Research finding M-R-95

1982

The ideal skill mix in the civil engineering industry

S.S. Terblanche

RGN·HSRC

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PREFACE

This research has been commissioned by The South African Institute of Civil Engineers (SAICE) and funded by the CEAC. SAICE has indicated that it has no objection to the publication of the report.

I wish to thank the *ad hoc* advisory committee set up by SAICE for its comments on the original drafts of the questionnaire and report. A special word of thanks is due to Mr R.A. Heydenrych who chaired the meetings, and to all the engineers and technicians who participated in the survey.

DIRECTOR
July 1982

CONTENTS

		PAGE
1	INTRODUCTION	1
1.1	Background and aim	1
1.2	Method	2
1.3	The survey group	3
2	UTLIZATION OF WORKING TIME	9
2.1	Introduction	9
2.2	Time devoted to job functions	9
2.3	Length of working week and number of weeks worked per annum	14
2.4	Working time devoted by engineers to functions that persons with lower qualifications could do	14
2.5	Working time devoted by technicians to functions which persons with lower qualifications could do	18
3	THE PRESENT "IDEAL" RATIO BETWEEN ENGINEERS AND TECHNICIANS	20
3.1	Introduction	20
3.2	The present occupational structure	20
3.3	The "ideal" ratio	23
3.4	Factors influencing the ratio	24
3.5	The realism of the "ideal" ratios as training target	34
3.6	Recommendations	39
	APPENDIX A	40
	APPENDIX B	47
	BIBLIOGRAPHY	49

THE IDEAL SKILL MIX IN THE CIVIL ENGINEERING INDUSTRY

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND AIM

Both the engineer and the engineering technician play a crucial role in the civil engineering industry. Although this industry is sensitive to economic fluctuations and the demand for labour varies in accordance with the economic cycle, there is little doubt that both these categories of labour will be in short supply over the long term (Van Pletzen 1981, Terblanche 1981). Because of the relatively long training period there is no quick and easy way to alleviate the problem of manpower shortages except to pursue an active immigration policy, and these categories of labour should consequently be regarded as scarce resources and used accordingly.

Research conducted by the HSRC in 1973 (Ebersohn 1975) has indicated that engineers were often doing tasks on the technician level. As engineers are usually drawn from the top scholars (a very scarce resource) such a situation is undesireable. Research by Smit (1976) has shown clearly that, although technicians at the NDT level are drawn from the above average achiever in maths and science at school, only a very small percentage (about 5 %) of the learner technicians would complete an engineering degree. Because the potential pool of school leavers from which learner technicians can be drawn is larger than that from which engineers can be drawn, it can be concluded that it should be easier to increase the supply of technicians than the supply of engineers.

The South African Institute of Civil Engineers (SAICE) believes that if the "ideal" ratio between professional engineers and technicians could be determined, a more realistic assessment of training needs in the civil engineering field could then be made. SAICE has requested the HSRC's Institute for Manpower Research to undertake research in this regard. It is therefore the aim of this study to determine the present ratio between engineers and technicians and to indicate what a more "ideal" ratio should be.

1.2 METHOD

The present ratio between engineers and technicians is *inter alia* influenced by how these groups are utilized. If the engineer is indeed doing work that could be performed just as efficiently by a person with a lower qualification, then he is underutilized. Basic to this approach is the assumption that a qualified engineer and a technician (although individual differences will occur) should each be able to do a certain minimum amount of work at a certain level of complexity.

Only a few research options were open. The ratio could have been determined by detailed job evaluation but this approach would have been extremely expensive and time consuming, not only in terms of real research expenses but also in terms of lost production time for any organization taking part in the survey. A more economical but also more subjective research design was therefore used. The engineers and technicians were asked to indicate the percentage working time spent on a list of job functions and to indicate, for each job function, what percentage of the time spent on each function could be performed just as efficiently by a person with other qualifications (see Appendix A, Question 10, Columns A, B and C).

The list of job functions was drawn up after discussions with civil engineers and finalized by an advisory committee appointed by SAICE. This committee also agreed with the methodological approach used in the study.

A sample of 226 firms, nine government departments, local authorities and provincial administrations were contacted and asked if they would be willing to distribute questionnaires among the civil engineers and technicians (including draughtsmen) in their employ.

