0	0	15
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)	2	13	0	2	0	0	0	1	1	0	0	0	2	0	0	0	0	0	1	2	13
using computer package	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
using models	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
using systems analysis	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Hydrostatics	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Hydrodynamics	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Water engineering	2	13	0	2	0	0	0	0	1	1	0	0	0	0	0	0	0	2	0	2	13
Other (please specify)	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
ditto	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15

APPENDIX 7 TASK ANALYSIS QUESTIONNAIRE

- TECHNICAL MATTERS

The frequency of response is given in each of the cells of the table below for

TECHNICIANS - OTHER WORK n = 15

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	2	13	1	1	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	1	14
Field investigations	4	11	1	3	0	0	0	2	1	1	0	0	2	1	0	0	1	1	2	2	13
Laboratory investigations	5	10	0	4	1	0	2	0	1	2	1	0	2	1	0	0	1	2	2	3	12
Foundation design or assessment	3	12	0	3	0	0	0	0	1	2	0	0	2	1	0	0	0	2	1	2	13
Earth structures design (e.g. embankments dams, road bases)	4	11	0	3	1	0	0	2	0	2	0	0	2	1	1	0	0	2	2	3	12
Mechanics	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Engineering	2	13	0	2	0	0	0	0	1	1	0	0	1	1	0	0	0	1	1	1	14
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
CONSTRUCTION:-																					
Critical Path Methods	1	14	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	14
Explosives	2	13	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	1	1	1	14
Drilling	3	12	0	2	0	1	0	0	1	2	0	0	1	2	0	0	0	1	2	1	14
ELECTRICAL ENGINEERING:-																					
Network analysis	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Equipment specification	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
MATHEMATICS																					
Basic algebra, geometry and trigonometry	11	4	0	10	1	0	1	5	3	2	1	1	6	1	2	1	0	4	6	10	5
Calculus	4	11	0	3	1	0	0	1	2	1	0	0	3	1	0	0	0	3	1	3	12
Numerical Methods	4	11	0	3	0	1	0	2	0	2	1	0	1	2	0	0	0	2	2	1	14
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
COMPUTERS																					
System Analysis	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Writing programs	5	10	0	3	1	1	0	1	2	2	1	1	1	1	1	0	3	2	0	4	11
Using programs	6	9	1	3	2	0	2	1	2	1	1	0	3	1	1	0	0	2	4	4	11
Other (please specify)	2	13	0	2	0	0	0	1	0	1	0	0	1	1	0	0	0	2	0	1	14
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
EQUIPMENT & PLANT	3	12	0	2	0	1	0	0	1	2	0	0	2	1	0	0	0	2	1	0	15
SURVEYING																					
Levelling	6	9	1	3	2	0	2	2	0	2	2	0	3	1	0	0	0	1	5	3	12
Setting out	6	9	1	3	2	0	2	1	0	3	1	1	3	1	0	0	0	3	3	3	12
Traversing	4	11	1	2	1	0	1	1	1	1	1	0	2	1	0	0	0	2	2	2	13
Photogrammetry	2	13	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	2	0	1	14
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
CHEMISTRY - ENGINEERING	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TECHNICIANS - OTHER WORK n = 15

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use: Do use	Use: Do not use	Level of Knowledge: Advanced	Level of Knowledge: General	Level of Knowledge: Specialised	Level of Knowledge: V. Specialised	Frequency: Regularly	Frequency: Frequently	Frequency: Not Frequently	Frequency: Infrequently	Importance: V. Important-easy	Importance: V. Important-diff.	Importance: Important-easy	Importance: Important-diff.	Importance: Not important	Difficulty: Very difficult	Difficulty: Difficult	Difficulty: Mod. difficult	Difficulty: Easy	Use in Year: Used	Use in Year: Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment	2	13	1	1	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	1	14
Field investigations	4	11	1	3	0	0	0	2	1	1	0	0	2	1	0	0	1	1	2	2	13
Laboratory investigations	5	10	0	4	1	0	2	0	1	2	1	0	2	1	0	0	1	2	2	3	12
Foundation design or assessment	3	12	0	3	0	0	0	0	1	2	0	0	2	1	0	0	0	2	1	2	13
Earth structures design (e.g. embankments dams, road bases)	4	11	0	3	1	0	0	2	0	2	0	0	2	1	1	0	0	2	2	3	12
Mechanics	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Engineering	2	13	0	2	0	0	0	0	1	1	0	0	1	1	0	0	0	1	1	1	14
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
CONSTRUCTION:-																					
Critical Path Methods	1	14	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	14
Explosives	2	13	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	1	1	1	14
Drilling	3	12	0	2	0	1	0	0	1	2	0	0	1	2	0	0	0	1	2	1	14
ELECTRICAL ENGINEERING:-																					
Network analysis	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Equipment specification	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
MATHEMATICS																					
Basic algebra, geometry and trigonometry	11	4	0	10	1	0	1	5	3	2	1	1	6	1	2	1	0	4	6	10	5
Calculus	4	11	0	3	1	0	0	1	2	1	0	0	3	1	0	0	0	3	1	3	12
Numerical Methods	4	11	0	3	0	1	0	2	0	2	1	0	1	2	0	0	0	2	2	1	14
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
COMPUTERS																					
System Analysis	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
Writing programs	5	10	0	3	1	1	0	1	2	2	1	1	1	1	1	0	3	2	0	4	11
Using programs	6	9	1	3	2	0	2	1	2	1	1	0	3	1	1	0	0	2	4	4	11
Other (please specify)	2	13	0	2	0	0	0	1	0	1	0	0	1	1	0	0	0	2	0	1	14
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
EQUIPMENT & PLANT	3	12	0	2	0	1	0	0	1	2	0	0	2	1	0	0	0	2	1	0	15
SURVEYING																					
Levelling	6	9	1	3	2	0	2	2	0	2	2	0	3	1	0	0	0	1	5	3	12
Setting out	6	9	1	3	2	0	2	1	0	3	1	1	3	1	0	0	0	3	3	3	12
Traversing	4	11	1	2	1	0	1	1	1	1	1	0	2	1	0	0	0	2	2	2	13
Photogrammetry	2	13	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	2	0	1	14
Other (please specify)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
ditto	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
CHEMISTRY - ENGINEERING (e.g. corrosion)	2	13	0	2	0	0	0	1	0	1	0	1	0	1	0	0	1	1	0	1	14
PHYSICS - ENGINEERING (e.g. thermodynamics)	1	14	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	15
GEOLOGY - ENGINEERING (e.g. stability of rocks)	2	13	0	2	0	0	0	0	0	2	0	1	0	1	0	0	1	1	0	0	15
BIOLOGY - ENGINEERING (e.g. water & sewerage, environment, public health)	3	12	0	3	0	0	0	1	1	1	0	0	1	2	0	0	0	2	1	2	13
OTHER (please specify)	2	13	0	2	0	0		0	0	1	0	0	1	1	0	0	0	2	0	1	14

APPENDIX 8

TASK ANALYSIS QUESTIONNAIRE - TRAINING ANALYSIS

Pages 9 and 10 of the Task Analysis questionnaire were concerned with training in relation to the specific categories of task viz. technical, manual, economic, communication, and management. Analysis of the data generated in answers to specific questions was, in the first place, carried out by reference to categories of formal qualifications. Originally there were fourteen categories, shown in Table A.8.1., but these were reduced to eight, shown in Table A.8.2.

TABLE A.8.1.

QUALIFICATION CATEGORIES AND NUMBER OF RESPONDENTS IN EACH CATEGORY

QUALIFICATION	NUMBER OF RESPONDENTS
B.E. (Civil)	81
B.Sc. (Civil Engineering)	20
Professional Institute qualification	5
Diploma - civil engineering	37
Local Government certificate	14
Degree - other	13
Diploma - other	5
Structural engineering certificate	21
Drafting certificate	14
Engineering surveying certificate	28
Materials testing certificate	4
Certificate - other	36
No qualification	45
No answer	8
TOTAL	331

TABLE A.[illegible]

[illegible]-GROUPED QUALIFICATION CATEGORIES

[illegible]	QUALIFICATION	NUMBER OF RESPONDENTS
1	[illegible] (Civil), B.Sc. (Civil Engineering) [illegible] Professional Institute qualification	[illegible]
	[illegible] civil engineering	
	[illegible] Government certificate	[illegible]
	[illegible] other, and Diploma - other	18
	[illegible] certificate, and Drafting [illegible]	[illegible]
	[illegible] surveying certificate	[illegible]
	[illegible] certificate and other [illegible]	46
	[illegible] no [illegible]	[illegible]
	TOTAL	[illegible]

[illegible] the training sought answers with respect [illegible] matters, manual skills, economic/financial [illegible] information matters, and management [illegible] questions were applied firstly [illegible] manual skill and so on.

[illegible] five of the six questions were as follows:

[illegible] needed to perform the task - was it part of [illegible] training?

[illegible] indicate by writing a number selected from the 4 point [illegible]

strongly emphasised — emphasised — some mention — none "

1 — [illegible] — 3 — 4

[illegible] practical experience been of importance in the acquisition of skill in relation to this task?

[illegible] indicate by writing a number selected from the 4-point [illegible]

very much — much — some — very little "

1 — 2 — 3 — 4

[illegible] "What do you think is the best pattern of training for acquiring the knowledge required for the performance of the task? Select one of the following for each of the categories of task. Full

1	B.E. (Civil), B.Sc. (Civil Engineering) and Professional Institute qualification	106
	Diploma - civil engineering	[illegible]
	[illegible] Government certificate	14
	[illegible] and Diploma - other	18
	[illegible] certificate, and Drafting [illegible]	[illegible]
	[illegible]	[illegible]
	[illegible] and other [illegible]	[illegible]
	[illegible]	[illegible]
	Total	[illegible]

[illegible] answers with respect [illegible] economic/[illegible] information matters, and management [illegible] questions were applied [illegible] skill [illegible] so on.

[illegible] of the six questions were as follows:

[illegible] perform the task - was it part of [illegible] training?

[illegible] by writing a number selected from the 4-point [illegible]

strongly emphasized	emphasized	some mention	none
1	2	3	4

") [illegible] experience been of importance in the acquisition of [illegible] in relation to this task?

[illegible] by writing a number selected from the 4-point [illegible]

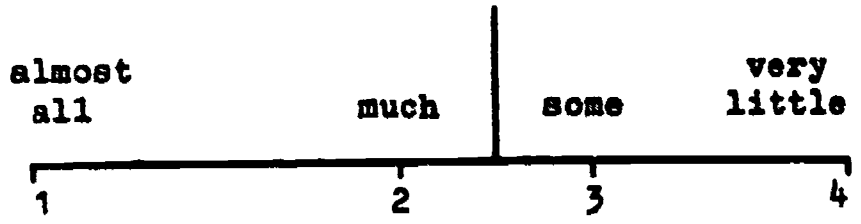
very much	much	some	very little
1	2	3	4

") "What do you think is the best pattern of training for acquiring [illegible] required for the performance of the task? Select [illegible] the following for each of the categories of task. Full [illegible] Full time followed by part-time. Sandwich/block [illegible] T.W.I. (training within industry). Short intensive [illegible] Correspondence, Self learning, Other."

[illegible] whether the course should [illegible] degree or sub-degree level."

5) "To what extent is your post-secondary/tertiary training specifically used in the performance of the category of task?

Please indicate by writing a number selected from the following 4-point scale.



"

Table A.8.3. deals exclusively with data concerned with technical matters related to the questions one-five, and examined with reference to the eight categories of qualifications detailed earlier.

There were numbers of nil answers in this section and we have therefore included in this table and subsequent tables of this appendix the percentages for each frequency. This may be of assistance in spite of the tables appearing were formidable with the extra figures.

Table A.8.4., deals with manual skills, A.8.5. with economic matters, A.8.6. with communication matters, and A.8.7. with management matters, each with respect to questions one to five.

A 8 p.3.

TABLE A.8.3.

TECHNICAL MATTERS

(frequency first, percent age second)

Question		QUALIFICATION CATEGORY															
		1		2		3		4		5		6		7		8	
		B. Eng. etc.		Diploma		Local Government certificate		Degree/ Diploma - other		Structural/ Draft. certificate		Eng. survey certificate		Other certificates		No qualif-ication	
1) Answer	0		2%		3%		0%		6%		11%		5%		0%		11%
	1	59	56	10	27	6	43	4	22	7	20	15	38	10	36	9	17
	2	32	30	18	49	6	43	10	56	12	34	11	28	11	39	13	25
	3	12	11	8	22	1	7	3	17	11	31	12	29	6	21	14	26
	4	1	1	0	0	1	7	0	0	1	3	0	0	1	4	11	21
2) Answer	0		2		3		0		6		14		3		0		6
	1	50	47	19	51	9	64	8	44	17	49	25	63	17	61	36	68
	2	31	29	9	24	4	29	3	17	7	20	10	25	9	32	8	15
	3	14	13	6	16	1	7	4	22	4	11	3	8	1	4	4	8
	4	9	9	2	5	0	0	2	11	2	6	1	3	1	4	2	4
3) Answer	0		6		8		0		11		20		15		7		8
Full-time	1	62	59	11	30	6	43	3	17	3	9	7	18	3	11	7	13
Full/part-time	2	15	14	5	14	3	21	5	28	1	3	6	15	0	0	6	11
Part-time	3	11	10	9	24	1	7	5	28	16	46	12	30	13	46	19	36
Sandwich	4	7	7	7	19	4	29	3	17	3	9	3	8	6	21	3	6
T.W.I.	5	1	1	2	5	0	0	0	0	3	9	5	13	3	11	16	21
Short-course	6	3	3	0	0	0	0	0	0	2	6	6	0	0	0	3	6
Correspond.	7	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0
Self-learning	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	9	1	1	0	0	0	0	0	0	0	0	1	3	0	0	0	0
4) Answer	0		53		57		29		44		51		45		50		64
Degree level	1	47	44	14	38	9	64	8	44	6	17	10	25	6	21	3	6
Sub " "	2	3	3	2	5	1	7	2	11	11	31	11	28	8	29	16	30
5) Answer	0		2		3		0		6		14		5		0		17
	1	26	25	8	22	1	7	4	22	4	11	10	25	6	21	8	15
	2	44	42	17	46	6	43	9	50	8	23	14	35	9	32	17	32
	3	28	26	8	22	5	36	2	11	12	34	12	30	10	36	10	19
	4	6	6	2	5	2	14	2	11	6	17	2	5	3	11	9	17
n =		106		37		14		18		35		40		28		53	

CORRIGENDUM. Due to an error arising from transposition

Question		E. Eng. etc.		Diploma		Local Government certificate		Degree/Diploma - other		Structural/Draft. certificate		Eng. survey certificate		Other certificate		No qualification	
1) Answer	0		2%		3%		0%		6%		11%		5%		0%		11%
	1	59	56	10	27	6	43	4	22	7	20	15	38	10	36	9	17
	2	32	30	18	49	6	43	10	56	12	34	11	28	11	39	13	25
	3	12	11	8	22	1	7	3	17	11	31	12	29	6	21	14	26
	4	1	1	0	0	1	7	0	0	1	3	0	0	1	4	11	21
2) Answer	0		2		3		0		6		14		3		0		6
	1	50	47	19	51	9	64	8	44	17	49	25	63	17	61	36	68
	2	31	29	9	24	4	29	3	17	7	20	10	25	9	32	8	15
	3	14	13	6	16	1	7	4	22	4	11	3	8	1	4	4	8
	4	9	9	2	5	0	0	2	11	2	6	1	3	1	4	2	4
3) Answer	0		6		8		0		11		20		15		7		8
Full-time	1	62	59	11	30	6	43	3	17	3	9	7	18	3	11	7	13
Full/part-time	2	15	14	5	14	3	21	5	28	1	3	6	15	0	0	6	11
Part-time	3	11	10	9	24	1	7	5	28	16	46	12	30	13	46	19	36
Sandwich	4	7	7	7	19	4	29	3	17	3	9	3	8	6	21	3	6
T.W.I.	5	1	1	2	5	0	0	0	0	3	9	5	13	3	11	16	21
Short-course	6	3	3	0	0	0	0	0	0	2	6	6	0	0	0	3	6
Correspond.	7	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0
Self-learning	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	9	1	1	0	0	0	0	0	0	0	0	1	3	0	0	0	0
4) Answer	0		53		57		29		44		51		45		50		64
Degree level	1	47	44	14	38	9	64	8	44	6	17	10	25	6	21	3	6
Sub " "	2	3	3	2	5	1	7	2	11	11	31	11	28	8	29	16	30
5) Answer	0		2		3		0		6		14		5		0		17
	1	26	25	8	22	1	7	4	22	4	11	10	25	6	21	8	15
	2	44	42	17	46	6	43	9	50	8	23	14	35	9	32	17	32
	3	28	26	8	22	5	36	2	11	12	34	12	30	10	36	10	19
	4	6	6	2	5	2	14	2	11	6	17	2	5	3	11	9	17
n =		106		37		14		18		35		40		28		53	

CORRIGENDUM. Due to an error arising from transposition of columns in a computer print-out, all figures under columns 6 and 7 should be transposed in Tables A.8.3. - A.8.15, in Table A.8.22., and Table A.8.23. In Tables A.8.16., A.8.17., and A.8.24., only the values of 'n' in columns 6 and 7 should be transposed.

TABLE A.8.4.

MANUAL SKILLS

(frequency first, percent age second)

Question		1 B. Eng. etc.		2 Diploma		3 Local Government certificate		4 Degree/ Diploma - other		5 Structural/ Draft. certificate		6 Eng. survey certificate		7 Other certificates		8 No qualif- ication	
1) Answer	0		11%		24%		7%		17%		26%		33%		7%		25%
	1	16	15	1	3	1	7	0	0	10	29	7	18	10	36	10	19
	2	32	30	17	46	6	43	6	33	7	20	12	30	10	36	18	34
	3	37	35	6	16	6	43	8	44	8	23	5	13	3	11	5	9
	4	9	9	4	11	0	0	1	6	1	3	3	8	3	11	7	13
2) Answer	0		11		24		21		17		23		30		7		19
	1	40	38	14	38	7	50	6	33	18	51	18	45	19	68	31	59
	2	21	20	8	22	3	21	5	28	6	17	6	15	6	21	7	13
	3	24	23	4	11	1	7	3	17	3	9	4	10	0	0	2	4
	4	9	8	2	5	0	0	1	6	0	0	0	0	1	4	3	6
3) Answer	0		14		35		14		17		26		40		18		25
Full-time	1	19	18	1	3	1	7	1	6	0	0	0	0	0	0	2	4
Full/part-time	2	3	3	2	5	0	0	3	17	2	6	0	0	1	4	1	2
Part-time	3	25	24	7	19	3	21	3	17	13	37	9	23	12	43	15	28
Sandwich	4	6	6	2	5	3	21	2	11	1	3	2	5	2	7	1	2
T.W.I.	5	28	26	9	24	3	21	5	28	10	29	13	33	7	25	19	36
Short course	6	6	6	2	5	1	7	1	6	0	0	0	0	0	0	1	2
Correspondence	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Self learning	8	3	3	1	3	1	7	0	0	0	0	0	0	1	4	1	2
Other	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4) Answer	0		66		78		71		78		71		80		71		81
Degree level	1	17	16	3	8	1	7	2	11	1	3	3	8	1	4	0	0
Sub " "	2	19	18	5	14	3	21	2	11	9	26	5	12	7	25	10	19
5) Answer	0		10		27		21		17		23		33		7		30
	1	13	12	1	3	0	0	0	0	3	9	3	8	6	21	12	23
	2	21	20	9	24	2	14	5	28	10	29	8	20	10	36	11	21
	3	40	38	13	35	6	43	6	33	6	17	10	25	8	29	6	11
	4	21	20	4	11	3	21	4	22	8	23	6	15	2	7	8	15

n = 106 37 14 18 35 40 28 53

A.8. P.5.

TABLE A.8.5.