All the consulting firms listed by the South African Association of Consulting Engineers and a selection of the large construction firms listed by the South African Federation of Civil Engineering Contractors, as well as nine public authorities (Government departments, local authorities and provincial administrations) were asked to participate in the survey by distributing questionnaires among the civil engineers and technicians (including draughtsmen) in their employ.

The co-operation of 103 firms was obtained. Questionnaires were then sent to these firms (see Appendix B) in which they were requested to indicate the structure of their personnel. Of the 103 firms, 65 returned satisfactorily completed questionnaires. The survey took place during June to August 1981.

1.3 THE SURVEY GROUP

Table 1.1 shows the research group in terms of organization and position in the organization. Table 1.2 gives a qualification breakdown and Table 1.3 the age structure. The totals in the various tables differ slightly because not all the respondents supplied all the required information.

Engineers (both professional and graduated) made up the bulk of the sample (66 %).

The employer group structure of the engineers was as follows:

	N	%
Consulting firms	700	59,7
Construction firms	184	15,7
Government sector	288	24,6
	1 172	100

Table 1.3 shows that the group of graduated engineers must contain quite a number of engineers in training because 71 % are in the age group 25-29 years, after which the percentage drops sharply when compared to professional engineers. The age structure of this sample compares well with the age structure obtained in IMAN's salary survey (Van der Walt 1981) in which 1 952 civil engineers took part.

The educational level of the survey group was categorized as follows:

Group 1

Std 10, NTC III

Group 2

RSA qualifications

National Technical Certificate (NTC IV & V)
Advanced Technical Certificate (ATC I and II)
National Certificate for Technicians (NCT)

Intermediate Diploma for Technicians (IDT)

National Teaching Diploma (Technical)

Certificate of Competency as Telecommunications Technicians (Post Office)

Typing Diploma - two years' post matriculation training

Secretarial Training - two years' post matriculation training

Other

"B" certificate with specialization (Belgium)

Meisterprüfung (Germany)

Ordinary National Certificate (ONC Britain)

City and Guilds of London Institute (CGLI)

Final Technical Course (Britain)

Engineering Certificate (Victoria, Australia)

Group 3

RSA qualifications

National Technical Diploma (NTD)

National Engineering Diploma

Higher National Certificate for Technicians (HNCT)

Other

Staatlich Geprüfter Techniker (Germany)

Middelbare Technische School (MTS, Netherlands)

Uitgebreid Technische School (UTS,Netherlands)

Higher National Certificate (HNC,Britain)

CGLI Full Technical Course (Britain)

Engineering Diploma (Australia)

Diploma for Electronic Technicians (Bulgaria)

General Mechanical Technician Diploma (Hungary)

Technical Diploma (Poland)

National Technical Certificate (Switzerland)

Technical Diploma (Czechoslovakia)

Group 4

National Diploma for Technicians (NDT)
Higher National Diploma for Technicians (HNDT)
Government Certificate of Competency
Certificate as Mine Surveyor

Group 5

Hogere Technische School (HTS,Netherlands)
Government Certificate (Rhodesia)
Chartered Engineer (CE, Britain)
Diplom HTL (Switzerland)
Technische Ingineer with Specialization "A_2" (Belgium)
Technische Ingineer with Specialization "A_3" (Belgium)
B. Tech. (Australia)
Dip. Tech. (Britain)
Higher National Diploma (HND, Britain)
Technische Ingineer "A" (Belgium)
Ing-Grad (Germany)

Group 6

Bachelor's degree in engineering

Group 7

Honours and higher degrees

As can be expected, more than 90 % of the engineers had at least a B. degree in Engineering.

A total of 476 technicians, draughtsmen and technologists were included in the survey. The technicians in the government sector and construction firms had an appreciably higher educational level than those in the consulting firms.

TABLE 1.1

OCCUPATIONAL STRUCTURE OF THE SURVEY GROUP BY EMPLOYER

Occupation	Consulting firm				Government sector		Construction firm				Total	
	Director/ partner		Employee		Employee		Director/ partner		Employee			
	N	%	N	%	N	%	N	%	N	%	N	%
Professional engineer	219	96,9	309	38,8	193	45,1	34	69,4	66	25,6	821	46,7
Graduated engineer	5	2,2	165	20,7	94	22,0	9	18,4	76	29,5	349	19,9
Technologist			24	3,0	20	4,7	1	2,0	5	1,9	50	2,8
Technician			186	23,4	89	20,8	2	4,1	77	29,8	354	20,1
Learner technician			27	3,4	11	2,6			13	5,0	51	2,9
Draughtsman			56	7,0	12	2,8	1	2,0	1	0,4	70	4,0
Learner draughtsman			8	1,0	1	0,2					9	0,5
Other	2	0,9	21	2,6	8	1,9	2	4,1	20	7,8	53	3,0
TOTAL	226	100	796	100	428	100	49	100	258	100	1757	100

TABLE 1.2

QUALIFICATION LEVEL OF THE SURVEY GROUP BY OCCUPATION

Occupation		Qualification level							Total	
		1	2	3	4	5	6	7	N	%
A. Consulting firm										
Professional engineer	N					31	353	146	530	52,2
	%					5,8	66,7	27,5	100	
Graduated engineer	N					3	117	50	170	16,7
	%					1,8	68,8	29,4	100	
Technologist	N	1	4	3	15	1			24	2,4
	%	4,2	16,7	12,5	62,5	4,2			100	
Technician	N	40	36	25	73	6	1		181	17,8
	%	22,1	19,9	13,8	40,3	3,3	0,6		100	
Learner technician	N	17	6	3	1				27	2,7
	%	63,0	22,2	11,1	3,7				100	
Draughtsman	N	25	15	4	8	2			54	5,3
	%	46,3	27,8	7,4	14,8	3,7			100	
Learner draughtsman	N	7	1						8	0,8
	%	87,5	12,5						100	
Other	N	8		1	5	1	4	3	22	2,2
	%	36,4		4,5	22,7	4,5	18,2	13,6	100	
TOTAL	N	98	62	36	102	44	475	199	1 016	100
	%	9,6	6,1	3,5	10,0	4,3	46,8	19,5	100	
B Government sector										
Professional engineer	N				1	6	131	55	193	45,0
	%				0,5	3,1	67,9	28,5	100	
Graduated engineer	N					1	76	18	95	22,1
	%					1,1	80,0	18,9	100	
Technologist	N	1	1	2	15	1			20	4,7
	%	5,0	5,0	10,0	75,0	5,0			100	
Technician	N	13	5	6	62	2		1	89	20,7
	%	14,6	5,6	6,7	69,7	2,2		1,1	100	
Learner technician	N	7	1	2	1				11	2,6
	%	63,6	9,1	18,2	9,1				100	
Draughtsman	N	9	2		1				12	2,8
	%	75,0	16,7		8,3				100	
Learner draughtsman	N	1							1	0,2
	%	100,0							100	
Other	N	6					1	1	8	1,9
	%	75,0					12,5	12,5	100	
TOTAL	N	37	9	10	80	10	208	75	429	100
	%	8,6	2,1	2,3	18,6	2,3	48,5	17,5	100	
C Construction firm										
Professional engineer	N	3		1		11	71	13	99	32,6
	%	3,0		1,0		11,1	71,7	13,1	100	
Graduated engineer	N			1	2	13	54	15	85	28,0
	%			1,2	2,4	15,3	63,5	17,6	100	
Technologist	N			1	1	4			6	2,0
	%			16,7	16,7	66,7			100	
Technician	N	5	3	8	60	2			78	25,7
	%	6,4	3,8	10,3	76,9	2,6			100	
Learner technician	N	6	6		1				13	4,3
	%	46,2	46,2		7,7				100	
Draughtsman	N				1		1		2	0,7
	%				50,0		50,0		100	
Learner draughtsman	N									
	%									
Other	N	2	2	5	7	2	1	2	21	6,9
	%	9,5	9,5	23,8	33,3	9,5	4,8	9,5	100	
TOTAL	N	16	11	16	72	32	127	30	304	100
	%	5,3	3,6	5,3	23,7	10,5	41,8	9,9	100	