ECONOMIC/FINANCIAL MATTERS

(frequency first, percent age second)

Question		QUALIFICATION CATEGORY															
		1		2		3		4		5		6		7		8	
		B. Eng. etc.		Diploma		Local Government certificate		Degree/ Diploma - other		Structural/ Draft certificate		Eng. survey certificate		Other certificates		No qualification	
1) Answer	0		9%		24%		7%		11%		66%		35%		7%		51%
	1	1	1	0	0	0	0	0	0	0	0	2	5	0	0	2	4
	2	6	6	4	11	1	7	0	0	0	0	3	8	0	0	4	8
	3	59	56	13	35	6	43	9	50	4	11	13	32	13	46	7	13
	4	30	28	11	30	6	43	7	39	8	23	8	20	13	46	13	24
2) Answer	0		9		22		7		11		66		32		7		47
	1	53	50	13	35	8	57	9	50	4	11	9	23	0	29	15	28
	2	32	30	15	41	4	29	3	17	2	6	4	10	4	14	6	11
	3	10	9	1	3	1	7	3	17	2	6	8	20	8	29	4	8
	4	1	1	0	0	0	0	1	6	4	11	6	15	6	21	3	6
3) Answer	0		14		30		7		17		63		45		25		49
Full-time	1	23	22	2	5	1	7	1	6	1	3	1	3	1	4	2	4
Full/part-time	2	4	4	0	0	0	0	3	17	0	0	1	3	1	4	2	4
Part-time	3	16	15	5	14	4	29	2	11	4	11	5	13	3	11	7	13
Sandwich	4	4	4	2	5	0	0	2	11	0	0	1	2	2	7	0	0
T.W.I.	5	22	21	5	14	5	36	3	17	2	6	7	18	5	18	9	17
Short course	6	16	15	12	32	3	21	3	17	3	9	3	7	8	29	6	11
Correspondence	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Self learning	8	5	5	0	0	0	0	1	6	3	9	4	10	1	4	1	2
Other	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4) Answer	0		70		78		79		67		86		80		82		91
Degree level	1	20	19	4	11	0	0	3	17	0	0	3	8	0	0	1	2
Sub " "	2	12	11	4	11	3	21	3	17	5	14	5	12	5	18	4	8
5) Answer	0		11		27		14		11		63		35		14		57
	1	4	4	1	3	0	0	0	0	0	0	1	2	1	4	5	9
	2	8	8	2	5	1	7	0	0	0	0	4	10	0	0	1	2
	3	29	27	11	30	4	29	4	22	2	6	6	15	3	11	6	11
	4	53	50	13	35	7	50	12	67	11	31	15	38	20	71	11	21
n =		106		37		14		18		35		40		28		53	

TABLE A.8.6.

COMMUNICATION MATTERS

(frequency first, percent age second)

Question		QUALIFICATION CATEGORY															
		1		2		3		4		5		6		7		8	
		B. Eng. etc.		Diploma		Local Government certificate		Degree/ Diploma - other		Structural/ Draft certificate		Eng. survey certificate		Other certificates		No qualification	
1) Answer	0		9%		19%		7%		17%		40%		25%		7%		47%
	1	3	3	1	3	0	0	0	0	0	0	2	5	0	0	0	0
	2	9	9	2	5	2	14	1	6	4	11	3	8	7	25	6	11
	3	50	47	15	41	5	36	3	17	7	20	17	43	12	43	11	21
	4	35	33	12	32	6	43	11	61	10	29	8	20	7	25	11	21
2) Answer	0		9		19		7		17		40		23		7		38
	1	68	64	16	43	7	50	7	39	7	20	11	28	4	14	23	43
	2	17	16	12	32	5	36	6	33	4	11	7	18	10	36	8	15
	3	8	8	2	5	1	7	1	6	5	14	9	23	4	14	1	2
	4	4	4	0	0	0	0	1	6	5	14	4	10	8	29	1	2
3) Answer	0		15		27		7		22		37		33		21		43
Full-time	1	8	8	0	0	0	0	0	0	1	3	0	0	1	4	1	2
Full/Part time	2	2	2	0	0	0	0	2	11	0	0	1	3	1	4	2	4
Part-time	3	10	10	4	11	3	21	1	6	3	9	5	13	3	11	5	9
Sandwich	4	4	4	0	0	0	0	1	6	0	0	1	3	2	7	0	0
T.W.I.	5	28	26	12	32	7	50	3	17	6	17	13	33	5	18	7	13
Short course	6	22	21	8	22	3	21	4	22	6	17	4	10	9	32	9	17
Correspondence	7	1	1	0	0	0	0	0	0	2	6	0	0	1	4	0	0
Self Learning	8	14	13	2	5	0	0	2	11	4	11	3	8	0	0	6	11
Other	9	1	1	1	3	0	0	1	6	0	0	0	0	0	0	0	0
4) Answer	0		71		89		79		72		86		83		75		93
Degree level	1	12	11	0	0	0	0	1	6	0	0	2	5	1	4	0	0
Sub " "	2	19	18	4	11	3	21	4	22	5	14	5	12	6	21	4	7
5) Answer	0		11		22		14		17		37		25		14		51
	1	5	5	2	5	0	0	0	0	1	3	1	2	1	4	4	8
	2	5	5	2	5	0	0	1	6	4	11	7	18	1	3	4	7
	3	28	26	11	30	3	21	3	17	4	11	10	25	12	43	6	11
	4	56	53	14	38	9	64	11	61	13	37	12	30	10	36	12	23
n =		106		37		14		18		35		40		28		53	

TABLE A.8.7.

MANAGEMENT/PERSONNEL MATTERS

(frequency first, percent age second)

Question		QUALIFICATION CATEGORY 1 B. Eng. etc.		2 Diploma		3 Local Government certificate		4 Degree/Diploma - other		5 Structural/Draft certificate		6 Eng. survey certificate		7 Other certificates		8 No qualification	
) Answer	0		13%		24%		7%		17%		49%		33%		14%		51%
	1	3	3	0	0	1	7	0	0	1	3	1	2	0	0	0	0
	2	4	4	2	5	0	0	0	0	2	6	4	10	2	7	1	2
	3	36	34	8	22	2	14	5	28	3	9	9	22	7	25	7	13
	4	49	46	18	49	16	72	10	56	12	34	13	33	15	54	18	34
.) Answer	0		13		24		7		17		49		30		14		45
	1	65	61	15	41	8	57	9	50	10	29	11	28	5	18	18	34
	2	15	14	8	22	3	22	3	17	0	0	6	15	2	7	4	8
	3	9	9	4	11	2	14	1	6	3	9	8	20	5	18	1	2
	4	3	3	1	3	0	0	2	11	5	14	3	7	12	43	6	11
.) Answer	0		18		32		7		28		46		40		32		51
ull-time	1	13	12	3	8	0	0	0	0	1	3	0	0	0	0	1	2
ull/Part-time	2	1	1	0	0	0	0	2	11	1	3	1	3	0	0	2	4
art-time	3	10	9	4	11	1	7	2	11	4	11	8	20	3	11	5	9
andwich	4	7	7	2	5	1	7	2	11	1	3	1	3	3	11	0	0
.W.I.	5	29	27	8	22	8	58	1	6	5	14	10	25	4	14	9	17
hort course	6	20	19	7	19	3	21	4	22	5	14	3	8	8	29	9	17
Correspondence	7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Self Learning	8	5	5	1	3	0	0	2	11	1	3	1	2	1	4	0	0
ther	9	1	1	0	0	0	0	0	0	1	3	0	0	0	0	0	0
:) Answer	0		74		87		86		78		83		78		82		89
egree level	1	16	15	2	5	1	7	2	11	2	6	3	8	1	4	1	2
ub " "	2	12	11	3	8	1	7	2	11	4	11	6	15	4	14	5	9
5) Answer	0		16		27		14		17		46		30		21		53
	1	4	4	2	5	0	0	0	0	1	3	1	2	0	0	4	8
	2	4	4	1	3	0	0	0	0	0	0	5	13	0	0	2	4
	3	19	18	6	16	2	14	2	11	4	11	11	28	2	7	2	4
	4	62	58	18	49	10	72	13	72	14	40	11	27	20	72	17	32
n =		106		37		14		18		35		40		28		53	

A8. P.8

Question six, slightly complex, asked [illegible] to recommend the best way of acquiring the knowledge for performance of the [illegible] sub-categories of task, viz: technical, [illegible], etc., and to nominate three methods in order of priority. To check if subjects were [illegible] with the usual methods of acquiring knowledge they were first asked to circle those methods of which they had experience. The question read as follows:

6) "The following [illegible]

a) Live lecture [illegible] [illegible] 6
Tutorial [illegible] [illegible] 6
Audio-visual methods [illegible] Simulation [illegible] games 7
Individual project 4 [illegible]
Group project [illegible] [illegible] job experience 9

Which of these have you [illegible] experience of? Please circle number.

b) What is the best way of acquiring the knowledge for the performance of the "task? Please state up to 3 answers in order of priority.

Tables A.8.8. to A.8.13 present the data dealing with question six, table A.8.8. showing respondents' experience of ways of acquiring knowledge, and tables A.8.9. - A.8.13. with the nominated ways of acquiring knowledge.

TABLE A.8.8.

EXPERIENCE OF WAYS OF ACQUIRING KNOWLEDGE

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
Way of Acquiring Knowledge	[illegible]	Diploma	Local Government Certificate	Degree/ Diploma [illegible]	[illegible] Certificate	[illegible] Survey Certificate	Other Certificate	[illegible]
	%	%	%	%	%	%	%	%
Live lecture	[illegible]	95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64
Tutorial	34	81	57	83	60	53	61	40
Audio-visual methods	61	43	[illegible]	50	26	45	56	26
Individual project	30	[illegible]	57	72	63	[illegible]	64	43
Group project	80	57	[illegible]	[illegible]	34	43	[illegible]	38
Demonstration	87	87	[illegible]	[illegible]	57	[illegible]	61	53
Practical/Field work	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56	7.
Simulation/games	[illegible]	[illegible]	43	22	3	15	7	11
On the job instruction	7	73	80	83	66	55	71	66
Practical job experience	91	95	100	89	74	73	93	83

TABLE A.8.9.

WAYS OF ACQUIRING KNOWLEDGE FOR PERFORMANCE OF TASK

(3 IN ORDER OF PRIORITY)

TECHNICAL MATTERS

Way of Acquiring Knowledge	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
No answer	6.0.13.	2.3.	0.0.0.	2.2.3.	5.5.9.	5.6.7.	2.2.5.	6.7.12.
Live lecture	70.9.21.	24.1.	10.2.1.	14.1.0.	15.2.2.	19.2.2.	13.3.2.	17.6.4.
Tutorial	12.40.5.	4.11.	2.3.1.	1.9.1.	0.6.1.	4.5.1.	3.4.1.	4.8.2.
Audio/visual methods	1.3.6.	0.0.	0.1.0.	0.0.0.	0.2.0.	0.3.1.	2.0.1.	2.3.0.
Ind. project	2.15.19.	1.3.	0.1.2.	1.0.1.	0.2.3.	0.2.3.	1.5.1.	0.2.3.
Group project	1.5.13.	1.2.	0.1.0.	0.2.1.	1.1.0.	0.1.1.	0.0.0.	2.1.0.
Demonstration	2.5.8.	0.5.	0.3.2.	0.2.3.	0.0.1.	3.4.1.	0.2.2.	4.6.4.
Prac./field work	3.6.11.	1.1.	1.2.2.	0.0.2.	4.4.6.	5.6.4.	1.3.4.	2.10.7.
Simul./games	0.0.0.	0.1.	0.0.1.	0.0.0.	0.0.1.	0.0.0.	0.0.0.	1.0.0.
On job instruc.	1.8.5.	2.3.	0.1.2.	0.1.2.	3.8.4.	1.7.6.	1.7.6.	7.4.11.
Prac. job experience	8.8.21.	2.7.	1.0.3.	0.1.5.	7.5.8.	3.4.14.	5.2.6.	8.6.10.
n =	106	37	14	18	35	40	28	53

TABLE A.8.1.10.

WAYS OF ACQUIRING KNOWLEDGE FOR PERFORMANCE OF TASK

(3 IN ORDER OF PRIORITY)

MANUAL SKILLS

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
Way of Acquiring Knowledge	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
No answer	15.25.33.	11.14.	2.3.3.	3.3.3.	9.12.14.	16.17.19	5.7.8.	13.18.24.
Live lecture	14.2.5.	6.2.	1.1.0.	8.1.0.	5.3.3.	8.0.1.	7.1.0.	6.5.2.
Tutorial	8.6.2.	3.1.	0.0.0.	1.2.1.	1.1.1.	1.2.0.	3.2.1.	4.2.0.
Aud/visual	2.5.0.	2.0.	1.0.0.	1.0.0.	1.0.1.	1.1.1.	1.1 1.	1.0.1.
Ind. project	3.2.6.	0.0.	1.1.0.	0.1.0.	0.2.1.	0.1.0.	0.2.3.	1.3.0.
Group project	0.2.9.	0.0.	1.1.1.	0.0.1.	0.1.0.	0.1.0.	0.0.2.	1.0.1.
[illegible]	20.17.8	3.7.	3.1.1.	1.5.2.	0.0.2.	2.1.2.	1.1.1.	5.3.3.

Acquiring Knowledge	1	2	3	4	5	6	7	8
No answer	6.0.13.	2.3.	0.0.0.	2.2.3.	5.5.9.	5.6.7.	2.2.5.	6.7.12.
Live lecture	70.9.21.	24.1.	10.2.1.	14.1.0.	15.2.2.	19.2.2.	13.3.2.	17.6.4.
Tutorial	12.40.5.	4.11.	2.3.1.	1.9.1.	0.6.1.	4.5.1.	3.4.1.	4.8.2.
Audio/visual methods	1.3.6.	0.0.	0.1.0.	0.0.0.	0.2.0.	0.3.1.	2.0.1.	2.3.0.
Ind. project	2.13.19.	1.3.	0.1.2.	1.0.1.	0.2.3.	0.2.3.	1.5.1.	0.2.3.
Group project	1.5.13.	1.2.	0.1.0.	0.2.1.	1.1.0.	0.1.1.	0.0.0.	2.1.0.
Demonstration	2.5.8.	0.5.	0.3.2.	0.2.3.	0.0.1.	3.4.1.	0.2.2.	4.6.4.
Prac./field work	3.6.11.	1.1.	1.2.2.	0.0.2.	4.4.6.	5.6.4.	1.3.4.	2.10.7.
Simul./games	0.0.0.	0.1.	0.0.1.	0.0.0.	0.0.1.	0.0.0.	0.0.0.	1.0.0.
On job instruc.	1.8.5.	2.3.	0.1.2.	0.1.2.	3.8.4.	1.7.6.	1.7.6.	7.4.11.
Prac. job experience	8.8.21.	2.7.	1.0.3.	0.1.5.	7.5.8.	3.4.14.	5.2.6.	8.6.10.
n =	106	37	14	18	35	40	28	53

TABLE A.8.1.10.

WAYS OF ACQUIRING KNOWLEDGE FOR PERFORMANCE OF TASK

(3 IN ORDER OF PRIORITY)

MANUAL SKILLS

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
Way of Acquiring Knowledge	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificate	No qualification
No answer	15.25.33.	11.14.	2.3.3.	3.3.3.	9.12.14.	16.17.19	5.7.8.	13.18.24.
Live lecture	14.2.5.	6.2.	1.1.0.	8.1.0.	5.3.3.	8.0.1.	7.1.0.	6.5.2.
Tutorial	8.6.2.	3.1.	0.0.0.	1.2.1.	1.1.1.	1.2.0.	3.2.1.	4.2.0.
Aud/visual	2.5.0.	2.0.	1.0.0.	1.0.0.	1.0.1.	1.1.1.	1.1.1.	1.0.1.
Ind. project	3.2.6.	0.0.	1.1.0.	0.1.0.	0.2.1.	0.1.0.	0.2.3.	1.3.0.
Group project	0.2.9.	0.0.	1.1.1.	0.0.1.	0.1.0.	0.1.0.	0.0.2.	1.0.1.
Demonstration	20.17.8.	3.7.	3.1.1.	1.5.2.	0.0.2.	2.1.2.	1.1.1.	5.3.3.
Pract/field	25.17.12.	5.4.	4.2.1.	1.0.6.	2.4.5.	4.9.3.	4.5.1.	5.5.6.
Simul./games	0.0.0.	0.0.	0.0.0.	0.0.0.	0.0.0.	0.0.0.	0.0.0.	0.0.0.
On job instruc	6.12.11.	4.5.	0.4.2.	1.3.1.	4.6.5.	5.6.4.	0.9.5.	4.10.6.
Pract. job ex.	13.18.20.	3.4.	1.1.6.	2.3.4.	13.6.3.	3.2.10.	7.0.6.	13.7.10.
n =	106	37	14	18	35	40	28	53

TABLE A.8.1.11.

ECONOMIC/FINANCIAL MATTERS

(3 CHOICES IN ORDER OF PRIORITY)

Way of Acquiring Knowledge	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
No answer	66.25.33.	11.15.	1.2.2.	2.2.4.	22.23.23.	18.19.22	7.10.11	29.32.37
Live lecture	41.5.6.	12.3.	6.0.1.	12.0.1.	7.1.1.	10.0.2.	10.0.0.	10.2.1.
Tutorial	10.20.6.	4.3.	0.2.0.	3.8.0.	0.2.2.	1.5.0.	3.5.1.	4.5.0.
Aud/visual	0.2.3.	0.0.	1.0.0.	0.1.0.	0.1.1.	0.2.0.	0.1.0.	0.0.0.
Ind. project	4.8.9.	3.1.	1.2.0.	0.2.2.	2.1.0.	1.3.3.	1.2.2.	2.3.0.
Group project	3.6.5.	1.2.	1.1.0.	0.0.1.	1.1.1.	1.0.2.	0.1.1.	0.2.0.
Demonstration	1.0.2.	0.2.	0.0.0.	0.0.0.	0.1.0.	0.1.0.	0.1.0.	0.1.0.
Prac/field wk.	0.4.7.	0.2.	0.1.3.	0.0.0.	0.3.2.	3.2.1.	1.1.3.	1.0.3.
Simul. games	2.5.5.	1.1.	1.0.1.	0.0.2.	0.0.0.	0.2.1.	0.1.0.	1.0.0.
On job instruc	13.17.4.	1.7.	2.5.2.	0.3.1.	3.1.2.	2.4.7.	2.3.5.	2.4.4.
Pract. job. ex	15.14.26.	4.1.	1.1.5.	1.2.7.	0.1.3.	4.2.2.	4.3.5.	4.4.8.
n =	106	37	14	18	35	40	28	53

TABLE A.8.1.12.

COMMUNICATION MATTERS

(3 CHOICES IN ORDER OF PRIORITY)

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
Way of Acquiring Knowledge	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
No answer	16.29.48.	10.14.	1.2.2.	3.3.6.	15.19.23.	13.15.17	5.7.11	24.30.37
Live lecture	17.4.6.	12.1.	4.0.0.	8.1.2.	3.2.2.	14.0.1.	14.1.0.	6.1.2.
Tutorial	10.6.3.	3.2.	1.1.0.	1.2.1.	3.2.1.	2.3.0.	3.2.3.	6.0.0.
Aud./visual	3.8.2.	3.1.	0.1.1.	0.2.0.	1.2.1.	1.2.0.	2.1.1.	1.2.0.
Ind. project	3.6.3.	0.2.	0.1.1.	0.0.1.	2.3.0.	0.1.3.	0.3.1.	0.2.0.
Group project	5.4.10.	3.1.	1.2.1.	1.1.0.	0.1.0.	2.2.0.	1.2.1.	1.1.0.
Demonstration	2.0.3.	0.2.	0.0.1.	0.0.0.	0.0.0.	0.2.0.	0.1.0.	0.2.1.
Pract/field wk	3.9.4.	0.1.	1.2.3.	0.1.0.	0.0.2.	2.7.1.	0.1.1.	2.1.2.
[illegible] games	3.5.1.	1.1.	1.0.1.	0.1.1.	0.0.2.	0.2.2.	0.0.0.	0.0.0.
[illegible]b instr.	12.19.6.	1.8.	3.2.1.	1.4.1.	4.2.1.	3.3.5.	0.4.1.	3.7.4.

No answer	66.25.33.	11.15.	1.2.2.	2.2.4.	22.23.23.	18.19.22	7.10.11	29.32.37
Live lecture	41.5.6.	12.3.	6.0.1.	12.0.1.	7.1.1.	10.0.2.	10.0.0.	10.2.1.
Tutorial	10.20.6.	4.3.	0.2.0.	3.8.0.	0.2.2.	1.5.0.	3.5.1.	4.5.0.
Aud/visual	0.2.3.	0.0.	1.0.0.	0.1.0.	0.1.1.	0.2.0.	0.1.0.	0.0.0.
Ind. project	4.8.9.	3.1.	1.2.0.	0.2.2.	2.1.0.	1.3.3.	1.2.2.	2.3.0.
Group project	3.6.5.	1.2.	1.1.0.	0.0.1.	1.1.1.	1.0.2.	0.1.1.	0.2.0.
Demonstration	1.0.2.	0.2.	0.0.0.	0.0.0.	0.1.0.	0.1.0.	0.1.0.	0.1.0.
Prac/field wk.	0.4.7.	0.2.	0.1.3.	0.0.0.	0.3.2.	3.2.1.	1.1.3.	1.0.3.
Simul. games	2.5.5.	1.1.	1.0.1.	0.0.2.	0.0.0.	0.2.1.	0.1.0.	1.0.0.
On job instruc	13.17.4.	1.7.	2.5.2.	0.3.1.	3.1.2.	2.4.7.	2.3.5.	2.4.4.
Pract. job. ex	15.14.26.	4.1.	1.1.5.	1.2.7.	0.1.3.	4.2.2.	4.3.5.	4.4.8.
n =	106	37	14	18	35	40	28	53

TABLE A.8.1.12.