TABLE 1.3

AGE STRUCTURE OF THE SURVEY GROUP

Age group	Occupation																	
	Professional engineer		Graduated engineer		Technologist		Technician		Learner technician		Draughtsman		Learner draughtsman		Other		Un-specified		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
15 - 19									6	11,8			1	10,0					7	0,4
20 - 24			34	9,8	3	5,9	13	3,7	32	62,7	5	7,0	6	60,0	4	7,4	2	66,7	99	5,6
25 - 29	70	8,5	215	61,8	7	13,7	86	24,3	11	21,6	12	16,9	3	30,0	12	22,2			416	23,6
30 - 34	199	24,2	55	15,8	16	31,4	90	25,4	1	2,0	15	21,1			12	22,2			388	22,0
35 - 39	151	18,3	23	6,6	7	13,7	67	18,9			16	22,5			7	13,0			271	15,4
40 - 44	140	17,0	7	2,0	9	17,6	36	10,2	1	2,0	8	11,3			6	11,1	1	33,3	208	11,8
45 - 49	82	10,0	4	1,1	4	7,8	26	7,3			9	12,7			6	11,1			131	7,4
50 - 54	75	9,1	4	1,1	1	2,0	24	6,8											104	5,9
55 - 59	60	7,3	1	0,3	3	5,9	9	2,5			2	2,8			6	11,1			81	4,6
60 - 64	31	3,8	4	1,1	1	2,0	2	0,6			1	1,4			1	1,9			40	2,3
65 +	15	1,8	1	0,3			1	0,3			3	4,2							20	1,1
TOTAL	823	100	348	100	51	100	354	100	51	100	71	100	10	100	54	100	3		1 765	100

CHAPTER 2
UTILIZATION OF WORKING TIME

2.1 INTRODUCTION

The first step in determining the ratio between engineers and technicians was to determine how engineers and technicians spend their working time. How to obtain information in mail questionnaires has been frequently debated by researchers. Should one state a specific time span or would a general question suffice? To determine the difference in results between these two approaches, both questions were asked (see Appendix A, Question 10, Columns A and B). In Column A the respondent was asked to indicate the average time spent on each of a list of specified job functions and in Column B to indicate the time spent during the last two weeks.

After obtaining an indication of the percentage of working time spent on each job function, the respondent was then asked to indicate what percentage of the time devoted to a specific job function could be performed just as efficiently by a person with other qualifications (see Question 10, Column C).

2.2 TIME DEVOTED TO JOB FUNCTIONS

Table 2.1 indicates the percentage time spent on the various job functions during the last two weeks and Table 2.2 the average time spent.

It should be remembered that the percentages supplied by respondents were not exactly determined. They should therefore be regarded as estimates since many respondents supplied percentages in multiples of five. The total percentage time spent on all functions should of course add up to 100 but totals ranging from 95 to 105 were accepted. The $\bar{X}$ columns in Tables 2.1 and 2.2, therefore, do not add up exactly to 100 and decimal points are left out.

Tables 2.1 and 2.2 indicate the average working time spent on a function for the number of respondents in a group. Not all the respondents in a group devoted time to a specific function. Analysis shows, for example,

that only 152 of the 350 graduated engineers (43 %) devoted time to preliminary investigation during the last two weeks. On the other hand 234 (67 %) indicated a percentage on the "on average" question. Generally speaking, a much higher percentage was indicated on the "last two weeks" question by those who performed the function over the last two weeks, than on the "on average" question. Taking graduated engineers again as an example, 43 % indicated an average of 28 % of their time devoted to preliminary investigation in the case of the "last two" weeks and 67 % indicated an average of 12 % in the case of "on average".

Table 2.1 and 2.2 show that, provided the numbers in a group are relatively large so that the specific situation of a few individuals does not have much influence, the way in which the question is asked does not make that much difference. The differences in the two tables for professional engineers, for example, are small. Both tables indicate that project management and managerial and administrative functions are the two job functions on which the largest percentage of working time is spent, both in the order of 16 %. Graduated engineers devote less time to managerial functions than professional engineers, but more to detail design. Project management is their single most important function. As can be expected, draughtsmen devote the bulk of their time to detail documentation.

Table 2.3 shows the results of the answer to Question 10, Column C, i.e. what percentage of the work indicated in Column B could be performed just as efficiently by a person with other qualifications? As far as the engineer group is concerned "measurement" stands out as the job function in which a considerable amount of the work can also be done by people with other qualifications. Also high on the list is managerial and administrative functions. There is of course an interrelationship between the percentage of the work that other people can do and the percentage of time devoted to a specific function. Table 2.1 indicates that 16 % of the working time of professional engineers is devoted to managerial functions and 9 % to measurement. If 18 % of this time is devoted to work which another person can do it means that roughly 3 % of the total working time or job can be done by persons with other qualifications. In the case of measurement it is about 2 %.