COMMUNICATION MATTERS

(3 CHOICES IN ORDER OF PRIORITY)

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
Way of Acquiring Knowledge	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
No answer	16.29.48.	10.14.	1.2.2.	3.3.6.	15.19.23.	13.15.17	5.7.11	24.30.37
Live lecture	17.4.6.	12.1.	4.0.0.	8.1.2.	3.2.2.	14.0.1.	14.1.0.	6.1.2.
Tutorial	10.6.3.	3.2.	1.1.0.	1.2.1.	3.2.1.	2.3.0.	3.2.3.	6.0.0.
Aud./visual	3.8.2.	3.1.	0.1.1.	0.2.0.	1.2.1.	1.2.0.	2.1.1.	1.2.0.
Ind. project	3.6.3.	0.2.	0.1.1.	0.0.1.	2.3.0.	0.1.3.	0.3.1.	0.2.0.
Group project	5.4.10.	3.1.	1.2.1.	1.1.0.	0.1.0.	2.2.0.	1.2.1.	1.1.0.
Demonstration	2.0.3.	0.2.	0.0.1.	0.0.0.	0.0.0.	0.2.0.	0.1.0.	0.2.1.
Pract/field wk	3.9.4.	0.1.	1.2.3.	0.1.0.	0.0.2.	2.7.1.	0.1.1.	2.1.2.
Simul. games	3.5.1.	1.1.	1.0.1.	0.1.1.	0.0.2.	0.2.2.	0.0.0.	0.0.0.
On job instr.	12.19.6.	1.8.	3.2.1.	1.4.1.	4.2.1.	3.3.5.	0.4.1.	3.7.4.
Prac. job. ex.	32.16.20.	4.4.	2.3.3.	4.3.6.	7.4.3.	3.3.11.	3.6.9.	10.7.7.
n =	106	37	14	18	35	40	28	53

TABLE A.8.1.13.

MANAGEMENT/PERSONNEL MATTERS

(3 CHOICES IN ORDER OF PRIORITY)

Way of Acquiring Knowledge	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
No answer	20.30.43.	13.15.	1.2.2.	3.3.4.	17.19.22.	15.15.16	10.12.14	26.33.40
Live lecture	21.9.4.	9.0.	5.0.0.	8.2.2.	7.1.1.	14.0.1.	11.0.0.	10.3.1.
Tutorial	10.5.4.	4.2.	0.0.0.	1.2.2.	1.3.1.	3.4.0.	2.3.3.	4.0.0.
Aud/visual	3.2.2.	0.2.	0.0.0.	0.1.0.	0.3.1.	0.1.0.	0.1.1.	0.2.0.
Ind. project	0.6.3.	2.1.	0.2.0.	0.0.0.	2.0.0.	0.1.4.	0.2.1.	1.1.0.
Group project	4.5.11.	2.1.	1.3.0.	0.1.0.	0.1.1.	1.3.1.	2.3.1.	0.2.0.
Demonstration	0.0.1.	0.1.	0.0.1.	0.0.0.	0.0.0.	0.1.0.	0.1.0.	0.1.0.
Prac/field wk.	4.6.7.	2.1.	0.1.5.	1.2.0.	2.1.2.	3.4.1.	0.1.1.	0.2.2.
Simul. games	6.8.7.	0.2.	3.0.1.	1.0.2.	0.1.1.	0.4.4.	1.0.0.	1.1.0.
On job instr.	9.15.6.	2.6.	2.4.1.	1.3.1.	1.3.3.	1.5.4.	0.2.1.	2.2.4.
Pract. job. ex.	29.20.18.	3.6.	2.2.4.	3.4.7.	5.3.3.	3.2.9.	2.3.9.	9.6.6.
n =	106	37	14	18	35	40	28	53

The last question, No. 7 in this section attempted to deal with generality versus specificity in the tertiary training of respondents. It read:

7) "How do you view your post-secondary/tertiary training? Please indicate by ringing one of the numbers on each of the following 5-point scales.

a) 1 — 2 — 3 — 4 — 5

too few general principles of civ.eng. (1) — about right (3) — too many general principles of civ.eng. (5)

b) 1 — 2 — 3 — 4 — 5

too little detailed factual subject content re civ.eng. (1) — about right (3) — too much detailed factual subject content re civ.eng. (5)

c) 1 — 2 — 3 — 4 — 5

too little "general engineering education" (1) — about right (3) — too much "general engineering education" (5)

These results are given in Table A.8.14.

TABLE A.8.14.

Question		QUALIFICATION CATEGORY															
		1		2		3		4		5		6		7		8	
		B. Eng. etc.		Diploma		Local Government certificate		Degree/ Diploma - other		Structural/ Draft certificate		Eng. survey certificate		Other certificates		No qualification	
7a) Answer	0		3%		3%		0%		6%		9%		13%		0%		28%
	1	8	8	2	5	0	0	1	6	6	17	6	15	7	25	11	21
	2	23	22	7	19	6	43	6	33	14	40	6	15	6	21	9	17
	3	64	60	25	68	7	50	8	44	8	23	18	45	12	43	11	21
	4	8	8	2	5	1	7	2	11	3	9	3	8	3	11	7	13
	5	0	0	0	0	0	0	0	0	1	3	2	5	0	0	0	0
7b) Answer	0		4		0		0		6		9		13		0		28
	1	15	14	5	14	0	0	2	6	8	23	7	18	6	25	11	21
	2	27	26	6	16	9	64	6	33	7	20	9	23	9	21	12	17
	3	38	36	22	60	3	21	5	28	16	46	15	38	9	43	11	21
	4	18	17	3	8	2	14	4	22	1	3	1	3	2	11	4	13
	5	4	4	1	2	0	0	0	0	0	0	2	5	1	0	0	0
7c) Answer	0		6		0		0		6		6		10		4		28
	1	11	10	9	24	2	14	2	11	10	29	7	18	11	39	10	19
	2	40	38	8	22	8	57	4	22	10	29	12	30	9	32	12	23
	3	33	31	16	43	4	29	9	50	9	26	15	38	5	18	9	17
	4	14	13	2	5	0	0	1	6	3	9	1	3	2	7	4	8
	5	21	2	2	5	0	0	1	6	1	3	1	3	0	0	3	6
n =		106		37		14		18		35		40		28		53	

Page 11 of the questionnaire contained a number of open-ended questions mainly concerned with deficiencies in training. In the next few pages of this appendix these questions are dealt with in turn, by first repeating the questions and then giving the data gathered from the replies.

Questions 1 and 2 were related and were:

1) "Did you enjoy your post-secondary/tertiary education program overall? Yes or No. If not, why?"

2) "What did you like most about your post secondary/tertiary education program?"

The data have been combined in table A.8.15. The reasons for "not liking", and the aspects of tertiary training "most liked" were numerous, but they grouped together fairly readily into the types of answer shown in the table. Some of these could be further grouped together without difficulty but they have been left as they were originally in the editing of the replies.

Question		B. Eng. etc.		Diploma		Local Governmen certificat		Degree/ Diploma other		Structural Draft certificat		Eng. surve certificat		Other certificat		No qualific- ation	
7a) Answer	0		3%		3%		0%		6%		9%		13%		0%		28%
	1	8	8	2	5	0	0	1	6	6	17	6	15	7	25	11	21
	2	23	22	7	19	6	43	6	33	14	40	6	15	6	21	9	17
	3	64	60	25	68	7	50	8	44	8	23	18	45	12	43	11	21
	4	8	8	2	5	1	7	2	11	3	9	3	8	3	11	7	13
	5	0	0	0	0	0	0	0	0	1	3	2	5	0	0	0	0
7b) Answer	0		4		0		0		6		9		13		0		28
	1	15	14	5	14	0	0	2	6	8	23	7	18	6	25	11	21
	2	27	26	6	16	9	64	6	33	7	20	9	23	9	21	12	17
	3	38	36	22	60	3	21	5	28	16	46	15	38	9	43	11	21
	4	18	17	3	8	2	14	4	22	1	3	1	3	2	11	4	13
	5	4	4	1	2	0	0	0	0	0	0	2	5	1	0	0	0
7c) Answer	0		6		0		0		6		6		10		4		28
	1	11	10	9	24	2	14	2	11	10	29	7	18	11	39	10	19
	2	40	38	8	22	8	57	4	22	10	29	12	30	9	32	12	23
	3	33	31	16	43	4	29	9	50	9	26	15	38	5	18	9	17
	4	14	13	2	5	0	0	1	6	3	9	1	3	2	7	4	8
	5	21	2	2	5	0	0	1	6	1	3	1	3	0	0	3	6
n =		106		37		14		18		35		40		28		53	

Page 11 of the questionnaire contained a number of open-ended questions mainly concerned with deficiencies in training. In the next few pages of this appendix these questions are dealt with in turn, by first repeating the questions and then giving the data gathered from the replies.

Questions 1 and 2 were related and were:

1) "Did you enjoy your post-secondary/tertiary education program overall? Yes or No. If not, why?"

2) "What did you like most about your post secondary/tertiary education program?"

The data have been combined in table A.8.15. The reasons for "not liking", and the aspects of tertiary training "most liked" were numerous, but they grouped together fairly readily into the types of answer shown in the table. Some of these could be further grouped together without difficulty but they have been left as they were originally in the editing of the replies.

[illegible] REASONS FOR NOT LIKING, AND FOR LIKING
TERTIARY EDUCATION PROGRAM OVERALL

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
Did you enjoy your tertiary education programe overall. — Yes	69%	79%	72%	61%	57%	75%	64%	38%
Yes/No	4	0	0	0	0	3	0	0
No	20	16	14	28	29	13	36	26
No Answer	7	5	14	11	11	10	0	36
Reasons for not liking								
uninteresting — content	3%	22%	0%	38%	25%	29%	17%	22%
uninteresting — presentation	14	0	0	12	20	0	11	16
personal conditions	23	33	100	12	25	14	38	16
institution facilities	3	0	0	0	12	0	0	6
pressure	9	22	0	0	0	0	0	0
difficulties of course	3	22	0	12	12	14	0	0
disjointed, no integration	9	0	0	0	0	0	11	12
course structure	31	0	0	26	0	29	17	16
inadequate teaching methods	6	0	0	0	6	14	6	12
number of subjects	25	7	2	4	10	5	10	9
number of responses	35	9	1	8	16	7	18	18
Most liked aspects								
theoretical content	11%	15%	22%	13%	25%	9%	6%	16%
practical work "	21	31	22	18	38	23	9	29
presentation	2	8	0	6	2	9	13	4
course structure	12	10	0	13	7	16	22	16
advance of knowledge	16	15	11	13	20	16	22	10
sense of achievement	6	3	11	6	0	9	9	0
way of life	11	5	22	0	2	0	6	4
freedom of thought	8	0	11	13	0	0	0	0
application to job	10	13	0	18	0	9	13	16
nothing	2	0	0	0	6	9	0	4
number of subjects	89	32	8	11	32	28	25	23
number of responses	105	39	9	16	38	32	31	31

Questions 3, 4, 5 and 6 were related and were:

3) "With relation to the problems you meet and the types of work you have to do today, have any major deficiencies in your post-secondary/tertiary training become apparent? If so, what are they?"

"What topics of value in carrying out your work were omitted from your post-secondary/tertiary training?"

	B. Eng. etc.	Diploma	Local Governm certifi	Degree/ Diploma other	Structu Draft certifi	Eng. sub certifi	Other certifi	No qualifi
Did you enjoy your tertiary education programe overall. — Yes	69%	79%	72%	61%	57%	75%	64%	38%
Yes/No	4	0	0	0	0	3	0	0
No	20	16	14	28	29	13	36	26
No Answer	7	5	14	11	11	10	0	36
Reasons for not liking								
uninteresting — content	3%	22%	0%	38%	25%	29%	17%	22%
uninteresting — presentation	14	0	0	12	20	0	11	16
personal conditions	23	33	100	12	25	14	38	16
institution facilities	3	0	0	0	12	0	0	6
pressure	9	22	0	0	0	0	0	0
difficulties of course	3	22	0	12	12	14	0	0
disjointed, no integration	9	0	0	0	0	0	11	12
course structure	31	0	0	26	0	29	17	16
inadequate teaching methods	6	0	0	0	6	14	6	12
number of subjects	25	7	2	4	10	5	10	9
number of responses	35	9	1	8	16	7	18	18
Most liked aspects								
theoretical content	11%	15%	22%	13%	25%	9%	6%	16%
practical work "	21	31	22	18	38	23	9	29
presentation	2	8	0	6	2	9	13	4
course structure	12	10	0	13	7	16	22	16
advance of knowledge	16	15	11	13	20	16	22	10
sense of achievement	6	3	11	6	0	9	9	0
way of life	11	5	22	0	2	0	6	4
freedom of thought	8	0	11	13	0	0	0	0
application to job	10	13	0	18	0	9	13	16
nothing	2	0	0	0	6	9	0	4
number of subjects	89	32	8	11	32	28	25	23
number of responses	105	39	9	16	38	32	31	31

Questions 3, 4, 5 and 6 were related and were:

3) "With relation to the problems you meet and the types of work you have to do today, have any major deficiencies in your post-secondary/tertiary training become apparent? If so, what are they?"

4) "What topics of value in carrying out your work were omitted from your post-secondary/tertiary training?"

5) "With relation to your work as it affects the community generally, what topics do you think you should have stuided, or skills you should have acquired?"

6) "What topics or skills have you had to acquire without formal courses?"

In view of the wide spread of answers to questions 3, 4, 5 and 6, and in view of the similar nature of the four questions, they were all concerned with deficiencies in training, it was decided to examine the answers to the four questions together. Whilst this did not reduce the spread of answers it did facilitate the study of the data. Not unexpectedly, a small number of the answers occurred repeatedly. In some cases it was possible to group answers and so reduce the list to a few pre-dominant items.

These pre-dominant items are listed in table A.8.16., approximately in rank order, for each of the qualification categories. It is surprising that just slightly less than one thousand responses over these four questions reduced to seven pre-dominant items. The table contains thirteen items in order to show how the list tails off.

TABLE A.8.16.

DEFICIENCIES IN TRAINING

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
n =	106	37	14	18	35	40	28	53
Total no. of responses	383	121	57	73	66	88	97	111
from no. of subjects	99	35	12	12	27	25	24	41
Ratio responses:subjects	3.9	3.5	4.8	6.1	2.4	3.5	4.0	2.7
Management/personnel								
No. of items grouped	7	3	3	1	7	3	7	4
All responses in group	78	26	11	10	12	11	20	9
Ratio responses:subjects	7.8	7.4	9.2	8.3	4.4	5.5	8.3	2.2
Economic/financial								
No. of items grouped	6	5	3	2	-	3	2	4
All responses in group	69	19	9	9	-	11	7	5
Ratio responses:subjects	6.9	5.4	7.5	7.5	-	5.5	3.1	1.2
Communication								
No. of items grouped	7	5	3	2	-	-	5	5
All responses in group	46	8	9	4	-	-	9	6
Ratio responses:subjects	4.6	2.3	7.5	3.3	-	-	3.8	1.5
Lack of practical work								
All responses	23	8	-	6	3	5	-	5
Responses:subjects	2.3	2.3	-	5.0	1.1	2.0	-	1.2
Public relations								
All responses	18	11	4	-	4	5	7	5
Responses:subjects	1.8	3.1	3.3	-	1.5	2.0	3.1	1.2
Computers								
All responses	13	6	-	4	-	5	-	-
Responses:subjects	1.3	1.7	-	3.3	-	2.0	-	-
Environment ideas								
All responses	13	-	3	4	-	-	5	-
Responses:subjects	1.3	-	2.5	3.3	-	-	2.1	-
Design - general								
All responses	-	-	-	4	6	5	5	8
Responses:subjects	-	-	-	3.3	2.2	2.0	2.1	2.0
Construction - general								
All responses	-	-	5	-	3	-	-	5
Responses:subjects	-	-	4.2	-	1.1	-	-	1.2

TABLE A.8.16. (Cont.)

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
n =	106	37	14	18	35	40	28	53
Lack of specialisation								
All responses	-	-	3	-	-	9	-	-
Responses:subjects	-	-	2.5	-	-	4.5	-	-
Drawing and drafting								
All responses	-	-	-	-	7	-	-	-
Responses:subjects	-	-	-	-	2.6	-	-	-
Basic knowledge only								
All responses	-	-	-	-	3	6	-	-
Responses:subjects	-	-	-	-	1.1	3.0	-	-
Everything								
All responses	-	-	-	-	-	-	-	9
Responses:subjects	-	-	-	-	-	-	-	2.2

Question 7 asked -

"What are the criteria of success in your job as you see them?"

In the first place answers were examined according to qualification categories, and frequencies for the various types of answer are given below.

TABLE A.8.17 — CRITERIA OF SUCCESS (Frequency of Answers)

	QUALIFICATION CATEGORY								
	1	2	3	4	5	6	7	8	
	B.Eng. etc.	Diploma	Local Government certificate	Degree/Diploma - other	Structural/Draft certificate	Eng. survey certificate	Other certificates	No qualification	Totals
n =	106	37	14	18	35	40	28	53	
No. of responses	194	52	26	30	49	40	49	74	514
Honesty/integrity	1	1	2	0	1	0	2	2	9
Initiative/drive	7	2	0	2	0	1	3	5	20
Personal relationships/diplomacy	21	2	1	0	0	0	5	1	30
Reliability	2	0	0	0	0	0	2	2	6
Commonsense	5	2	1	0	2	0	3	3	16
Opportunities	1	0	0	0	0	0	0	0	1
Selling the client	5	1	0	1	0	0	0	0	7
Minimum complaints	1	1	0	1	0	1	2	0	6
Seniority	4	0	0	0	3	5	1	3	16
Conformity/submission to authority	2	2	0	1	1	0	0	1	7
Public relations	3	3	4	4	2	1	2	3	22
Flexibility	1	2	1	0	0	2	0	3	9
Responsibility	7	0	0	1	0	0	0	0	8
Leadership	1	0	0	1	0	0	0	2	4
Efficiency/competency-technical	34	8	4	5	15	7	7	15	95
Efficiency/competency - speed	12	2	1	0	6	3	4	8	36
Efficiency/competency - financial	12	3	1	3	0	2	2	3	26
Dedication/hard work	1	4	2	0	2	2	2	3	16
Experience	4	2	0	1	4	3	2	3	19
Original thought/creativity	6	0	0	0	1	0	0	1	8
Good management	14	5	4	1	1	1	0	2	28
Knowledge/qualifications	15	5	3	2	7	6	5	9	52
Decision making	7	2	0	0	1	2	5	1	18
Communication	6	0	2	1	2	3	0	0	14
Creation of work/productivity	22	5	0	6	1	1	2	4	41

TABLE A.8.17

CRITERIA OF SUCCESS
(Frequency of Answers)

	QUALIFICATION CATEGORY								
	1	2	3	4	5	6	7	8	
	B.Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification	Totals
n =	106	37	14	18	35	40	28	53	
No. of responses	194	52	26	30	49	40	49	74	514
Honesty/integrity	1	1	2	0	1	0	2	2	9
Initiative/drive	7	2	0	2	0	1	3	5	20
Personal relationships/ diplomacy	21	2	1	0	0	0	5	1	30
Reliability	2	0	0	0	0	0	2	2	6
Commonsense	5	2	1	0	2	0	3	3	16
Opportunities	1	0	0	0	0	0	0	0	1
Selling the client	5	1	0	1	0	0	0	0	7
Minimum complaints	1	1	0	1	0	1	2	0	6
Seniority	4	0	0	0	3	5	1	3	16
Conformity/submission to authority	2	2	0	1	1	0	0	1	7
Public relations	3	3	4	4	2	1	2	3	22
Flexibility	1	2	1	0	0	2	0	3	9
Responsibility	7	0	0	1	0	0	0	0	8
Leadership	1	0	0	1	0	0	0	2	4
Efficiency/competency-technical	34	8	4	5	15	7	7	15	95
Efficiency/competency - speed	12	2	1	0	6	3	4	8	36
Efficiency/competency - financial	12	3	1	3	0	2	2	3	26
Dedication/hard work	1	4	2	0	2	2	2	3	16
Experience	4	2	0	1	4	3	2	3	19
Original thought/ creativity	6	0	0	0	1	0	0	1	8
Good management	14	5	4	1	1	1	0	2	28
Knowledge/qualifications	15	5	3	2	7	6	5	9	52
Decision making	7	2	0	0	1	2	5	1	18
Communication	6	0	2	1	2	3	0	0	14
Completion of work/ productivity	22	5	0	6	1	1	2	4	41

Answers were next examined according to level of employment and type of work. Frequencies for the various types of answer follow:

TABLE A.8. 18. CRITERIA OF SUCCESS (Frequency of Answer)

	LEVEL OF EMPLOYMENT & TYPE OF WORK						
	Engineers - design	Engineers - construction	Engineers - other work	Technicians - design	Technicians - construction	Technicians - other work	Totals
n =	60	91	49	98	16	15	329
No. of responses	110	156	68	132	18	22	506
Honesty/integrity	1	3	0	3	0	2	9
Initiative/drive	2	4	3	4	2	2	17
Personal relationships/ diplomacy	11	11	5	1	0	1	29
Reliability	2	2	0	3	0	1	8
Commonsense	6	3	0	2	1	0	12
Opportunities	1	0	0	1	0	0	2
Selling the client	3	3	2	0	0	0	8
Minimum complaints	1	2	0	11	1	1	16
Seniority	2	0	0	2	1	1	6
Conformity/submission to authority	0	3	1	2	0	0	6
Public relations	5	7	3	3	0	2	20
Flexibility	1	2	1	4	0	1	9
Responsibility	4	3	1	0	0	0	8
Leadership	0	0	1	1	1	1	4
Efficiency/competency - technical	23	21	16	29	2	2	93
Efficiency/competency - speed	1	13	5	16	1	0	36
Efficiency/competency - financial	3	16	0	3	1	0	23
Dedication/hard work	1	8	2	6	1	1	19
Experience	5	5	0	6	2	1	19
Original thought/ creativity	3	1	2	2	0	0	8
Good management	5	14	5	2	0	2	28
Knowledge/qualifications	13	10	7	17	2	3	52
Decision making	4	6	4	4	1	0	19
Communication	4	1	4	4	0	1	14
Completion of work/ productivity	9	18	[illegible]	6	2	0	41

Answers to the question dealing with "criteria of success" were next examined according to level of employment and age of respondent. Frequencies for the various types of answer are given in the following Table A.8.19.

TABLE A.8. 19. CRITERIA OF SUCCESS
(Frequency of Answer)

	LEVEL OF EMPLOYMENT AND AGE						
	Engineers 20-30 years	Engineers 31-40 years	Engineers >40 years	Technicians 20-30 years	Technicians 31-40 years	Technicians >40 years	Totals
n =	83	61	57	87	24	19	331
No. of responses	137	99	102	115	35	22	510
Honesty/integrity	1	1	2	3	0	0	7
Initiative/drive	5	3	1	3	3	3	18
Personal relationships/ diplomacy	11	7	9	0	1	1	29
Reliability	2	0	2	2	0	0	6
Commonsense	2	3	5	4	0	2	16
Opportunities	0	1	0	0	0	0	1
Selling the client	3	4	1	1	0	0	9
Minimum complaints	2	0	1	2	1	0	6
Seniority	2	0	1	9	1	2	15
Conformity/submission to authority	0	2	2	2	0	0	6
Public relations	6	5	4	4	2	1	22
Flexibility	0	6	1	3	0	2	12
Responsibility	5	2	1	0	0	0	8
Leadership	1	0	0	2	0	1	4
Efficiency/competency - technical	26	17	18	27	5	1	94
Efficiency/competency - speed	9	5	5	13	3	1	36
Efficiency/competency - financial	11	4	5	2	2	0	24
Dedication/hard work	2	1	5	4	2	2	16
Experience	3	2	5	7	1	1	19
Original thought/ creativity	5	1	0	2	0	0	8
Good management	10	7	7	3	0	1	28
Knowledge/qualifications	8	9	13	16	3	3	52
Decision making	8	4	2	2	3	0	19
Communication	2	2	5	4	1	0	14
Completion of work/ productivity	13	13	7	0	5	3	41

Finally, answers relating to "criteria of success" were examined according to level of employment and the type of employer. Frequencies are given in Table A.8.20.

TABLE A.8.20. CRITERIA OF SUCCESS
(Frequency of Answer)

	LEVEL OF EMPLOYMENT AND TYPE OF EMPLOYER								
	Engineers C'wlth/State Government	Engineers Local Govt.	Engineers Consultants	Engineers Contractors	Technicians C'wlth/State Government	Technicians Local Govt.	Technicians Consultants	Technicians Contractors	Totals
n =	73	57	35	32	58	23	38	6	327
No. of responses	120	96	62	53	71	35	57	8	502
Honesty/integrity	0	1	0	3	0	1	0	1	6
Initiative/drive	2	2	1	4	5	2	1	1	18
Personal relationships/ diplomacy	11	6	5	5	2	0	0	0	29
Reliability	1	1	0	2	0	1	1	0	6
Commonsense	1	5	3	1	3	1	2	0	16
Opportunities	0	0	1	0	0	0	0	0	1
Selling the client	0	1	4	2	1	0	0	0	8
Minimum complaints	1	2	0	0	2	1	0	0	6
Seniority	1	0	2	0	11	1	0	0	15
Conformity/submission to authority	1	2	0	1	2	0	0	0	6
Public relations	4	7	3	1	3	2	2	0	22
Flexibility	0	4	0	0	2	1	2	0	9
Responsibility	4	2	1	1	0	0	0	0	8
Leadership	1	0	0	0	2	1	0	0	4
Efficiency/competency - technical	27	14	15	5	11	5	17	0	94
Efficiency/competency - speed	9	4	4	1	2	2	12	1	35
Efficiency/competency - financial	9	6	2	5	1	2	0	1	26
Dedication/hard work	2	2	1	3	2	2	4	0	16
Experience	2	4	2	1	3	2	3	1	18
Original thought/ creativity	3	2	0	1	1	0	1	0	8
Good management	10	9	2	3	2	1	1	0	28
Knowledge/qualifications	11	6	7	5	8	6	7	1	51
Decision making	5	6	1	2	1	1	2	1	19
Communication	3	4	1	1	4	1	0	0	14
Completion of work/ productivity	12	6	7	6	3	2	2	1	39

Question 8 read as follows:

"For what and at what level do you think your post-secondary/ tertiary training most fitted you?"

Three sorts of answers were received, one dealing with type of employer, the second with type of work and the third with level in an organisation. The range within each type was limited, and the frequencies for all answers are given in the following Table A.8.21.

TABLE A.8.21

WHAT RESPONDENTS' TRAINING FITTED THEM FOR

(IN THEIR OPINION)

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
TYPE OF EMPLOYER								
Government Department	3	2	0	1	2	1	1	1
Local Government	2	2	6	1	0	2	5	1
Industry (general)	0	0	0	0	0	0	0	0
Private practice	3	1	1	0	0	0	0	0
Academic	1	0	0	0	0	0	0	0
All	1	1	0	0	0	1	0	0
None	5	1	0	0	0	0	2	1
TYPE OF WORK								
Design	25	9	2	6	3	0	3	6
Structure	8	2	1	1	3	0	2	
Research/Teaching	3	0	1			0	0	1
Sales	1	0				0	0	
Specialised - other	5	2		1		1	2	2
Drafting	0	0			14	7	1	12
Surveying	0	1			1	5	2	2
General background engineering	20	9	2	3	2	3	7	1
Inspector	0	0				0	1	
LEVEL								
Professional assistant management	3	1	1	2		3	1	2
Professional junior management	22	3		3		1	0	1
Senior technician	1	2			2	4	7	4
Assistant technician	0	1			4	1	3	1
Junior technician	1	0			1	1	2	1
Supervisory level	2	0		1	1	1	4	2
Professional senior management	10	9	2	1		0	2	

Question 9 was:

"Did your post-secondary/tertiary training develop skills in technical decision making, or value judgements? If so, which parts of your training were most effective?"

and the data are given in the following table:

TABLE A.8.22

TECHNICAL DECISION MAKING

(frequencies)

		QUALIFICATION CATEGORY							
		1	2	3	4	5	6	7	8
		B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
Did education help develop technical decision making skill	No Ans.	17	7	2	6	7	17	11	32
	Yes	51	17	6	5	14	14	5	1
	No	38	13	6	7	14	9	12	3
If yes - what?									
Design of structures		14	7	0	2	7	2	5	7
Lab/practical work		6	2	0	0	1	5	1	3
Group projects		5	0	0	0	0	1	0	0
Maths		4	1	1	0	0	0	0	0
Tutorials		3	1	0	0	0	1	1	0
Safety factors and codes of practice		2	0	0	0	0	0	0	0
Geology		0	0	0	0	1	0	0	0

Questions 9 and 10 were concerned with creativity in a broad sense and sought to differentiate between the use of traditional methods and encouragement to develop and use a students own ideas. They were:

9) "Did your post-secondary/tertiary training encourage and assist you to -

a) develop your own ideas and use your own ideas, or

b) encourage you to use traditional methods to solve your problems? "

10) "If you find greater use for your own ideas please give examples."

The data are given in Table A.8.23. which follows.

TABLE A.8.23.

ENCOURAGEMENT TO DEVELOP OWN IDEAS

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. survey certificate	Other certificates	No qualification
n =	106	37	14	18	35	40	28	53
a = develop own ideas	17	1	1	5	6	4	2	5
b = use trad. methods	43	21	6	9	20	17	13	22
a > b	5	2	0	0	0	0	1	1
a < b	10	1	1	1	2	2	2	3
a = b	24	8	2	0	2	8	6	2
neither a nor b	2	0	1	0	1	0	0	0
If 'a' - what?								
1. Computer programme	3	0	0	0	0	1	0	0
2. New theories	1	1	0	0	0	0	1	2
3. Management techniq.	4	0	2	1	0	1	0	2
4. New methods	14	4	1	2	5	2	3	1
5. Practical projects	2	2	0	0	1	0	1	2
6. Feasibility studies	3	0	0	0	1	0	0	0
7. None	5	1	0	1	0	0	2	2

1.8. P 24.

Question 11, the final question, was based on the idea that people engaged in civil engineering would probably have views on the trend of development in the industry. If there were a concensus of opinion this could be of value to those concerned with designing curricula for the future.

The question read:

> "Looking ahead to 1980 what do you think will be the major differences in civil engineering, and what new approaches or subjects should civil engineers of all grades be taught today to better fit them for work in 1980?"

In the first instance answers were examined according to the qualification categories used hitherto. Frequencies are given in Table A.8.24.

TABLE A.8. 24. THE FUTURE

	QUALIFICATION CATEGORY								
	1	2	3	4	5	6	7	8	
	B.Eng. etc.	Diploma	Local Government certificate	Degree/ Diploma - other	Structural/ Drafting certificate	Engineering Surveying Certificate	Other certificates	No qualification	Totals
n =	106	37	14	18	35	40	28	53	331
No. of responses	149	42	13	27	30	28	39	41	369
Improved and/or more systems	60	19	7	8	13	14	15	12	148
New materials	15	2	1	3	8	2	5	7	43
New equipment	3	1	1	1	1	3	3	8	21
More attention to economics	17	3	0	2	0	0	2	0	24
Greater social concern	25	6	1	5	3	2	7	1	50
More specialization	18	8	0	5	3	3	3	3	43
No idea	2	0	1	0	1	1	0	2	7
More general education	3	2	0	0	0	0	0	0	5
Refresher courses	1	1	0	1	0	1	0	3	7
More practical	2	0	0	2	0	1	2	5	12
No differences	3	0	2	0	1	1	2	0	9

In the second instance answers were examined according to level of employment and type of work.

TABLE A.8. 25. THE FUTURE

	LEVEL OF EMPLOYMENT AND TYPE OF WORK						
	Engineers - Design	Technicians - Design	Engineers - Construction	Technicians - Construction	Engineers - other work	Technicians - other work	
n =	60	98	91	16	49	15	329
No. of responses	83	84	120	11	58	15	371
Improved and/or more systems	36	35	44	3	23	7	148
New materials	6	15	12	1	6	3	43
New equipment	2	8	8	0	0	3	21
More attention to economics	6	0	14	0	5	0	25
Greater social concern	15	6	13	1	14	2	51
More specialization	13	7	16	1	7	0	44
No idea	1	3	1	1	1	0	7
More general education	1	0	4	0	0	0	5
Refresher courses	1	4	1	0	1	0	7
More practical	1	4	3	3	1	0	12
No differences	1	2	4	1	0	0	8

In the third instance answers were examined according to level of employment and age of respondent. Frequencies are given in Table A.8. 26.

TABLE A.8. 26. THE FUTURE

	LEVEL OF EMPLOYMENT AND AGE						
	Engineers 20-30 years	Engineers 31-40 years	Engineers > 40 years	Technicians 20-30 years	Technicians 31-40 years	Technicians > 40 years	Totals
n =	83	61	57	87	24	19	331
No. of responses	109	77	75	72	21	17	371
Improved and/or more systems	44	29	30	31	8	6	148
New materials	11	6	8	9	6	3	43
New equipment	2	3	5	5	3	3	21
More attention to economics	15	3	7	0	0	0	25
Greater social concern	16	17	9	5	2	2	51
More specialization	13	12	11	5	1	2	44
No idea	2	1	0	4	0	0	7
More general education	2	1	2	0	0	0	5
Refresher courses	0	2	0	5	0	0	7
More practical	2	1	2	5	1	1	12
No differences	2	2	2	2	0	0	8

Finally, answers relating to the "future" were examined according to level of employment and the type of employer. Frequencies for the various types of answer are given in Table A.8.27.

TABLE A.8. 27. THE FUTURE

	LEVEL OF EMPLOYMENT AND TYPE OF EMPLOYER								
	Engineers C'wlth/State Government	Engineers Local Govt.	Engineers Consultants	Engineers Contractors	Technicians C'wlth/State Government	Technicians Local Govt.	Technicians Consultants	Technicians Contractors	Totals
n =	73	57	35	32	58	28	38	6	327
No. of responses	94	70	48	43	52	27	26	5	365
Improved and/or more systems	37	27	23	15	21	10	11	3	147
New materials	8	4	5	7	9	3	7	0	43
New equipment	2	2	1	5	6	3	1	1	21
More attention to economics	11	7	1	5	0	0	0	0	24

	Engineers 20-30 years	Engineers 31-40 years	Engineers > 40 years	Technicians 20-30 years	Technicians 31-40 years	Technicians > 40 years	Totals
n =	83	61	57	87	24	19	331
No. of responses	109	77	75	72	21	17	371
Improved and/or more systems	44	29	30	31	8	6	148
New materials	11	6	8	9	6	3	43
New equipment	2	3	5	5	3	3	21
More attention to economics	15	3	7	0	0	0	25
Greater social concern	16	17	9	5	2	2	51
More specialization	13	12	11	5	1	2	44
No idea	2	1	0	4	0	0	7
More general education	2	1	2	0	0	0	5
Refresher courses	0	2	0	5	0	0	7
More practical	2	1	2	5	1	1	12
No differences	2	2	2	2	0	0	8

Finally, answers relating to the "future" were examined according to level of employment and the type of employer. Frequencies for the various types of answer are given in Table A.8.27.

TABLE A.8. 27. THE FUTURE

	LEVEL OF EMPLOYMENT AND TYPE OF EMPLOYER								
	Engineers C'wlth/State Government	Engineers Local Govt.	Engineers Consultants	Engineers Contractors	Technicians C'wlth/State Government	Technicians Local Govt.	Technicians Consultants	Technicians Contractors	Totals
n =	73	57	35	32	58	28	38	6	327
No. of responses	94	70	48	43	52	27	26	5	365
Improved and/or more systems	37	27	23	15	21	10	11	3	147
New materials	8	4	5	7	9	3	7	0	43
New equipment	2	2	1	5	6	3	1	1	21
More attention to economics	11	7	1	5	0	0	0	0	24
Greater social concern	17	10	10	4	5	2	1	1	50
More specialization	10	13	5	6	3	4	1	0	42
No idea	0	1	1	0	1	1	2	0	6
More general education	4	0	1	0	0	0	0	0	5
Refresher courses	2	0	1	1	1	1	2	0	8
More practical	1	3	0	0	3	3	1	0	11
No differences	2	3	0	0	3	0	0	0	8

TASK ANALYSIS QUESTIONNAIRE - RESPONSIBILITY RATING

Page 12 of the Task Analysis questionnaire sought information from subjects about the responsibility associated with their job, on the basis of a scheme devised for this study. The scheme divided responsibility into three, responsibility for men, responsibility for money, and responsibility for policy. Each type of responsibility was further sub-divided, each sub-division having its own scale, and each point on the scale given a score. Individual scores from each scale were summed, thus providinf a summed score for each of the separate types of responsibility. The system and its defects have been discussed in Chapter 8.1.6.

The data that follow are presented in a number of ways. Table A.9.1 shows the mean scores for men responsibility, money responsibility and policy responsibility. Also given are mean salaries for the various qualification categories. These latter have been difficult to determine because the salary ranges chosen were wide (intervals of $1000) intentionally so, and the scale terminated at a maximum ($10,000 p.a.) which was exceeded by many respondents (24 per cent of the response to this question).

To calculate a mean salary therefore, for a category is possible in some cases, but in others virtual guesses have had to be made based on a knowledge of the civil engineering industry.

TABLE A.9.1. MEAN RESPONSIBILITY SCORES AND SALARIES FOR VARIOUS CATEGORIES OF QUALIFICATION

	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B. Eng. - etc.	Diploma	Local Govt. certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. Survey certificate	Other certificates	No qualification
n =	103	36	14	15	32	26	39	53
(mean score)								
Man responsibility	28	41	47	42	6	14	14	29
Money responsibility	47	54	67	40	22	29	37	31
Policy responsibility	61	66	83	68	33	38	51	41
Salary (rounded mean)$	9,500	9700	11,000	10,700	6,700	6,700	7,800	6,200

The next table shows mean scores, as above, but according to level of employment and type of work.

The information relating to the salaries earned by respondents within qualification categories are given in Table A.9.2.

TABLE A.9. 2. SALARY DISTRIBUTION WITHIN VARIOUS CATEGORIES OF QUALIFICATION (frequencies)

Annual Salary $	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B.Eng. etc.	Diploma	Local Govt. certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. Survey certificate	Other certificates	No qualification
n =	103	36	14	15	32	26	39	53
≤ 4000	0	0	0	1	3	2	1	11
4001 - 5000	0	0	0	0	5	3	3	8
5001 - 6000	10	0	0	0	8	13	9	6
6001 - 7000	9	5	1	0	9	6	5	10
7001 - 8000	9	5	1	0	6	1	7	7
8001 - 9000	22	8	1	4	1	1	4	7
9001 -10,000	17	5	2	1	0	0	2	4
> 10,000	36	13	9	9	0	2	8	0

The next table shows mean scores for the three responsibilities according to level of employment and type of work.

TABLE A.9.3. MEAN RESPONSIBILITY SCORES FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK

	LEVEL OF EMPLOYMENT AND TYPE OF WORK					
	Engineers - design	Engineers - construction	Engineers - other work	Technicians - design	Technicians - construction	Technicians - other work
n =	60	91	50	98	17	15
(mean score)						

Annual Salary $	QUALIFICATION CATEGORY							
	1	2	3	4	5	6	7	8
	B.Eng. etc.	Diploma	Local Govt. certificate	Degree/ Diploma - other	Structural/ Draft certificate	Eng. Survey certificate	Other certificates	No qualification
n =	103	36	14	15	32	26	39	53
< 4000	0	0	0	1	3	2	1	11
4001 - 5000	0	0	0	0	5	3	3	8
5001 - 6000	10	0	0	0	8	13	9	6
6001 - 7000	9	5	1	0	9	6	5	10
7001 - 8000	9	5	1	0	6	1	7	7
8001 - 9000	22	8	1	4	1	1	4	7
9001 -10,000	17	5	2	1	0	0	2	4
> 10,000	36	13	9	9	0	2	8	0

The next table shows mean scores for the three responsibilities according to level of employment and type of work.