TABLE 2.1

AVERAGE PERCENTAGE OF WORKING TIME SPENT ON EACH JOB FUNCTION DURING THE LAST TWO WEEKS BY THE TOTAL SURVEY GROUP

Job function	Professional engineer N=823		Graduated engineer N=350		Tech-nologist N=51		Technician N=354		Learner technician N=51		Draughts-man N=71		Learner draughtsman N=10		Other N=54	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
1 Preliminary investigation	10	15,8	7	12,9	10	14,8	6	11,7	5	12,1	2	8,0			8	19,1
2 Development of design	9	14,1	11	18,3	7	10,7	7	13,6	4	7,0	9	15,9	12	16,8	3	7,7
3 Detail design	9	16,4	14	22,9	11	17,2	8	15,6	6	11,9	6	13,3			2	4,8
4 Detail documentation	6	13,5	9	17,2	11	18,6	16	27,3	27	35,2	67	36,3	32	36,4	9	24,3
5 Technical writing	11	15,4	9	16,1	7	9,2	6	13,3	3	6,0	2	7,0	4	9,8	7	15,1
6 Measurement, etc.	9	12,6	13	18,6	12	18,4	14	19,8	22	25,6	5	6,0	9	9,0	23	26,9
7 Project management	17	22,4	18	24,4	13	18,4	11	21,3	1	3,4	<1	6,0	1	3,2	15	23,5
8 Investigation and testing	1	4,4	2	6,7	6	14,3	5	14,8	5	16,0					3	10,7
9 Surveying	1	3,6	4	10,8	8	15,3	12	22,0	9	19,5	<1	3,7	2	4,2	7	16,5
10 Control of company as a client	2	7,8	1	5,6	2	3,9	<1	3,3							<1	2,6
11 Managerial and administrative	16	20,2	8	15,0	10	13,3	10	16,4	3	8,1	6	15,5			13	20,0
12 Travel	5	7,0	5	7,1	5	5,4	5	8,4	4	9,7	<1	2,8	<1	1,6	6	7,7
13 Education and training																
(a) Giving	1	3,1	<1	1,6	2	7,3	2	5,1	<1	1,2	3	6,9			2	6,8
(b) Receiving	1	7,1	<1	3,4	<1	3,1	<1	5,2	13	27,6	<1	4,9	<1	2,5	3	7,7
(c) Research	<1	3,1	<1	1,4	<1	1,4	<1	1,5	<1	2,0	<1	0,9			2	7,8
14 Other	2	8,7	1	8,2	<1	2,8	2	8,9	3	14,7	<1	4,0	5	8,3	5	13,7

TABLE 2.2

AVERAGE PERCENTAGE OF WORKING TIME SPENT ON EACH JOB FUNCTION BY TOTAL SURVEY GROUP

Job function	Professional engineer N=823		Graduated engineer N=350		Technologist N=51		Technician N=354		Learner technician N=51		Draughtsman N=71		Learner draughtsman N=10		Other N=54	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
1 Preliminary investigation	11	10,8	8	10,8	8	11,2	6	10,2	5	12,6	3	7,0	1	3,2	8	16,0
2 Development of design	10	9,9	10	12,3	9	9,7	8	10,7	7	10,0	8	9,8	9	12,2	3	6,3
3 Detail design	10	12,9	16	19,7	12	16,8	9	12,3	6	8,2	7	14,2	4	9,8	2	5,1
4 Detail documentation	6	9,2	9	13,8	10	12,0	16	24,4	24	31,1	66	31,1	38	34,4	12	26,8
5 Technical writing	11	11,7	8	10,2	9	9,2	6	10,0	4	5,8	<1	2,6	2	4,2	6	10,7
6 Measurement, etc.	6	7,1	9	12,4	9	16,3	9	13,8	9	17,9	2	4,4	3	6,7	13	22,1
7 Project management	16	20,5	19	24,7	10	11,7	11	18,6	<1	2,2	<1	5,0	<1	0,3	17	23,4
8 Investigation and testing	2	4,2	2	4,5	6	12,7	5	13,3	7	18,2	<1	0,6			5	12,7
9 Surveying	1	3,1	4	8,0	8	13,8	11	19,5	9	18,9	<1	1,8	1	3,1	8	16,7
10 Control of company as client	2	7,6	1	5,2	2	3,5	1	3,8							<1	2,7
11 Managerial and administrative	16	18,5	8	13,7	19	10,5	10	16,1	2	6,5	6	15,1			11	16,5
12 Travel	5	4,9	3	4,7	4	4,8	5	6,3	3	5,6	<1	2,0	1	3,2	5	6,1
13 Education and training																
(a) Giving	1	3,0	<1	1,2	3	6,5	2	4,7	<1	1,0	2	5,2	2	5,7	2	8,2
(b) Receiving	<1	2,2	1	3,4	<1	1,1	<1	4,8	18	24,0	2	6,7	14	22,6	2	9,2
(c) Research	<1	2,8	<1	1,2	<1	1,8	<1	1,9	<1	2,2	<1	1,2	<1	1,3	2	9,2
14 Other	2	6,7	1	6,7	<1	1,6	1	6,9	1	7,2	1	2,5	3	9,4	4	8,5