TABLE A.9.3. MEAN RESPONSIBILITY SCORES FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK

	LEVEL OF EMPLOYMENT AND TYPE OF WORK					
	Engineers - design	Engineers - construction	Engineers - other work	Technicians - design	Technicians - construction	Technicians - other work
n =	60	91	50	98	17	15
(mean score)						
Man responsibility	15	31	29	3	6	2
Money "	36	56	46	22	34	24
Policy "	58	62	58	32	45	40

No figures for average salaries are given above but the frequencies for each of the salary brackets are given below for engineers and technicians in various types of work.

TABLE A.9.4. SALARY DISTRIBUTION FOR ENGINEERS AND TECHNICIANS IN VARIOUS TYPES OF WORK (frequencies)

	LEVEL OF EMPLOYMENT AND TYPE OF WORK					
SALARY GRADE	Engineers - Design	Engineers - Construction	Engineers - other work	Technicians - Design	Technicians - Construction	Technicians - other work
n =	56	88	47	94	15	15
< $4000	0	0	0	15	1	2
4001 - 5000	0	0	0	14	4	1
5001 - 6000	4	6	1	25	3	4
6001 - 7000	4	8	6	20	1	5
7001 - 8000	5	9	7	11	0	3
8001 - 9000	12	22	5	6	3	0
9001 -10,000	11	11	7	1	1	0
> 10,000	20	32	21	2	2	0

The following table gives mean responsibility scores for engineers and technicians of various ages.

TABLE A.9.5. MEAN RESPONSIBILITY SCORES FOR ENGINEERS AND TECHNICIANS IN VARIOUS AGE GROUPS

	LEVEL OF EMPLOYMENT AND AGE					
	Engineers 20-30 years	Engineers 31-40 years	Engineers > 40 years	Technicians 20-30 years	Technicians 31-40 years	Technicians 40 years
n =	83	61	57	87	24	19
(mean score)						
Man responsibility	12	20	56	1	4	11
Money "	45	49	52	24	24	30
Policy "	56	63	70	30	43	43

Table A.9.6 which follows, gives the frequencies for each of the salary brackets for engineers and technicians of various ages.

TABLE A.9.6. SALARY DISTRIBUTION FOR ENGINEERS AND TECHNICIANS IN VARIOUS AGE GROUPS

SALARY GRADE	LEVEL OF EMPLOYMENT AND AGE					
	Engineers 20-30 years	Engineers 31-40 years	Engineers > 40 years	Technicians 20-30 years	Technicians 31-40 years	Technicians 40 years
n =	78	57	57	83	23	19
< $4000	0	0	0	17	0	1
4001 - 5000	0	0	0	17	1	1
5001 - 6000	11	0	1	28	3	2
6001 - 7000	14	1	3	14	8	4
7001 - 8000	11	4	6	6	5	3
8001 - 9000	23	11	5	1	2	6
9001 -10,000	13	11	5	0	1	1
> $10,000	6	30	37	0	3	1

Tables A.9. 7 and A.9.8 show the mean scores for the three types of responsibility for each of the salary ranges, for engineers and for technicians.

TABLE A.9.7. MEAN RESPONSIBILITY SCORES FOR ENGINEERS FOR EACH OF THE SALARY RANGES

Salary range	n	MEAN RESPONSIBILITY SCORE FOR		
		Men	Money	Policy
< $4000	0	0	0	0
$4001 - 5000	0	0	0	0
$5001 - 6000	12	8	41	43
$6001 - 7000	18	4	23	51
$7001 - 8000	22	27 *	48	65
$8001 - 9000	39	12	45	61
$9001 -10,000	30	20	43	67
> $10,000	86	43	60	72

* high score due to 1 abnormally high individual subject score.

TABLE A.9.8. MEAN RESPONSIBILITY SCORES FOR TECHNICANS FOR EACH OF THE SALARY RANGES

Salary range	n	MEAN RESPONSIBILITY SCORE FOR		
		Men	Money	Policy
$4000	18	0	10	24
$4001 - 5000	19	1	25	30
$5001 - 6000	33	1	24	33
$6001 - 7000	26	2	23	34
$7001 - 8000	14	7	27	47
$8001 - 9000	9	15	30	56
$9001 -10,000	2	29 *	53 *	62 *
$10,000	4	0 *	33 *	64 *

* figures unreliable because of very small n (number of subjects in group)

TABLE A.10.1.

TABLE OF CHARACTERISTICS OF SUB-PROFESSIONAL/TECHNICIAN JOBS

PART ONE

Descriptive title of position or work	Nature of work	Frequency	Responsibility	KNOWLEDGE RE[illegible] Technical					
				Structures	Materials	Water	Soils	Construction	El
Technical Officer in Govt. employment	general and broad	variable frequency	varies	no	some yes	some yes	some yes	no	
Draftsman	specialized	routine	low for men low for money & design	no	no	no	no	no	
Survey Technician	"	"	low for men low for money	no	no	no	no	no	
Materials Testing Technician	"	"	low for men low for money	no	no	no	no	no	
Construction Supervisor	fairly specialised & general	variable frequency	high for men diffuse for money	no	possibly some	possibly some	possibly some	yes	y

TABLE OF CHARACTERISTICS OF SUB-PROFESSIONAL/TECHNICIAN JOBS

PART ONE

	KNOWLEDGE REQUIRED BY													
	Technical Matters													
	Struct -ures	Mater-ials	Water	Soils	Constru -ction	Elect'l Eng.	Maths	Com-puters	Equip-ment & Plant	Survey-ing	Chemistry	Physics	Geology	[illegible]
	no	some yes	some yes	some yes	no	no	some yes	no	yes	no	School cert. level & some further engineering bias in subjects			
en oney gn	no	no	no	no	no	no	no	Tech. Draft-sman	yes	photo gram-metry	← no →			
en oney	no	no	no	no	no	no	basic & calcu -lus	some yes	no	semi tech-nical yes	← no →			
en oney	no	no	no	no	no	no	stat-istics yes	no	yes	no	← no →			
men or	no	poss-ibly some	poss-ibly some	poss-ibly some	yes	yes	no	criti-cal path print-out	yes	some yes	no	no	no	so ye

APPENDIX 10. SPECIAL GROUP MEETINGS ON JOB CHARACTERISTICS.

Two levels of skill have been under consideration throughout this project - the professional and the sub-professional /technician. The sample selected for receiving questionnaires was representative of the levels of the hierarchy existing in the civil engineering industry. The response has shown that jobs at the various levels do differ with respect to skills, knowledge, frequency of task occurrence and responsibility. However, it seemed important that we should get further opinion on how the two broad levels were thought to differ, from a panel of experts. Consequently two groups, each of six people were assembled, one group comprised mainly people connected with and authoritative about those jobs in civil engineering generally classified as technician/sub-professional, and the other group comprised of people connected with and authoritative about jobs in civil engineering generally classified as professional. Several days before each meeting the purpose of the meeting was made clear to the participants and their thoughts were directed to those aspects in which we were mainly interested, e.g. knowledge, manual skill, head skill, responsibility and frequency of task occurrence. The panel were also given the background to the project and copies of the questionnaires. At the start of the meeting, the nature of the project was again briefly summarised and the purpose of the meeting emphasized and preliminary results concerning the broad task analysis, frequency of task occurrence and responsibility in tabulated form were presented to the panel.

A.10.1. Sub-professional/technician jobs.

The range and diversity of the technician/sub-professional staff engaged in the civil engineering industry was apparent througnout the discussion. At the Technical Officer end of the stectrum were men who were claimed to be doing work of a general and broad nature similar to that usually associated with an engineer. At the other end of the spectrum for example, materials testing, the technician operating the testing equipment was performing very specialised work of limited and repetitive nature. Construction supervisors did not fit into this general spectrum, their work was characterised by a high management skills content and clearly defined areas of responsibility, e.g. high for men, but more diffuse for money and policy.

The overall results can be tabulated in the following way:-

TABLE A.10.1. (contd.)

TABLE OF CHARACTERISTICS OF SUB-PROFESSIONAL/TECHNICIAN JOBS

PART TWO

		KNOWLEDGE REQUIRED OF							
Descriptive title of position or work	Manual Skills & Frequency	Economic Matters				Manageme			
		Feasibility studies	Cost Benefit Analyses	Market Studies	Costings & Costs	Planning	Organising	Directing	Contro ing
Technical Officer in Govt.employment	Yes Regularly	← Infrequently, very important and difficult to acquire →			Frequently and difficult to acquire	Often	Often	Often	Often
Draftsman	Yes Regularly	————			"	←———— ←————			Chi Dra
Survey Technician	Yes Regularly	————			"	←————			
Material Testing Technician	Yes Regularly	————			"	←————			
Construction Supervisor	Yes Regularly	————			"	←————			

TABLE OF CHARACTERISTICS
OF
SUB-PROFESSIONAL/TECHNICIAN JOBS
PART TWO

KNOWLEDGE REQUIRED OF

...ters		Management and Personnel Matters									
...arket ...udies	Cost-ings & Costs	Plann-ing	Organ-ising	Direct-ing	Controll-ing	Co-ord-inating	Inter-viewing	Labour Relat-ions	General Person-nel	Stat-istics on Staff	Safety Matters
→	Freq-uently and diffi-cult to acquire	Often	Often	Often	Often	Often	-	Seldom	-	-	Often
	"	← Chief draftsman - yes generally → ← Draftsmen - not at all →									
	"	← No →									
	"	← No →									
	"	← Yes →									

A.10.2. Engineer jobs.

The comments made by the members of the group discussing the work of engineers were much more general in nature and at one stage of the discussion it seemed that engineers operating in the civil engineering field were generalists with the ability to exceed a technician's specialised knowledge and repetitive skill in one task to include the "breaking in", or development of new techniques or skills because of their more lengthy training and/or their innate ability. The importance of management skills was emphasised and, surprisingly, the member of the group concerned with construction activities said some project managers were not trained as "civil engineers" at all, but had acquired knowledge of and skill in using management techniques purely by experience.

11.1. BASIC DATA CONCERNING RESPONDENTS

The response to the questionnaire distributed to construction foremen was seventy four. The first page of the questionnaire sought information from each subject on where he worked, his age, qualifications, years of work in his present job etc. These group data are presented in the following tables:

TABLE A11.1. Employer distribution.

Commonwealth Govt.	5	7%
State Government	31	42
Local Government	27	36
Consultants	-	-
Contractors	11	15
General Industry	-	-
Total response ..	74	100%

TABLE A11.2.. Age Distribution.

20 - 25 years	0	0%
26 - 30 "	1	1
31 - 35 "	10	13
36 - 40 "	11	15
41 - 45 "	8	11
46 - 50 "	15	20
51 - 55 "	12	16
56 - 60 "	8	11
> 60 "	7	10
No answer	2	3
Total response	74	100%

The employment pattern is shown in the following table:

TABLE A11.3. Employment Pattern.

Years in Present Job			Years in Civil Engineering		
< 1 year	3	4%	< 1 year	0	0%
2 years	2	3	2 years	0	0
3 "	4	5	3-4 "	0	0
4 "	4	5	5-7 "	1	1
5 "	5	7	8-10 "	6	8
6-7 "	7	10	11-15 "	13	18
8-10 "	7	10	16-20 "	11	15
> 10 "	41	55	21-30 "	29	39
No answer	1	1	> 30 "	8	11
Total ..	74	100%	No answer	6	8
			Total ..	74	100%

Some questions on formal training were asked with the following results:

TABLE A11.4. Formal Training.

Type of Qualification			Method		
Foreman's certificate Overseer's " Building Foreman's "	21	29%	Full-time	12	16
			Part-time	23	31
			Correspondence	4	6
Other certificate	18	24	Self-learn	1	1
Degree	1	1	Sandwich	0	0
No qualification	22	30		34	46
No answer	12	16			
	74	100%		74	100%

The training organisation and its location were as follows:

TABLE A11.5. Where Course Was Completed.

Organisation			State in Australia etc.		
Technical College	29	39.1%	N.S.W./A.C.T.	30	40.4%
University	1	1.4	Victoria	1	1.4
State Govt. Dept.	1	1.4	South Australia	1	1.4
At work and/or home	3	4.1	Tasmania	1	1.4
			Overseas	1	1.4
Armed Forces	0	0.0	Other States	0	0.0
No answer	40	54.0	No answer	40	54.0
Total ..	74	100.0%		74	100.0%

11.2. FREQUENCY OF USE OF 'ELEMENTS' OF KNOWLEDGE AND IMPORTANCE ATTACHED TO 'ELEMENTS'

The main part of the questionnaire distributed to foremen sought information on the usage, the importance and the level of knowledge or understanding of a list of 'elements' of civil engineering knowledge. This list is given below:-

TABLE A11.6. List of 'Elements'.

CONSTRUCTION

Strength of timber and concrete beams and columns
Bitumen
Circular formwork
Rigging
Underpinning
Coffer dams
Tunneling
Planning a simple construction job
Water pipe lines
Sewer construction
Plant
Placing concrete under water
Timber bridge construction
Concrete culverts
Steel sheets and bending

Organisation			State in Australia etc.		
Technical College	29	39.1%	N.S.W./A.C.T.	30	40.4%
University	1	1.4	Victoria	1	1.4
State Govt. Dept.	1	1.4	South Australia	1	1.4
At work and/or home	3	4.1	Tasmania	1	1.4
			Overseas	1	1.4
Armed Forces	0	0.0	Other States	0	0.0
No answer	40	54.0	No answer	40	54.0
Total ..	74	100.0%		74	100.0%

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Water pipe lines
Sewer construction
Plant
Placing concrete under water
Timber bridge construction
Concrete culverts
Steel sheets and bending

MECHANICS

Levers
Pulley blocks, winches
Safe working load; fibre and wire ropes, chains.
Safe sustaining power of piles
Drop hammers, steam hammers

TABLE A11.6.. (Continued)

SPECIFICATION WRITING AND CONTRACTS

Clearing
Grading drainage embankments
Explosives
Interpretation of contracts
Contractors risk
Security deposits
Responsibilities of parties

FOUNDATIONS

Properties of soils
Pile and pier foundations
Caissons
Air pressure work

CRITICAL PATH PROGRAMMING

BOOK AND RECORD KEEPING

PUBLIC HEALTH

Parks and gardens
Swimming facilities
Sanitary plumbing
House drainage
Camp sanitation
Sullage water
Sewage disposal
Stormwater drainage
Ventilation

CALCULATIONS

Trigonometry, areas and volumes
Material costing
Reduced levels
Calculation of wages

TIMBER

Timber growth conversion
Seasoning
Identification and weight
Durability and suitability
Timber joints
Piling

FASTENINGS

Nails, screws, bolts and rivets

CONCRETE

Concrete quantities
Types of cement and mixes
Aggregates and tests for impurities

Interpretation of contracts
Contractors risk
Security deposits
Responsibilities of parties

FOUNDATIONS

Properties of soils
Pile and pier foundations
Caissons
Air pressure work

CRITICAL PATH PROGRAMMING

BOOK AND RECORD KEEPING

PUBLIC HEALTH

Parks and gardens
Swimming facilities
Sanitary plumbing
House drainage
Camp sanitation
Sullage water
Sewage disposal
Stormwater drainage
Ventilation

CALCULATIONS

Trigonometry, areas and volumes
Material costing
Reduced levels
Calculation of wages

TIMBER

Timber growth conversion
Seasoning
Identification and weight
Durability and suitability
Timber joints
Piling

FASTENINGS

Nails, screws, bolts and rivets

CONCRETE

Concrete quantities
Types of cement and mixes
Aggregates and tests for impurities
Slump and strength
Methods of mixing
Strengths of concrete
Formwork
Reinforcement
SAA code CAZ 1958
Effects of weather conditions
Expansion and contraction
Durability

TABLE A11.6. (Continued)

SCAFFOLDING

Scaffolding different methods
Scaffolding and Lifts Act

REPORT WRITING

MISCELLANEOUS

Surveying
Training workers on the job
Solving problems
Developing group morale
Safety regulations
Concrete drying rate
Pneumatic drilling
Union regulations

The instructions concerning these items asked respondents to indicate -

(A) How often you use each element in your job.

(B) How important each element is to your job.

(C) How much you need to know about each element.

by placing your answer in the corresponding answer column and giving it a number from 1 - 4.

For Column (A)
1 would indicate that you spent almost all your time using that element
2 would indicate that you spent more than half of your time using that element
3 would indicate that you spent less than half your time using that element
4 would indicate that you spend almost no time using that element

For Column (B)
1 would indicate that the element was very important to your job
2 would indicate that the element was important to your job
3 would indicate that the element was not very important to your job
4 would indicate that the element was not important to your job at all

For Column (C)
1 indicates complete theoretical and working knowledge
2 indicates knowledge of principles only
3 indicates practical working knowledge
4 indicates basic facts only

REPORT WRITING

MISCELLANEOUS

Surveying
Training workers on the job
Solving problems
Developing group morale
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Union regulations

The instructions concerning these items asked respondents to indicate -

(A) How often you use each element in your job.

(B) How important each element is to your job.

(C) How much you need to know about each element.

by placing your answer in the corresponding answer column and giving it a number from 1 - 4.

For Column (A)
- 1 would indicate that you spent almost all your time using that element
- 2 would indicate that you spent more than half of your time using that element
- 3 would indicate that you spent less than half your time using that element
- 4 would indicate that you spend almost no time using that element

For Column (B)
- 1 would indicate that the element was very important to your job
- 2 would indicate that the element was important to your job
- 3 would indicate that the element was not very important to your job
- 4 would indicate that the element was not important to your job at all

For Column (C)
- 1 indicates complete theoretical and working knowledge
- 2 indicates knowledge of principles only
- 3 indicates practical working knowledge
- 4 indicates basic facts only
- 5 indicates no knowledge of element required for your job

Dealing firstly with the usage of the 'elements' of knowledge the following table can be compiled:

TABLE A11.7. (Part 1) Frequency of Use (Main Items Only).

Frequency of scoring 1. i.e. "spent almost all time using the element".	'Element'
35	Plant
25	Planning a simple construction job
23	Safety regulations
18	Concrete quantities
18	Solving problems
17	Sewer construction
14	Water pipe lines
13	Strengths of concrete
13	Formwork
13	Reinforcement
13	Report writing
12	Responsibilities of parties
12	Slump and strength (concrete)
12	Training workers on the job
11	Strength of timber and concrete beams and columns
11	Book and record keeping
11	Reduced levels (calculations)
11	Expansion and contraction (concrete)
11	Durability (concrete)
11	Concrete drying rate
10	Types of concrete and mixes
10	Aggregates and tests for impurities
10	Methods of mixing (concrete)
10	56 other items
At the bottom of the list were:-	
2	Tunneling
2	Parks and gardens (public health)

Frequency of scoring 1. i.e. "spent almost all time using the element".	'Element'
35	Plant
25	Planning a simple construction job
23	Safety regulations
18	Concrete quantities
18	Solving problems
17	Sewer construction
14	Water pipe lines
13	Strengths of concrete
13	Formwork
13	Reinforcement
13	Report writing
12	Responsibilities of parties
12	Slump and strength (concrete)
12	Training workers on the job
11	Strength of timber and concrete beams and columns
11	Book and record keeping
11	Reduced levels (calculations)
11	Expansion and contraction (concrete)
11	Durability (concrete)
11	Concrete drying rate
10	Types of concrete and mixes
10	Aggregates and tests for impurities
10	Methods of mixing (concrete)
10	56 other items
At the bottom of the list were:-	
2	Tunneling
2	Parks and gardens (public health)
2	Calculations of wages
2	Timber growth conversion
1	Swimming facilities (public health)

TABLE A11.7. (Part 2) Frequency of Use (Main Items Only).

Frequency of scoring 2. i.e. "spent more than half of time using element"	'Element'
19	Solving problems
18	Safety regulations
17	Developing group morale
15	Plant
15	Concrete quantities
15	Types of concrete and mixes
13	Concrete culverts
11	Planning a simple construction job
11	Book and record keeping
11	Reduced levels (calculations)
11	Reinforcement
11	Pneumatic drilling
10	Bitumen
10	Grading drainage embankments
10	Ventilation
10	Expansions and contractions (concrete)
10	Durability (concrete)
10	Report writing
At the bottom of the list were:-	
2	Underpinning
2	Coffer dams
2	Drop hammers, steam hammers
2	Interpretation of contracts
2	Calculation of wages
1	Circular formwork
1	Tunneling
1	Security deposits
1	Air pressure work
1	Caissons
0	Sewer construction

Trbles A11.7. Parts 1 and 2 can be combined to give:-

TABLE A11.7a. (Part 3) <u>Frequency of Use (Main Items Only)</u>.

Frequency of Scoring 1 + 2	'Element'
50	Plant
41	Safety regulations
37	Solving problems
36	Planning a simple construction job
33	Concrete quantities
27	Training workers on the job
24	Reinforcement (concrete)
24	Developing group morale
23	Report writing
22	Book and record keeping
22	Reduced levels (calculations)
22	Strengths of concrete
22	Formwork (concrete)
21	Expansion and contraction (concrete)
21	Durability (concrete)
21	Concrete culverts
19	Strength of timber and concrete beams and columns
19	Concrete drying rate
18	Slump and strength (concrete)
18	Grading drainage embankments
18	Ventilation
17	Sewer construction
17	Pneumatic drilling
17	Water pipe lines
And for interest, bottom of the list:	
4	Caissons
4	Swimming facilities
4	Calculation of wages
3	Tunneling
3	Timber growth conversion

One may argue that points on scales cannot be summed but nevertheless we are not drawing any conclusions between the rankings 1 and 2, and their sum, and rankings 3 and 4 and their sum.

1 + 2	
50	Plant
41	Safety regulations
37	Solving problems
36	Planning a simple construction job
33	Concrete quantities
27	Training workers on the job
24	Reinforcement (concrete)
24	Developing group morale
23	Report writing
22	Book and record keeping
22	Reduced levels (calculations)
22	Strengths of concrete
22	Formwork (concrete)
21	Expansion and contraction (concrete)
21	Durability (concrete)
21	Concrete culverts
19	Strength of timber and concrete beams and columns
19	Concrete drying rate
18	Slump and strength (concrete)
18	Grading drainage embankments
18	Ventilation
17	Sewer construction
17	Pneumatic dri ling
17	Water pipe lines
And for interest, bottom of the list:	
4	Caissons
4	Swimming facilities
4	Calculation of wages
3	Tunneling
3	Timber growth conversion

One may argue that points on scales cannot be summed but nevertheless we are not drawing any conclusions between the rankings 1 and 2, and their sum, and rankings 3 and 4 and their sum.

A brief check of the ratings 3 and 4 showed that they correlated inversely with ratings 1 and 2 as would be expected.

Turning now to the importance of the 'elements' of knowledge another series of tables can be constructed:-

TABLE A11.8. (Part 1) Importance (Main Items Only).

Frequency of scoring 1. i.e. "element was very important to job"	'Element'
45	Plant
45	Safety regulations
39	Planning a simple construction job
39	Solving problems
30	Formwork (concrete)
30	Training workers on the job
29	Reinforcement (concrete)
28	Reduced levels (calculations)
28	Report writing
27	Concrete quantities
24	Book and record keeping
24	Types of concrete and mixes
24	Methods of mixing (concrete)
24	Developing group morale
23	Concrete culverts
23	Slump and strength (concrete)
22	Effects of weather conditions (concrete)
22	Expansion and contraction (concrete)
22	Surveying
21	Water pipe lines
21	Durability (concrete)
20	Sewer construction
20	Union regulations
At the bottom of the list were:	
5	Caissons
5	Camp sanitation (Public Health)
5	Ventilation (Public Health)
4	Parks and gardens (Public Health)
3	Calculation of wages
2	Swimming facilities (Public Health)
1	Timber growth conversion

A similar table can be constructed by looking at the frequencies under column 2.

TABLE A11.8: (Part 2) Importance (Main Items Only).

Frequency of scoring 2. i.e. "element was important to job"	'Element'
30	Types of concrete and mixes
29	Safe working load, fibre and wire ropes, chains
29	Expansion and contraction (concrete)
29	Developing group morale
28	Trigonometry, areas and volumes (calculation)
28	Durability (concrete)
27	Book and record keeping
27	Union regulations
26	Strengths of concrete
26	Training workers on the job
25	Aggregates and tests for impurities (concrete)
24	Pulley blocks and winches
24	Concrete quantities
24	Slump and strength (concrete)
24	Methods of mixing (concrete)
24	Effects of weather conditions
24	Solving problems
24	Concrete drying rate
23	Material costing (calculations)
22	Stormwater drainage (Public Health)
22	Formwork (concrete)
22	Pneumatic drilling
21	Planning a simple construction job
21	Levers
21	Grading drainage, embankments
21	Reinforcement (concrete)
21	Report writing
20	Bitumen
20	Sewage disposal (Public Health)
20	Reduced levels (calculations)

At the bottom of the list were:-

Frequency of scoring 2, i.e. "element was important to job"	'Element'
30	Types of concrete and mixes
29	Safe working load, fibre and wire ropes, chains
29	Expansion and contraction (concrete)
29	Developing group morale
28	Trigonometry, areas and volumes (calculation)
28	Durability (concrete)
27	Book and record keeping
27	Union regulations
26	Strengths of concrete
26	Training workers on the job
25	Aggregates and tests for impurities (concrete)
24	Pulley blocks and winches
24	Concrete quantities
24	Slump and strength (concrete)
24	Methods of mixing (concrete)
24	Effects of weather conditions
24	Solving problems
24	Concrete drying rate
23	Material costing (calculations)
22	Stormwater drainage (Public Health)
22	Formwork (concrete)
22	Pneumatic drilling
21	Planning a simple construction job
21	Levers
21	Grading drainage, embankments
21	Reinforcement (concrete)
21	Report writing
20	Bitumen
20	Sewage disposal (Public Health)
20	Reduced levels (calculations)
At the bottom of the list were:-	
8	Steel sheets and bending
8	Calculation of wages
7	Drop hammers and steam hammers
7	Timber seasonin;

By combining the two previous tables one obtains the following:

TABLE A11.8. (Part 3) Importance (Main Items Only).

Frequency of scoring 1 + 2	'Element'
63	Safety regulations
63	Solving problems
62	Plant
60	Planning a simple construction job
56	Training workers on the job
56	Types of concrete and mixes
54	Strength of concrete
53	Concrete quantities
53	Developing group morale
52	Formwork (concrete)
51	Book and record keeping
51	Expansion and contraction (corcrete)
50	Reinforcement (concrete)
49	Durability (concrete)
49	Report writing
48	Reduced levels (calculation)
48	Methods of mixing (concrete)
47	Slump and strength (concrete)
47	Union regulations

Elements at the bottom of the list were not much different from those in previous "bottom of the lists".

UNIVERSITY OF MELBOURNE

DEPARTMENT OF CIVIL ENGINEERING

AIMS OF THE CIVIL ENGINEERING COURSE

A civil engineer should have received at the University an education appropriate firstly for a graduate, secondly for an engineer and thirdly for a civil engineer, in this order of importance.

This conclusion has been reached following a review of the mental characteristics, the habits of mind, the intellectual skills and the general and specialised knowledge which is looked for in the mature engineer, and which is expected, in embryo at least, in the fresh graduate.

The attributes of the University graduate should include the following:

a) A general understanding of the cultural, social and political structure of society.

b) An ability to ascertain the true nature of a problem or an event by a logical process of observation analysis and induction.

c) An ability to communicate ideas and information with others by speech, writing and in other ways.

d) An ability to find rapidly any information needed, either from the literature or by consultation with appropriate persons.

e) Self-reliance, in the sense of being willing to tackle unfamiliar problems.

The attributes of graduate engineers in general, in addition to those listed above, include the following:

a) A thorough understanding of the basic scientific knowledge and principles, and their engineering developments, underlying engineering work.

b) The attainment of some skill in engineering analysis - in particular, the stripping down of a problem to its essential elements, and its formulation where possible in mathematical terms for solution.

c) Some ability in synthesis i.e. the development of solutions to engineering problems which will satisfy prescribed criteria of function, cost, strength, appearance, etc.

d) An appreciation of the economic, social and political factors which may influence engineering decisions.

e) An awareness of the significance of the engineer's work in relation to the physical and social environment, and of the

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c) Some ability in synthesis i.e. the development of solutions to engineering problems which will satisfy prescribed criteria of function, cost, strength, appearance, etc.

d) An appreciation of the economic, social and political factors which may influence engineering decisions.

e) An awareness of the significance of the engineer's work in relation to the physical and social environment, and of the special duties and responsibilities of the engineer to the community.

f) Ability to express oneself by means of drawings, illustrations and models.

g) Ability to think ahead and to foresee, - the possible trends of future developments in engineering and to evaluate their implication.

h) Ability to work as part of a team.

i) An understanding of the principles underlying successful engineering management and organisation.

j) A recognition of the fact that engineering is life-long study, and an urge to extend continually one's knowledge and experience.

k) Adaptability, flexibility of outlook and resourcefulness.

It will be seen that the attributes sought in a civil engineering graduate are similar in essence to those desirable in any engineering graduate. It is, in fact, not easy to list additional attributes required specially in a civil engineer. Is there something in his work which makes it basically different from that of a chemical engineer, for example? The committee resisted the temptation to define civil engineering as covered by the fields of structures, hydraulics, soils and transport, because it recognised that these fields change from time to time - soil mechanics, for instance, has only been so recognised within the last 30 years, and even today there are some diehards among University professors who do not recognise the claims of transport to a part in a civil engineering degree course. By the same token, in twenty years' time civil engineering may have extended its boundaries, into submarine engineering, perhaps.

The discussions began as a review of the present course. Considerations of problems such as obsolescence, however, necessitated an examination of the basic aims of engineering courses. It became obvious that the precise content of a subject, in the later years at least, is less important than the way in which it is taught. Exactly what the student holds in his mind by way of facts is less significant than the permanently valuable attributes which the graduate civil engineer needs. The facts may soon become obsolete; the permanently valuable mental characteristics, by definition, will not.

Ideally the engineering student is being trained for conditions that will prevail throughout his professional life, not for those that exist today. But a particularly disconcerting feature associated with attempts to put this into practice is that new and important developments tend to occur more and more rapidly, and that it is usually not possible even for the best informed persons to foresee them. Computers are a case in point - only 10 years ago even those people who had been most closely concerned with their application in civil engineering did not expect them to make the major impact on the work of the profession that has occurred.

It is not possible to equip the graduate with techniques and specialised knowledge which will remain up-to-date during his working life. There is even no guarantee that what he acquires in the way of specialised skills will not be obsolete within 10 years. The only way by which this difficulty can be overcome is by developing a spirit of independent enquiry and self-education during the course so that these habits may be continued in later professional life. The student must

h) Ability to work as part of a team.

i) An understanding of the principles underlying successful engineering management and organisation.

j) A recognition of the fact that engineering is life-long study, and an urge to extend continually one's knowledge and experience.

k) Adaptability, flexibility of outlook and resourcefulness.

It will be seen that the attributes sought in a civil engineering graduate are similar in essence to those desirable in any engineering graduate. It is, in fact, not easy to list additional attributes required specially in a civil engineer. Is there something in his work which makes it basically different from that of a chemical engineer, for example? The committee resisted the temptation to define civil engineering as covered by the fields of structures, hydraulics, soils and transport, because it recognised that these fields change from time to time - soil mechanics, for instance, has only been so recognised within the last 30 years, and even today there are some diehards among University professors who do not recognise the claims of transport to a part in a civil engineering degree course. By the same token, in twenty years' time civil engineering may have extended its boundaries, into submarine engi eering, perhaps.

The discussions began as a review of the present course. Considerations of problems such as obsolescence, however, necessitated an examination of the basic aims of engineering courses. It became obvious that the precise content of a subject,in the later years at least, is less important than the way in which it is taught. Exactly what the student holds in his mind by way of facts is less significant than the permanently valuable attributes which the graduate civil engineer needs. The facts may soon become obsolete; the permanently valuable mental characteristics, by definition, will not.

Ideally the engineering student is being trained for conditions that will prevail throughout his professional life, not for those that exist today. But a particularly disconcerting feature associated with attempts to put this into practice is that new and important developments tend to occur more and more rapidly, and that it is usually not possible even for the best informed persons to foresee them. Computers are a case in point - only 10 years ago eventhose people who had been most closely concerned with their application in civil engineering did not expect them to make the major impact on the work of the profession that has occurred.

It is not possible to equip the graduate with techniques and specialised knowledge which will remain up-to-date during his working life. There is even no guarantee that what he acquires in the way of specialised skills will not be obsolete within 10 years. The only way by which this difficulty can be overcome is by developing a spirit of independent enquiry and self-education during the course so that these habits may be continued in later professional life. The student must be actively encouraged to continue to maintain and improve his qualifications by self study, attendance at lectures, participating in conferences, reading of the current literature, etc. Although some of the specialised training may become obsolete within a short time, there does exist a core of basic knowledge and principles on which new and unpredictable developments must be founded, and which are, therefore an essential part of the engineer's mental equipment.

As a result of the foregoing considerations our attention was drawn to a number of defects in engineering courses:

1. There should be less preoccupation with <u>what</u> is taught, and much more attention to <u>how</u> it is taught in such a way as to develop the attributes, general and engineering, listed earlier.

2. At the same time, the graduate civil engineer obviously must have mastered a basic stock of knowledge and techniques which can be brought into play and applied with little or no delay. Can this essential stock of basic knowledge and techniques be listed? The committee knows of no such list, but one would be very helpful to teachers as well as students, as they then would know which material in their courses would need to be mastered to this degree of thoroughness, and which would not.

3. Engineering courses are, in general, good in developing skill in analysis, but weak in developing ability to synthesise so as to produce a satisfactory design for a structure, or system, a process or an operation. The pedagogic principles behind success in either analytical or synthetical teaching, are not generally agreed among engineering teachers, most of whom are groping in the dark, especially in training students in the processes of synthesis.

4. Too little is done in training students to communicate effectively, either in writing or speech. For most people, skill in the written or spoken word comes very slowly, and only after long practice. One difficulty is that the standards of many engineering teachers themselves in these matters fall short of excellence, and they are therefore less critically helpful than they might be. Another difficulty is that under today's conditions of life the home background is often less stimulating intellectually than it was for the typical undergraduate of 50 years ago came from the more privileged classes. Much less attention is given in University courses today to the detailed engineering drawing than, say 40 years ago, and this is reasonable in view of the way offices are organised nowadays. The graduate engineer still, however, needs to be able to draw clearly and quickly and should be able to use freehand sketches to help convey his ideas. The emphasis should be on reasonable fluency in lettering and line work rather than on the traditional draftsmanship skills which can only come with continued practice.

5. Most new graduate engineers are weak on the non-technical factors set out in (d) in the list of attributes. In the U.S.A. particularly, Universities have taken steps to correct this by including humanities subjects in the engineering courses, and this is good so long as these are handled imaginatively and do not become merely a burdensome obligation to the student. In Australia the position is particularly bad because of the extreme degree of specialisation in the school curricula, which leaves the secondary school product with much less than a well-rounded basic education.

6. More attention should be given to the training of students to find information by a search of the literature, how to take notes and keep record cards, or how to cope with the flood of new literature (see (d) in the attributes of the University graduate).

much more attention to <u>how</u> it is taught in such a way as to develop the attributes, general and engineering, listed earlier.

2. At the same time, the graduate civil engineer obviously must have mastered a basic stock of knowledge and techniques which can be brought into play and applied with little or no delay. Can this essential stock of basic knowledge and techniques be listed? The committee knows of no such list, but one would be very helpful to teachers as well as students, as they then would know which material in their courses would need to be mastered to this degree of thoroughness, and which would not.

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5. Most new graduate engineers are weak on the non-technical factors set out in (d) in the list of attributes. In the U.S.A. particularly, Universities have taken steps to correct this by including humanities subjects in the engineering courses, and this is good so long as these are handled imaginatively and do not become merely a burdensome obligation to the student. In Australia the position is particularly bad because of the extreme degree of specialisation in the school curricula, which leaves the secondary school product with much less than a well-rounded basic education.

6. More attention should be given to the training of students to find information by a search of the literature, how to take notes and keep record cards, or how to cope with the flood of new literature (see (d) in the attributes of the University graduate).

7. More should be done to make a student conscious of the social consequences of his work, of its effect on the environment or of how

conflict can arise between his duty to an employer and his wider obligation to the community.

8. More emphasis should be given to instruction is the economic aspects of engineering work, since economics is one of the basic criteria of any engineering project, and the over riding one in many.

9. The graduate is not properly prepared for his further education to help him see that his University studies are only a start on the road and to produce in him the proper habits for effective study.

This document was prepared after discussion by the Course Revision Committee and is based on a paper by Prof. A.J. Francis which summarized the results of their discussions. The final draft was edited by Dr. P.J. Moore.

A.12. P.4.

INDIVIDUAL DATA SHEET

NAME OF ORGANISATION: **ADDRESS:** **TELEPHONE NO.:** **NATURE OF BUSINESS:**		*OFFICE USE*
Approximate total employees		
Department or section of business		
Please sketch an abbreviated organisation chart showing your position in organisation in relation to Head of Company, Department etc.		
What is your job title?		
Type of work: **Select one answer from:-** **Design, construction, maintenance, feasibility/economic studies, R&D/investigational, sales.**		
Your name	**Age:**	
Please give details of any formal qualifications you have e.g. Degree, Diploma, Certificate. **How were they obtained? Full-time, part-time or sandwich course.** **When?**	**a)** **b)** **c)**	
What special training or skills do you have? e.g. Management, Labour Relations, Computer Technology etc.		
l sort of practical Civil Engineering training have you had?		

NATURE OF BUSINESS:		
Approximate total employees		
Department or section of business		
Please sketch an abbreviated organisation chart showing your position in organisation in relation to Head of Company, Department etc.		
What is your job title?		
Type of work: Select one answer from:- Design, construction, maintenance, feasibility/economic studies, R&D/investigational, sales.		
Your name		Age:
Please give details of any formal qualifications you have e.g. Degree, Diploma, Certificate. How were they obtained? Full-time, part-time or sandwich course. When?	a) b) c)	
What special training or skills do you have? e.g. Management, Labour Relations, Computer Technology etc.		
What sort of practical Civil Engineering training have you had?		
How long have you been in your present job?		
[illegible] many years have you been working [illegible]ivil Engineering?		

APPENDIX 13. TASK ANALYSIS QUESTIONNAIRE

(called Survey Schedule for field work) SCHEDULE

No :-

CIVIL ENGINEERING EDUCATION PROJECT

CONDUCTED BY
MACQUARIE UNIVERSITY
AND
THE N.S.W. INSTITUTE OF TECHNOLOGY

ADDRESS: SCHOOL OF EDUCATION
MACQUARIE UNIVERSITY
NORTH RYDE
2113

SURVEY SCHEDULE

CONTENTS

CIVIL ENGINEERING EDUCATION PROJECT

CONDUCTED BY
MACQUARIE UNIVERSITY
AND
THE N.S.W. INSTITUTE OF TECHNOLOGY

ADDRESS: SCHOOL OF EDUCATION
MACQUARIE UNIVERSITY
NORTH RYDE
2113

SURVEY SCHEDULE

CONTENTS

INDIVIDUAL DATA SHEET p.1
TASK ANALYSIS 2
TRAINING ANALYSIS p.9
O.E. QUESTIONS 11
RESPONSIBILITY RATING 12

TECHNICAL MATTERS

In the section below please -

(a) write again your answer to the question on page 1 on Type of Work in the space below.

(b) select one of the branches of civil engineering from the two lists below which describes that part of civil engineering with which your work is concerned. Indicate selection by underlining branch and placing tick in box. If more than one branch is clearly your concern please state an approximate percentage against those involved.

(a) TYPE OF WORK

(b) BRANCH OF CIVIL ENGINEERING	BOX	OFFICE USE	BRANCH OF CIVIL ENGINEERING	BOX	OFFICE USE
Buildings			Water Supply		
Bridges			Sewerage works		
Roads			Pipe lines (other than water or sewerage)		
Railways			Harbours		
Dams			Airports		
Tunnels			Other (specify)		

In the section on pages 4 and 5 please indicate in connection with -

USE – those elements or parts of civil engineering knowledge which you use in the performance of your job, by placing a tick against them.
Please write 'O' against those you do not use.