TABLE 2.3

PERCENTAGE OF WORKING TIME SPENT ON A FUNCTION THAT COULD BE PERFORMED BY A PERSON WITH OTHER QUALIFICATIONS

Job function	Professional engineer		Graduated engineer		Tech-nologist		Technician		Learner technician		Draughts-man		Learner draughtsman		Other	
	N=823		N=350		N=51		N=354		N=51		N=71		N=10		N=54	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
1 Preliminary investigation	12	24,0	12	26,8	16	31,7	9	24,5	3	11,9	4	18,2			14	28,8
2 Development of design	14	26,4	13	26,8	12	28,8	11	27,0	7	19,1	5	13,0	7	11,9	11	28,1
3 Detail design	17	30,6	17	31,0	12	26,1	9	24,4	4	13,5	3	10,4			4	16,1
4 Detail documentation	15	31,1	19	34,7	23	36,0	17	31,6	15	27,7	29	36,4	5	11,1	4	17,3
5 Technical writing	13	24,5	16	29,8	16	28,7	11	26,0	3	12,2	3	17,0	4	9,8	6	19,9
6 Measurement, etc.	21	34,3	25	37,2	14	29,5	15	30,5	7	18,5	6	23,2	3	6,2	20	36,7
7 Project management	17	28,8	17	29,7	14	30,4	11	27,1	4	17,7	<1	3,0			11	24,4
8 Investigation and testing	5	18,9	9	25,2	10	26,2	6	21,4	5	18,5					5	19,2
9 Surveying	6	21,8	18	35,5	8	19,7	14	30,6	11	28,7	1	11,9	1	3,2	10	27,6
10 Control of company as client	3	12,3	3	15,1	3	14,1	2	13,0							1	5,4
11 Managerial and administrative	18	28,8	19	33,1	17	32,1	14	29,6	5	19,3	5	15,6			22	35,5

2.3 LENGTH OF WORKING WEEK AND NUMBER OF WEEKS WORKED PER ANNUM

Other information that is needed for the interpretation of the time spent on job functions is the actual time devoted to these functions and therefore questions were asked on the number of weeks worked per annum and the number of hours worked per week. The product of these two quantities yields the number of man hours worked per year.

Table 2.4 indicates the average length of the working year and the number of hours worked per week.

Most of the respondents work about 48 weeks per annum. The number of hours worked differs more than the number of weeks worked. The length of the average working week in construction firms is appreciably longer than in the other two employer groups.

2.4 WORKING TIME DEVOTED BY ENGINEERS TO FUNCTIONS THAT PERSONS WITH LOWER QUALIFICATIONS COULD DO

The occupational structure of a firm is a function of a number of factors. Examples would be the availability of support personnel, the use that is made of services available outside the firm, the size of the firm, the specific abilities of the available personnel, the history of the development of the firm and managerial efficiency. The interaction between these factors ultimately determines the occupational structure of the firm and therefore the ratio between engineers and technicians.