For those elements of civil engineering knowledge you use i.e., those you have ticked please indicate -

LEVEL OF KNOWLEDGE – by selecting one of the following code numbers with the meanings as given:-
1 = Advanced level of knowledge of the whole element
2 = General level of knowledge of whole element
3 = Specialised knowledge of part of element
4 = Very specialised knowledge of small part of element

FREQUENCY of use by selecting one of the following code numbers with their meanings as given:-

1 = Regularly, frequently, i.e. every day or every other day
2 = Frequently, i.e. about once a week
3 = Not frequently, i.e. about once a month
4 = Infrequently, i.e. less than 10 times a year

IMPORTANCE – i.e. whether knowledge of the particular element is important in your job. Your answer to be selected from the following code numbers with their meanings as given:-

1 = Very important, easy to acquire
2 = Very important, difficult to acquire
3 = Important, easy to acquire
4 = Important, difficult to acquire
5 = Not important

DIFFICULTY – please indicate how difficult you consider the handling or understanding of this particular element of knowledge to be. Please select your answer from the following code numbers with the meanings as given:-

(a) write again your answer to the question on page 1 on Type of Work in the space below.

(b) select one of the branches of civil engineering from the two lists below which describes that part of civil engineering with which your work is concerned. Indicate selection by underlining branch and placing tick in box. If more than one branch is clearly your concern please state an approximate percentage against those involved.

(a) TYPE OF WORK					
(b) BRANCH OF CIVIL ENGINEERING	**BOX**	**OFFICE USE**	**BRANCH OF CIVIL ENGINEERING**	**BOX**	**OFFICE USE**
Buildings			Water Supply		
Bridges			Sewerage works		
Roads			Pipe lines (other than water or sewerage)		
Railways			Harbours		
Dams			Airports		
Tunnels			Other (specify)		

In the section on pages 4 and 5 please indicate in connection with -

USE – those elements or parts of civil engineering knowledge which you use in the performance of your job, by placing a tick against them.
Please write 'O' against those you do not use.

For those elements of civil engineering knowledge you use i.e., those you have ticked please indicate -

LEVEL OF KNOWLEDGE – by selecting one of the following code numbers with the meanings as given:-
1 = Advanced level of knowledge of the whole element
2 = General level of knowledge of whole element
3 = Specialised knowledge of part of element
4 = Very specialised knowledge of small part of element

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1 = Regularly, frequently, i.e. every day or every other day
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3 = Not frequently, i.e. about once a month
4 = Infrequently, i.e. less than 10 times a year

IMPORTANCE – i.e. whether knowledge of the particular element is important in your job. Your answer to be selected from the following code numbers with their meanings as given:-

1 = Very important, easy to acquire
2 = Very important, difficult to acquire
3 = Important, easy to acquire
4 = Important, difficult to acquire
5 = Not important

DIFFICULTY – please indicate how difficult you consider the handling or understanding of this particular element of knowledge to be. Please select your answer from the following code numbers with the meanings as given:-

1 = Very difficult
2 = Difficult
3 = Moderately difficult
4 = Easy

USE IN YEAR – in the last column indicate whether you have used the element of civil engineering knowledge in the past 12 months. Please answer 1 or 0 (used, or not used).

Finally, if there are "elements" of civil engineering knowledge you use, and which are not included in the listing please write about them on page 6, or if there is insufficient space on pages 4 & 5, please continue on page 6, marking the section referred to clearly. Any amplification you think would be helpful would be appreciated.

TASK ANALYSIS

On this page we would like you to show how your working time is split-up over some broad categories of tasks. In order to do this with some accuracy we suggest you note down day by day for a period of two working weeks the approximate hours spent on each of the broad categories of task. At the end of the time the hours can be summed and a percentage calculated for each category. We are only interested in the percentage of the hours worked, and these should be indicated in the column headed "% or nil". Percentages to be given to the nearest 5%. In the next column headed "Frequency" please indicate how frequently you were engaged on the category of task over the last year, since the fortnight chosen may not have been typical of your working year. Your answer to be selected from the following list of code numbers with their meanings:-

1 = Regularly, frequently, i.e. every day or every other day
2 = Frequently, i.e. about once a week
3 = Not frequently, i.e. about once a month
4 = Infrequently, less than 10 times a year.

Please write the selected code number in its relevant column in your answers below.

We suggest you read all the pages of the Task Analysis section in order to gain an idea of what is meant by Technical Matters, Manual Skills, Economic & Financial Matters etc.

ALLOCATION OF TASKS

CATEGORY OF TASK	% OR NIL	FREQUENCY: Regularly 1	Frequently 2	Not Frequently 3	Infrequently 4	COMMENT
Example	30		2			
Technical Matters						
Manual Skills						
Economic and Financial Matters						
Communication Matters /Exchange of Information						
[illegible]nagement Matters and [illegible]rsonnel Matters						

the last year, since the fortnight chosen may not have been typical of your working year. Your answer to be selected from the following list of code numbers with their meanings:-

1 = Regularly, frequently, i.e. every day or every other day
2 = Frequently, i.e. about once a week
3 = Not frequently, i.e. about once a month
4 = Infrequently, less than 10 times a year.

Please write the selected code number in its relevant column in your answers below.

We suggest you read all the pages of the Task Analysis section in order to gain an idea of what is meant by Technical Matters, Manual Skills, Economic & Financial Matters etc.

ALLOCATION OF TASKS

CATEGORY OF TASK	% OR NIL	FREQUENCY: Regularly 1	Frequently 2	Not Frequently 3	Infrequently 4	COMMENT
Example	30		2			
Technical Matters						
Manual Skills						
Economic and Financial Matters						
Communication Matters /Exchange of Information						
Management Matters and Personnel Matters						
Other (specify) e.g. Legal, Social						
Other						
	100%					

TECHNICAL MATTERS

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
EXAMPLE	✓			2			1					2							4	1	
STRUCTURES:-																					
Stress calculations (e.g. $F = \frac{My}{I}$)																					
Frame Analysis																					
using manual methods																					
using computers																					
a) via terminal to large installation																					
b) on site small computer																					
c) desk top programmable calculator																					
using handbooks																					
elasticity (stress, strain etc.)																					
statics (i e virtual work)																					
Design																					
metal structures, inc. steel																					
concrete structures																					
timber																					
code of practice																					
safety factors and load factors																					
Other (please specify)																					
ditto																					
MATERIALS -																					
Mechanical Testing																					
Quality control																					
Selection & specifications																					
Metallic																					
Organic (including timber)																					
Concrete																					
Ceramic																					
Silicate																					
Road Materials																					
Rheology																					
Other (please specify)																					
ditto																					
WATER:-																					
Solution of hydraulic problems																					
from first principles																					
using empirical formulae																					
using computer packages																					
using handbooks																					
using models																					
Solution of hydrology problems																					
using raw data & first principles																					
using standard design procedures (e.g. Australia Rainfall & Runoff Handbook)																					
using computer package																					
using models																					
using systems analysis																					
Hydrostatics																					
Hydrodynamics																					
Water engineering																					
Other (please specify)																					
ditto																					

TASK ANALYSIS

TECHNICAL MATTERS (contd.)

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Use		Level of Knowledge				Frequency				Importance					Difficulty				Use in Year	
	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment																					
Field investigations																					
Laboratory investigations																					
Foundation design or assessment																					
Earth structures design (e.g. embankments dams, road bases)																					
Mechanics																					
Engineering																					
Other (please specify)																					
ditto																					
CONSTRUCTION:-																					
Critical Path Methods																					
Explosives																					
Drilling																					
ELECTRICAL ENGINEERING:-																					
Network analysis																					
Equipment specification																					
Other (please specify)																					
ditto																					
MATHEMATICS																					
Basic algebra, geometry and trigonometry																					
Calculus																					
Numerical Methods																					
Other (please specify)																					
ditto																					
COMPUTERS																					
System Analysis																					
Writing programs																					
Using programs																					
Other (please specify)																					
ditto																					
EQUIPMENT & PLANT																					
SURVEYING																					
Levelling																					
Setting out																					
Traversing																					
Photogrammetry																					
Other (please specify)																					
ditto																					
CHEMISTRY – ENGINEERING (e.g. corrosion)																					
PHYSICS – ENGINEERING (e.g. thermodynamics)																					
GEOLOGY – ENGINEERING (e.g. stability of rocks)																					
BIOLOGY – ENGINEERING (e.g. water & sewerage, environment, public health)																					

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Do use	Do not use	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy	Used	Not used
	✓	0	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	0
SOILS:-																					
Geological assessment																					
Field investigations																					
Laboratory investigations																					
Foundation design or assessment																					
Earth structures design (e.g. embankments dams, road bases)																					
Mechanics																					
Engineering																					
Other (please specify)																					
ditto																					
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Explosives																					
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Using programs																					
Other (please specify)																					
ditto																					
EQUIPMENT & PLANT																					
SURVEYING																					
Levelling																					
Setting out																					
Traversing																					
Photogrammetry																					
Other (please specify)																					
ditto																					
CHEMISTRY – ENGINEERING (e.g. corrosion)																					
PHYSICS – ENGINEERING (e.g. thermodynamics)																					
GEOLOGY – ENGINEERING (e.g. stability of rocks)																					
BIOLOGY – ENGINEERING (e.g. water & sewerage, environment, public health)																					
OTHER (please specify)																					

TECHNICAL MATTERS (contd.)

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE	Level of Knowledge				Frequency				Importance					Difficulty			
	Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy
	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4
On this page please add any technical "elements" of civil engineering knowledge that are not covered by the previous two pages, or any other items of a technical nature which are used in the performance of your job and which you think should be drawn to our attention.																	

"ELEMENTS" OF CIVIL ENGINEERING KNOWLEDGE

Advanced	General	Specialised	V. Specialised	Regularly	Frequently	Not Frequently	Infrequently	V. important-easy	V. important-diff.	Important-easy	Important-diff.	Not important	Very difficult	Difficult	Mod. difficult	Easy
1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4

On this page please add any technical "elements" of civil engineering knowledge that are not covered by the previous two pages, or any other items of a technical nature which are used in the performance of your job and which you think should be drawn to our attention.

TASK ANALYSIS

Please indicate in the three sections below viz. Manual skills, Economic, and Communication -

a) what percentage of the total time spent on the activities connected with that particular section can be allocated to the sub-categories of task listed in that section. Answers to nearest 10%. Percentage column to total 100%.

b) against those tasks where you have put a % figure indicate the frequency with which you perform the task. Use one of the code numbers 1, 2, 3 or 4 according to the notes in the lower part of page 3.

c) against those tasks where you have put a % figure indicate the importance of that task using one of the code numbers 1, 2, 3, 4 or 5; according to the notes in the lower part of page 3.

d) against all sub category tasks put either 1 or 0 (used, or not used) depending on whether you have performed the task in the past 12 months.

MANUAL SKILLS

SUB-CATEGORY TASK	% OR NIL	Frequency: Regularly 1	Frequently 2	Not Frequently 3	Infrequently 4	Importance: V.important-easy 1	V.important-diff. 2	Important-easy 3	Important-diff. 4	Not important 5	Use in Year: Used 1	Not used 0	COMMENT
Drawing & Drafting													
Using Survey Instruments													
Using Laboratory or Testing Apparatus													
Other (specify)	100%												
ECONOMIC AND FINANCIAL MATTERS													
Feasibility Studies													
Cost Benefit Analyses													
Market Studies													
Costing of, Costs of Projects													
Other (specify)	100%												
COMMUNICATION OR EXCHANGE OF INFORMATION													
WRITING letters, reports or filling in forms													
Sketching													
TALKING on telephone, in groups lecturing, attending meetings as a													

c) against those tasks where you have put a % figure indicate the importance of that task using one of the code numbers 1, 2, 3, 4 or 5; according to the notes in the lower part of page 3,

d) against all sub category tasks put either 1 or 0 (used, or not used) depending on whether you have performed the task in the past 12 months.

MANUAL SKILLS

SUB-CATEGORY TASK	% OR NIL	Frequency				Importance					Use in Year		COMMENT
		Regularly 1	Frequently 2	Not Frequently 3	Infrequently 4	V.important-easy 1	V.important-diff. 2	Important-easy 3	Important-diff. 4	Not important 5	Used 1	Not used 0	
Drawing & Drafting													
Using Survey Instruments													
Using Laboratory or Testing Apparatus													
Other (specify)	100%												
ECONOMIC AND FINANCIAL MATTERS													
Feasibility Studies													
Cost Benefit Analyses													
Market Studies													
Costing of, Costs of Projects													
Other (specify)	100%												
COMMUNICATION OR EXCHANGE OF INFORMATION													
WRITING letters, reports or filling in forms													
Sketching													
TALKING on telephone, in groups lecturing, attending meetings as a participant													
READING letters, reports, drawings or forms. Keeps up-to-date reading journals													
Other (specify)	100%												

TASK ANALYSIS

MANAGEMENT & PERSONNEL MATTERS

Please answer this section in the same way as the 3 immediately previous sections, i.e. indicate -

a) what percentage of the total time you spend on management and personnel activities can be allocated to the sub-categories listed below. Answers to nearest 10%. Percentage column to total 100%.

b) against those sub-category tasks where you have put a % figure indicate the frequency with which you perform the task. Use one of the code numbers 1, 2, 3 or 4 according to the notes on the lower part of p.3.

c) against those tasks where you have put a % figure indicate the importance of that task using one of the code numbers 1, 2, 3, 4 or 5, according to the notes on the lower part of p.3.

d) against all tasks put either 1 or 0 (used or not used) depending on whether you have performed the task in the past 12 months.

SUB-CATEGORY TASK	% OR NIL	Frequency				Importance					Use in Year		COMMENT
		Regularly 1	Frequently 2	Not Frequently 3	Infrequently 4	...ortant-easy	V. Important-diff. 2	Important-easy 3	Important-diff. 4	Not Important 5	Used 1	Not Used 0	
PLANNING, annual plans, budgets, P.E.R.T., critical path work, network analysis classification and statement of objectives													
ORGANISING, adapting resources to meet particular needs of jobs, defining procedures, assigning activities.													
DIRECTING, talking to staff in reporting sessions, following progress of work, motivating, leading, preserving morale.													
CONTROLLING, comparing with accepted or nominated modes of performance, budgetary control time control, production control.													
CO-ORDINATING, arranging inter departmental, inner company etc., discussions. Smoothing out obstacles.													
INTERVIEWING, engaging staff promoting, firing, staff counselling, staff appraisal session, filling in reports on staff.													
LABOUR RELATIONS, arbitrating etc., discussions with bodies representing groups of staff or labour, salary and wage discussions.													
GENERAL PERSONNEL MATTERS, absenteeism, health matters, arguments, worries, anxieties, frustrations of staff and labour.													

[illegible]

b) against those sub-category tasks where you have put a % figure indicate the frequency with which you perform the task. Use one of the code numbers 1, 2, 3 or 4 according to the notes on the lower part of p.3.

c) against those tasks where you have put a % figure indicate the importance of that task using one of the code numbers 1, 2, 3, 4 or 5, according to the notes on the lower part of p.3.

d) against all tasks put either 1 or 0 (used or not used) depending on whether you have performed the task in the past 12 months.

SUB-CATEGORY TASK	% OR NIL	Frequency				Importance					Use in Year		COMMENT
		Regularly	Frequ	Not Frequently	Infrequently	V. Important-easy	V. Important-diff.	Important-easy	Important-diff.	Not Important	Used	Not Used	
		1	2	3	4	1	2	3	4	5	1	0	
PLANNING, annual plans, budgets, P.E.R.T., critical path work, network analysis classification and statement of objectives													
ORGANISING, adapting resources to meet particular needs of jobs, defining procedures, assigning activities.													
DIRECTING, talking to staff in reporting sessions, following progress of work, motivating, leading, preserving morale.													
CONTROLLING, comparing with accepted or nominated modes of performance, budgetary control time control, production control.													
CO-ORDINATING, arranging inter departmental, inter company etc., discussions. Smoothing out obstacles.													
INTERVIEWING, engaging staff promoting, firing, staff counselling, staff appraisal session, filling in reports on staff.													
LABOUR RELATIONS, arbitrating etc., discussions with bodies representing groups of staff or labour, salary and wage discussions.													
GENERAL PERSONNEL MATTERS, absenteeism, health matters, arguments, worries, anxieties, frustrations of staff and labour.													
STATISTICS on labour and staff, compiling returns for accountants, government departments, etc.													
SAFETY MATTERS, dealing with safety regulations, policing safety precautions etc.													
OTHER (specify)	100%												

TRAINING ANALYSIS

CATEGORY OF TASK: TECHNICAL MATTERS

The following series of questions seek information on training for the various tasks associated with, or part of, civil engineering jobs. Each question seeks information with respect to each of the categories of task heading the columns on this and the next page, viz. technical matters, manual skills, economic matters, communication matters and management matters.

The knowledge needed to perform the task - was it part of your post-secondary/tertiary training?

Please indicate by writing a number selected from the 4-point scale.

1 strongly emphasised — 2 emphasised — 3 some mention — 4 None

---

Has practical experience been of importance in the acquisition of skill in relation to this task?

Please indicate by writing a number selected from the 4-point scale

1 Very much — 2 much — 3 some — 4 very little

What do you think is the best pattern of training for acquiring the knowledge required for the performance of the task? Select one of the following for each of the categories of task. Full time course. Full time followed by part-time. Part-time. Sandwich/block release. T.W.I. (training within industry) Short intensive course. Correspondence. Self learning. Other. Please indicate whether the courses should be at degree or sub-degree level.

The following lists most of the ways of acquiring knowledge -

Live lecture	0	Demonstration, laboratory & outside	5
Tutorial	1	Practical participation/field work	6
Audio-visual methods	2	Simulation/decision making games	7
Individual project	3	On the job instruction	8
Group project	4	Practical job experience	9

Which of these have you had experience of? Please circle number.

What is the best way of acquiring the knowledge for the performance of the task? Please state up to 3 answers in order of priority.

To what extent is your post-secondary/tertiary training specifically used in the performance of the category of task?

Please indicate by writing a number selected from the following 4-point scale.

1 almost all — 2 much — 3 some — 4 very little

To what extent do you believe your post-secondary/tertiary training has provided, in relation to each of the tasks -

a) principles which you can apply,
b) a basic ground work of facts,
c) knowledge of where to find the information,
d) an understanding of the language or jargon,
e) no value at all?

How do you view your post-secondary/tertiary training? Please indicate by ringing one of the numbers on each of the following 5-point scales.

1 too few general principles of civ.eng. — 2 — 3 about right — 4 too many general principles of civ.eng. — 5

Please indicate by writing a number selected from the 4-point scale.

strongly emphasised — emphasised | some mention — None

1 — 2 | 3 — 4

Has practical experience been of importance in the acquisition of skill in relation to this task?

Please indicate by writing a number selected from the 4-point scale

Very much — much | some — very little

1 — 2 | 3 — 4

What do you think is the best pattern of training for acquiring the knowledge required for the performance of the task? Select one of the following for each of the categories of task. Full time course. Full time followed by part-time. Part-time. Sandwich/block release. T.W.I. (training within industry) Short intensive course. Correspondence. Self learning. Other. Please indicate whether the courses should be at degree or sub-degree level.

The following lists most of the ways of acquiring knowledge -

Live lecture	0	Demonstration, laboratory & outside	5
Tutorial	1	Practical participation/field work	6
Audio-visual methods	2	Simulation/decision making games	7
Individual project	3	On the job instruction	8
Group project	4	Practical job experience	9

Which of these have you had experience of? Please circle number.

What is the best way of acquiring the knowledge for the performance of the task? Please state up to 3 answers in order of priority.

To what extent is your post-secondary/tertiary training specifically used in the performance of the category of task?

Please indicate by writing a number selected from the following 4-point scale.

almost all — much | some — very little

1 — 2 | 3 — 4

To what extent do you believe your post-secondary/tertiary training has provided, in relation to each of the tasks -

a) principles which you can apply,
b) a basic ground work of facts,
c) knowledge of where to find the information,
d) an understanding of the language or jargon,
e) no value at all?

How do you view your post-secondary/tertiary training? Please indicate by ringing one of the numbers on each of the following 5-point scales.

a) 1 — 2 — 3 — 4 — 5
too few general principles of civ.eng. (1) — about right (3) — too many general principles of civ.eng. (5)

b) 1 — 2 — 3 — 4 — 5
too little detailed factual subject content re civ. eng. (1) — about right (3) — too much detailed factual subject content re civ. eng. (5)

c) 1 — 2 — 3 — 4 — 5
too little "general engineering education" (1) — about right (3) — too much "general engineering education" (5)

TRAINING ANALYSIS

CATEGORIES OF TASK				
MANUAL SKILLS	ECONOMIC AND FINANCIAL MATTERS	COMMUNICATION MATTERS/ EXCHANGE OF INFORMATION	MANAGEMENT MATTERS AND PERSONNEL MATTERS	OTHER (specify)

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O.E. QUESTIONS

N.B. - For any of the following questions, please continue your answer on a separate sheet, if more space is necessary.