The factors mentioned above are all very nearly impossible to quantify. This study is aimed at determining the "ideal" ratio between engineers and technicians by concentrating on how working time is used. The respondents were requested to indicate, without giving any attention to the practical situation in their working environment, what percentage of their work could be performed just as efficiently by persons with other qualifications (Appendix A, Question 10, Column C). If a part of the work could be done by persons with lower qualifications it would mean that the personnel was "underutilized". The respondents were also asked to indicate the educational level of the hypothetical person.

TABLE 2.4

AVERAGE LENGTH OF WORKING WEEK AND NUMBER OF WEEKS WORKED PER YEAR

Occupation	Consulting firm				Construction firm				Government			
	Hours		Weeks		Hours		Weeks		Hours		Week	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
Professional engineer	503	43,7	527	48,0	100	50,1	99	48,4	191	41,5	192	48,1
Graduated engineer	169	42,0	167	47,9	84	53,4	84	48,7	95	41,6	95	47,4
Technologist	24	40,8	24	48,3	7	48,9	7	44,6	20	43,2	20	48,1
Technician	184	41,0	183	47,9	79	50,5	78	48,4	87	41,7	87	47,7
Learner technician	27	40,2	26	44,3	13	48,9	13	43,5	11	40,9	10	48,1
Draughtsman	56	40,1	56	48,0	2	47,5	2	48,0	13	37,8	12	47,0
Learner draughtsman	9	40,0	7	48,7								
Other	23	42,3	23	46,6	22	52,3	22	49,0	8	41,0	8	48,8

The time devoted to work which could be done by persons with lower qualifications is presented in number of man years and is calculated as follows:

If a = number of weeks worked p.a.,

b = number of hours worked per week,

then a x b = number of man hours worked p.a.

If x_i = % time devoted to a specific function i,

y_i = % time of a function that a person (A) with lower qualifications could do of function i.

Then $(a \times b) \times \frac{x_i}{100} \times \frac{y_i}{100}$ = number of man hours A could do in function i.

Say this quantity = mh

As each respondent indicating time, i.e. mh, also classified mh according to qualificational level, the total number of man hours (Σ mh) could be classified by educational level.

To find the number of man years "saved", the total number of man hours (Σ mh) was divided by the average number of man hours p.a. devoted to working time.

Thus $\frac{\Sigma \text{ mh}}{\frac{a \times b}{N}}$ = man years where N = number of persons in an occupational category.

A man year can also be equated to one personnel unit.

Table 2.5 indicates the results of this method for engineers (professional and graduated). To facilitate discussion, the amount of work, whether in man hours or man years, that could be done by persons with lower qualifications is referred to as "time saved".

In all, 1 161 engineers supplied information from which the results were calculated. Saving 308 man years means that hypothetically 26,5 % of the work now being done by the engineers could have been done by persons with lower qualifications. Looking at the qualification distribution the engineers were mainly (35 %) thinking about technicians with a National Diploma for Technicians (qualification Group 4) and technicians with the older National Technical Diploma (qualification Group 3). Even lower qualification levels were mentioned and 37 man years can be saved by the employment of persons at NTC III or NTC IV and V levels.

TABLE 2.5

ENGINEER MAN YEARS SAVED BY QUALIFICATION AND EMPLOYMENT GROUP

Employer group		Qualification group						
		1	2	3	4	5	Unspe-cified	Total
Consulting firm Small firm (10 or fewer engineers)(N=140)		0,65	4,13	10,51	15,66	2,88	4,06	37,89
Medium firm (11-29 engineers)(N=146)		0,78	4,29	5,74	12,51	6,71	3,18	33,21
Large firm (30 > engineers)(N=407)		1,89	10,47	26,73	34,76	16,23	11,09	101,17
Construction firm (N=182)		2,69	8,13	14,71	21,99	10,53	7,03	65,08
Government sector (N=286)		4,96	9,08	21,11	23,50	5,32	7,41	71,38
TOTAL (N=1 161)	Years	10,97	36,1	78,8	108,42	41,67	32,77	308,73
	%	3,6	11,7	25,5	35,1	13, 5	10,6	100

One can expect the size of the firm and the kind of work being done by the firm to have an influence on the number of support personnel available and on the way in which support personnel is utilized. The consulting firms were divided into three groups, i.e. small firms employing ten or fewer engineers, medium firms employing between 11 and 29 engineers and large firms employing more than 30 engineers. No division was made for the consulting groups because only the larger firms were initially contacted.