Did you enjoy your post-secondary/tertiary education program overall? Yes or No. If not why?	
What did you like most about your post-secondary/tertiary education program?	
With relation to the problems you meet and the types of work you have to do today, have any major deficiencies in your post-secondary/tertiary training become apparent? If so, what are they?	
What topics of value in carrying out your work were omitted from your post-secondary/tertiary training?	
With relation to your work as it affects the community generally what topics do you think you should have studied, or skills you should have acquired.	
What topics or skills have you had to acquire without formal courses?	
What are the criteria of success in your job as you see them?	
For what and at what level do you think your post-secondary/tertiary training most fitted you?	
Did your post-secondary/tertiary training develop skills in technical decision making, or value judgements? If so, which parts of your training were most effective?	
Did your post-secondary/tertiary training encourage and assist you to - (a) develop your own ideas and use your own ideas, or (b) encourage you to use traditional methods to solve your problems?	
If you find greater use for your own ideas please give examples.	
Looking ahead to 1980 what do you think will be the major differences in civil engineering, and what new approaches or subjects should	

What did you like most about your post-secondary/tertiary education program?	
With relation to the problems you meet and the types of work you have to do today, have any major deficiencies in your post-secondary/tertiary training become apparent? If so, what are they?	
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What topics or skills have you had to acquire without formal courses?	
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For what and at what level do you think your post-secondary/tertiary training most fitted you?	
Did your post-secondary/tertiary training develop skills in technical decision making, or value judgements? If so, which parts of your training were most effective?	
Did your post-secondary/tertiary training encourage and assist you to - (a) develop your own ideas and use your own ideas, or (b) encourage you to use traditional methods to solve your problems?	
If you find greater use for your own ideas please give examples.	
Looking ahead to 1980 what do you think will be the major differences in civil engineering, and what new approaches or subjects should civil engineers of all grades be taught today to better fit them for work in 1980?	

RESPONSIBILITY RATING

Please read the notes overleaf on responsibility rating before answering this page.

	Unskilled staff	Craftsmen and Tradesmen	Technic-ians	Graduates and Diplomates	Managers and 5 year Graduates	OFFICE USE ONLY
In each of the columns opposite please indicate the number of staff of that type, for whom you are responsible, i.e. you supervise, you control salary (where applicable), you select and engage, you discharge or fire, and you assess annually etc.	Number	Number	Number	Number	Number	

Answer the next 4 questions by putting a tick in the box applicable to your position in the organization.

Incidental expenditure, running expenditure - cheque signing limit	less than $25	$25 to $99	$100 to $249	$250 to $1,000	above $1,000	
Capital expenditure limit	less than $100	$100 to $500	$501 to $2,500	$2,501 to $10,000	above $10,000	
Value of plant and equipment for which responsible	less than $1,000	$1,000 to $5,000	$5,001 to $25,000	$25,001 to $100,000	above $100,000	
Value of work or project for which responsible	less than $5,000	$5,000 to $50,000	$50,001 to $500,000	$500,001 to $5M.	above $5M.	

Please answer the next 5 questions by putting a ring around a number on the 5-point scale.

What responsibility do you take for Technical decisions?	1 (All work checked by someone else)	2	3	4	5 (accepts all responsibility)	
What connection do you have with policy making?	1 (No connection)	2	3	4	5 (Very much connection and involvement)	
How much are you involved in policy interpretation?	1 (too far down line merely follow instructions)	2	3	4	5 (a great deal)	
What responsibility do you take for safety of staff, and safety of construction?	1 (low responsibility)	2	3	4	5 (high responsibility)	
What social responsibility and legal responsibility?	1 (low responsibility)	2	3	4	5 (high responsibility)	

What is your annual salary? Please place a tick in the relevant box.	less than $4,000	$4,001 – $5,000	$5,001 – $6,000	$6,001 – $7,000	
	$7,001 – $8,000	$8,001 – $9,000	$9,001 – $10,000	over $10,000	

Answer the next 4 questions by putting a tick in the box applicable to your position in the organization.

Incidental expenditure, running expenditure - cheque signing limit	less than $25	$25 to $99	$100 to $249	$250 to $1,000	above $1,000
Capital expenditure limit	less than $100	$100 to $500	$501 to $2,500	$2,501 to $10,000	above $10,000
Value of plant and equipment for which responsible	less than $1,000	$1,000 to $5,000	$5,001 to $25,000	$25,001 to $100,000	above $100,000
Value of work or project for which responsible	less than $5,000	$5,000 to $50,000	$50,001 to $500,000	$500,001 to $5M.	above $5M.

Please answer the next 5 questions by putting a ring around a number on the 5-point scale.

What responsibility do you take for Technical decisions?	All work checked by someone else — 1 2 3 4 5 — accepts all responsibility
What connection do you have with policy making?	No connection — 1 2 3 4 5 — Very much connection and involvement
How much are you involved in policy interpretation?	too far down line merely follow instructions — 1 2 3 4 5 — a great deal
What responsibility do you take for safety of staff, and safety of construction?	low responsibility — 1 2 3 4 5 — high responsibility
What social responsibility and legal responsibility?	low responsibility — 1 2 3 4 5 — high responsibility

What is your annual salary? Please place a tick in the relevant box.	less than $4,000	$4,001 – $5,000	$5,001 – $6,000	$6,001 – $7,000
	$7,001 – $8,000	$8,001 – $9,000	$9,001 – $10,000	over $10,000

We emphasise that this information will be treated as confidential

NOTES ON THE ASSESSMENT OF RESPONSIBILITY IN A JOB

Responsibility is associated with any engineering job, and a number of attempts have been made to define this responsibility. Civil engineering has, perhaps, more than its share of the various aspects of responsibility and it is important for our study that this is not omitted from the task analysis.

In Canada the Council of Professional Engineers defines each level of responsibility by reference to 5 factors -

i) duties
ii) recommendations, decisions and commitments
iii) supervision received
iv) leadership, authority and/or supervision received
v) entrance qualifications

Halden in his study of Swedish electrical engineers defined 5 levels of responsibility -

i) executive managers in companies ≫ 100 employees
ii) executive managers of small firms and heads of departments
iii) heads of small departments and heads of divisions in big firms
iv) heads of sections
v) younger engineers

Patton & Littlefield in their text on Job Evaluation, frequently discuss responsibility and break it up into responsibility for certain things: e.g. in the case of salaried and clerical staff it is responsibility for determining and applying company policy, for money and materials, for confidential data, and executive responsibility. Again, when evaluating executive positions, responsibility is broken up into initiative, accountability, effect on profits, responsibility for personnel relations, for policy making and policy interpretation.

In the Factor Comparison method, responsibility is defined as – what is entrusted to him that is valuable to the company and that may be affected by his decisions and judgements.

When coming to combination approaches and special plans, accountability is defined as – the requirements of independent responsibility for what happens. Since results are measured in terms of financial health and growth, responsibility winds up sooner or later in terms of money. This phrase – 'in terms of money' – seems to be one of the keys in assessing responsibility. Supervision, given and received, also is an important factor. Safety questions, social responsibility, are also involved.

A possible scheme for assessing responsibility can be based on the following factors:-

1. Number and type of staff for which responsible.
2. Incidental expenditure, running expenditure, cheque signing limit.
3. Capital expenditure limit.
4. Value of plant and equipment for which responsible.
5. Place in organization hierarchy.
6. Responsibility for technical decisions.
7. Connection with policy making.
8. Involvement in policy interpretation.
9. Safety decisions.
10. Social responsibility and legal responsibility.

A useful check could be the salary associated with the job because in any organised job evaluation and salary grading system responsibility is one of the major factors considered when putting a salary tag on a job.

A scheme on the above lines has been detailed on the page entitled Responsibility Rating. No claims are made for its correctness, in fact, there are some obvious defects. However, it is a serious attempt to come to grips with the problem of quantifying responsibility in a job.

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APPENDIX 14. FOREMAN'S QUESTIONNAIRE

SCHEDULE NO:-

CIVIL ENGINEERING EDUCATION PROJECT

Conducted by Macquarie University and The New South Wales Institute of Technology

Address c/o School of Education, Macquarie University.
North Ryde 2113

Telephone: 88-9173

BASIC DATA

1) Name of Organization:

Address:

Phone:

Nature of Business:

2) Approximate number of employees:

3) Department or Section of Business:

4) Job title:

5) Your name:

6) Age:

7) Formal qualifications e.g. Diploma, Certificate:

a) Full-time day, part-time day release, or evening part-time:

b) Where was course completed:

8) Other training or skills e.g. labour relations:

9) Practical Civil Engineering Training:

10) Length of time spent in present job:

11) Total years in civil engineering:

WOULD YOU PLEASE TEAR THIS PAGE OUT AND USE IT FOR EASY REFERENCE FOR COMPLETION OF THE FIRST SECTION OF THIS FORM:

TASK ANALYSIS

IN THIS SECTION WOULD YOU PLEASE INDICATE:

A) HOW OFTEN YOU USE EACH ELEMENT IN YOUR JOB.
B) HOW IMPORTANT EACH ELEMENT IS TO YOUR JOB.
C) HOW MUCH YOU NEED TO KNOW ABOUT EACH ELEMENT.

BY PLACING YOUR ANSWER IN THE CORRESPONDING ANSWER COLUMN AND GIVING IT A NUMBER FROM 1 - 4

FOR COLUMN A)
1 WOULD INDICATE THAT YOU SPENT ALMOST ALL YOUR TIME USING THAT ELEMENT
2 WOULD INDICATE THAT YOU SPENT MORE THAN HALF OF YOUR TIME USING THAT ELEMENT
3 WOULD INDICATE THAT YOU SPENT LESS THAN HALF YOUR TIME USING THAT ELEMENT
4 WOULD INDICATE THAT YOU SPEND ALMOST NO TIME USING THAT ELEMENT

FOR COLUMN B)
1 WOULD INDICATE THAT THE ELEMENT WAS VERY IMPORTANT TO YOUR JOB
2 WOULD INDICATE THAT THE ELEMENT WAS IMPORTANT TO YOUR JOB
3 WOULD INDICATE THAT THE ELEMENT WAS NOT VERY IMPORTANT TO YOUR JOB
4 WOULD INDICATE THAT THE ELEMENT WAS NOT IMPORTANT TO YOUR JOB AT ALL

FOR COLUMN C)
1 INDICATES COMPLETE THEORETICAL AND WORKING KNOWLEDGE
2 INDICATES KNOWLEDGE OF PRINCIPLES ONLY
3 INDICATES PRACTICAL WORKING KNOWLEDGE
4 INDICATES BASIC FACTS ONLY
5 INDICATES NO KNOWLEDGE OF ELEMENT REQUIRED FOR YOUR JOB

TASK ANALYSIS

IN THIS SECTION WOULD YOU PLEASE INDICATE:

A) HOW OFTEN YOU USE EACH ELEMENT IN YOUR JOB.
B) HOW IMPORTANT EACH ELEMENT IS TO YOUR JOB.
C) HOW MUCH YOU NEED TO KNOW ABOUT EACH ELEMENT.

BY PLACING YOUR ANSWER IN THE CORRESPONDING ANSWER COLUMN AND GIVING IT A NUMBER FROM 1 - 4

FOR COLUMN A)
1 WOULD INDICATE THAT YOU SPENT ALMOST ALL YOUR TIME USING THAT ELEMENT
2 WOULD INDICATE THAT YOU SPENT MORE THAN HALF OF YOUR TIME USING THAT ELEMENT
3 WOULD INDICATE THAT YOU SPENT LESS THAN HALF YOUR TIME USING THAT ELEMENT
4 WOULD INDICATE THAT YOU SPEND ALMOST NO TIME USING THAT ELEMENT

FOR COLUMN B)
1 WOULD INDICATE THAT THE ELEMENT WAS VERY IMPORTANT TO YOUR JOB
2 WOULD INDICATE THAT THE ELEMENT WAS IMPORTANT TO YOUR JOB
3 WOULD INDICATE THAT THE ELEMENT WAS NOT VERY IMPORTANT TO YOUR JOB
4 WOULD INDICATE THAT THE ELEMENT WAS NOT IMPORTANT TO YOUR JOB AT ALL

FOR COLUMN C)
1 INDICATES COMPLETE THEORETICAL AND WORKING KNOWLEDGE
2 INDICATES KNOWLEDGE OF PRINCIPLES ONLY
3 INDICATES PRACTICAL WORKING KNOWLEDGE
4 INDICATES BASIC FACTS ONLY
5 INDICATES NO KNOWLEDGE OF ELEMENT REQUIRED FOR YOUR JOB

TASK ANALYSIS

HOW OFTEN DOES THE ELEMENT OCCUR IN YOUR JOB 1 - 4	HOW IMPORTANT IS THE ELEMENT TO YOUR JOB 1 - 4	ELEMENT	HOW MUCH DO YOU NEED TO KNOW ABOUT THE ELEMENT FOR THE CARRYING OUT OF YOUR JOB 1 - 5
		<u>CONSTRUCTION</u>	
		Strength of timber and concrete beams and columns	
		Bitumen	
		Circular formwork	
		Rigging	
		Underpinning	
		Coffer dams	
		Tunneling	
		Planning a simple construction job	
		Water pipe lines	
		Sewer construction	
		Plant	
		Placing Concrete under water	
		Timber bridge construction	
		Concrete culverts	
		Steel sheets and bending	

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TASK ANALYSIS

HOW OFTEN DOES THE ELEMENT OCCUR IN YOUR JOB 1 - 4	HOW IMPORTANT IS THE ELEMENT TO YOUR JOB 1 - 4	ELEMENT	HOW MUCH DO YOU NEED TO KNOW ABOUT THE ELEMENT FOR THE CARRYING OUT OF YOUR JOB 1 - 5
		MECHANICS	
		Levers	
		Pulley blocks, winches	
		Safe working load; fibre and wire ropes, chains.	
		Safe sustaining power of piles	
		Drop hammers, steam hammers	
		SPECIFICATION WRITING AND CONTRACTS	
		Clearing	
		Grading drainage embankments	
		Explosives	
		Interpretation of Contracts	
		Contractors risk	
		Security deposits	
		Responsibilities of parties	
		FOUNDATIONS	
		Properties of soils	
		Pile and pier foundations	
		Caissons	
		Air pressure work	

TASK ANALYSIS

HOW OFTEN DOES THE ELEMENT OCCUR IN YOUR JOB 1 - 4	HOW IMPORTANT IS THE ELEMENT TO YOUR JOB 1 - 4	ELEMENT	HOW MUCH DO YOU NEED TO KNOW ABOUT THE ELEMENT FOR THE CARRYING OUT OF YOUR JOB 1 - 5
		Critical path programming	
		<u>CONCRETE QUANTITIES</u>	
		Concrete quantities	
		<u>BOOK AND RECORD KEEPING</u>	
		Book and record keeping	
		<u>PUBLIC HEALTH</u>	
		Parks and gardens	
		Swimming facilities	
		Sanitary plumbing	
		House drainage	
		Camp sanitation	
		Sullage water	
		Sewage disposal	
		Stormwater drainage	
		Ventillation	

T A S K   A N A L Y S I S

HOW OFTEN DOES THE ELEMENT OCCUR IN YOUR JOB 1 - 4	HOW IMPORTANT IS THE ELEMENT TO YOUR JOB 1 - 4	ELEMENT	HOW MUCH DO YOU NEED TO KNOW ABOUT THE ELEMENT FOR THE CARRYING OUT OF YOUR JOB 1 - 5
		CALCULATIONS	
		Trigonometry, areas and volumes	
		Material Costing	
		Reduced Levels	
		Calculation of wages	
		TIMBER	
		Timber growth conversion	
		Seasoning	
		Identification and weight	
		Durability and suitability	
		Timber joints	
		Piling	
		FASTENINGS	
		Nails, screws, bolts and rivets	
		CONCRETE	
		Types of cement and mixes	
		Aggregates and tests for impurities	
		Slump and strength	

TASK ANALYSIS

HOW OFTEN DOES THE ELEMENT OCCUR IN YOUR JOB 1 - 4	HOW IMPORTANT IS THE ELEMENT TO YOUR JOB 1 - 4	ELEMENT	HOW MUCH DO YOU NEED TO KNOW ABOUT THE ELEMENT FOR THE CARRYING OUT OF YOUR JOB 1 - 5
		CONCRETE (contd.)	
		Methods of Mixing	
		Strengths of concrete	
		Formwork	
		Reinforcement	
		SAA code CAZ 1958	
		Effects of weather conditions	
		Expansion and contraction	
		Durability	
		SCAFFOLDING	
		Scaffolding different methods	
		Scaffolding and Lifts ACT	
		REPORT WRITING	
		Report writing	
		MISCELLANEOUS	
		Surveying	
		Training workers on the job	

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TASK ANALYSIS

HOW OFTEN DOES THE ELEMENT OCCUR IN YOUR JOB 1 - 4	HOW IMPORTANT IS THE ELEMENT TO YOUR JOB 1 - 4	ELEMENT	HOW MUCH DO YOU NEED TO KNOW ABOUT THE ELEMENT FOR THE CARRYING OUT OF YOUR JOB 1 - 5
		<u>MISCELLANEOUS</u> (contd.)	
		Solving problems	
		Developing group morale	
		Safety regulations	
		Concrete drying rate	
		Pneumatic drilling	
		Union regulations	

QUESTION PLEASE INDICATE THE NUMBER OF YOUR ANSWER IN THE ANSWER COLUMN	ANSWER
How much time do you spend directly supervising people? 1) most of the time 3) less than half 2) more than half 4) very little	
How much time do you spend writing and reading letters, reports, filling in forms; drawing and other forms of communication? 1) most 3) less than half 2) more than half 4) very little	
What is the major way you communicate with people? 1) by talking 2) by writing	
How much of your time do you spend in industrial relations? 1) more than half 3) less than half 2) most 4) very little	

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ON THIS PAGE PLEASE SELECT YOUR ANSWER FROM THE FOUR FOLLOWING CHOICES

1) most of the time   3) less than half

2) more than half   4) very little

FOR THE FOLLOWING 9 ITEMS, AND PLACE THE NUMBER IN THE ANSWER COLUMN.

	ANSWER
A) HOW MUCH TIME DO YOU SPEND IN ONE AVERAGE WEEK DEALING WITH:	
Problems of the nature of work	
Problems of the type of work	
Problems of wages	
Problems of conflict between management and workers/union	
B) HOW MUCH TIME DO YOU SPEND IN ONE AVERAGE WEEK DEALING WITH:	
Problems between workers	
Problems of absenteeism	
Problems of hiring and firing staff	
Dealing with health matters	
Policing safety regulations.	

TRAINING ANALYSIS	ANSWER
If you had to train someone to do your job which would you choose: (Please rank in order of preference)	
a) Full time formal course	1)
b) Full time followed by part time	2)
c) Part time formal course followed by full time practical experience, followed by full time course etc.	3)
d) Short intensive course	4)
e) Training within industry	5)
f) Correspondence course	6)
g) Self learning	7)
h) Other (please tell us)	8)
How many of these methods have you had experience of in learning your job?	
1) Formal classroom teaching	
2) T.V. and Films in conjunction with your course	
3) Individual project	
4) Group project	
5) Demonstrations	
6) On the job instruction.	

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ANSWER

How much of your training is of value in your job?

1) almost all
2) much
3) some
4) very little

How were you trained:

1) Formal course at an institution
2) apprenticeship
3) picked it up as you went along
4) self study
5) course conducted by employer
6) on the job training

Was this training carried out

1) at least one year before obtaining your present job
2) just before obtaining your present job
3) after obtaining your present job

	ANSWER
When did you last have any sort of formal training other than primary and secondary school? 1) during the last 12 months 2) between 1 and 5 years ago 3) more than 5 years ago 4) not at all What type (or types) was it? (please indicate) What attitude does your employer have to 'tech' or similar type courses for foremen? What support would he give?	A.14. p.15.

QUESTION	ANSWER
Do you feel your training fitted you for your present job? 1) Yes 2) No	

In what areas do you think you could have benefited by additional or further assistance?

1)

2)

3)

4)

5)

Do you think that there is any alternative to learning a foreman's job other than first hand practical experience? If so, what?

Could the training/experience required to make a good foreman be made shorter? If so how?

How could training be conducted in the country?

A.14. p.17.

Please tell us as much as you can about a foreman's job and the training he should receive - you are the expert in this type of work and in a position to tell us.

A.14.p.18.

From the small number of foremen in civil engineering practice we have consulted, it seems that many foremen are originally trained as carpenters and joiners. Is this true from your knowledge? If so, do you think there is a particular reason for this?