To make the information in Table 2.6 more comparable, the man years have been divided by the number of engineers in the group. The results give an index which can be called the underutilization index because it gives the fraction of man years per engineer that can be saved. The decimal points have been left out and the index worked to two digits.

TABLE 2.6

UNDERUTILIZATION INDEX FOR ENGINEERS

Employer groups	Qualification group						
	1	2	3	4	5	Unspe-cified	Total
Consulting firm							
Small	-	3	8	11	2	3	27
Medium	1	3	4	9	5	2	23
Large	-	3	7	9	4	3	25
Construction firm	1	4	8	12	6	4	35
Government sector	2	3	7	8	2	3	25

The higher the index the more work that can be done by persons with lower qualifications. Table 2.6 shows that the engineers in the construction firms are spending relatively more of their time on functions they feel could be performed by technicians.

One would have expected that in the case of consulting firms there would have been a clear trend towards better utilization as the firm grows bigger. This is apparently not the case. Separate underutilization indices have also been worked out for the professional and graduated engineers.

TABLE 2.7

UNDERUTILIZATION INDEX FOR PROFESSIONAL AND GRADUATED ENGINEERS

Employer group	Qualification group											
	1		2		3		4		5		Unspecified	
	P	G	P	G	P	G	P	G	P	G	P	G
Consulting firm												
Small		1	2	3	7	8	11	12	3		3	2
Medium		2	2	5	2	9	9	6	5	4	2	1
Large		1	2	3	5	10	8	11	4	4	3	2
Construction firm		3	3	6	5	12	10	15	5	6	5	3
Government sector	2	1	3	3	4	14	7	10	2	1	2	4

According to Table 2.7 there tends to be a difference in the utilization of professional and graduated engineers; with the graduated engineers indicating a larger percentage of their time spent on functions that persons with lower qualifications could do. This is especially true for construction firms and the government sector. In Chapter 1 it was shown that, based on the age structure of the graduated engineers, a large percentage of them should be regarded as engineers in training. The difference between the professional and the graduated engineers can be expected.

2.5 WORKING TIME DEVOTED BY TECHNICIANS TO FUNCTIONS WHICH PERSONS WITH LOWER QUALIFICATIONS COULD DO

The exercise that was done for engineers (see Table 2.5) was repeated for the technicians in the survey group, but only for those who were

in possession of qualifications in Groups 4 or 5. The number of man years saved is indicated in Table 2.8.

TABLE 2.8

MAN YEARS THAT COULD BE SAVED FOR TECHNICIANS WITH QUALIFICATIONS 4 OR 5

Employer group		Qualification group			Total
		1	2	3	
Consulting firm	(N=104)	5,54	7,15	9,93	22,62
Construction firm	(N=77)	2,50	2,00	3,49	7,99
Government sector	(N=68)	2,60	3,84	3,84	10,28
TOTAL (N=249)	Years	10,64	12,99	17,26	40,89
	%	26,0	31,8	42,2	100,0

Table 2.8 shows that the technicians felt that they were also doing work which could be performed by personnel with lower qualifications, i.e. qualification groups 1 to 3. In the case of consulting firms the technicians estimated that 21,8 % of their working time was devoted to such functions. In the case of construction firms and the government sector these percentages were 10,4 and 15,1. Two conclusions can possibly be drawn: it seems as though qualified technicians can be more gainfully employed and that the consulting firms form the group which should have a close look at the utilization of their highly qualified technicians.

CHAPTER 3
THE PRESENT "IDEAL" RATIO BETWEEN ENGINEERS AND TECHNICIANS

3.1 INTRODUCTION

In the previous chapter it was shown that engineers and technicians felt that a certain portion of their work could be performed just as efficiently by persons with lower qualifications.

A short questionnaire (see Appendix B) was posted to the 103 private firms that were willing to participate in the research asking them to indicate their present technical manpower structure. Of the 103 firms 65 returned completed questionnaires. Comparable information was also received form seven public sector institutions, i.e. government departments, provincial administrations and local authorities. Using this information as well as the data from Chapter 2 the present "ideal" ratio between engineers and technicians was calculated. This ratio is purely hypothetical because the practical situation in the organizations cannot be taken into account.

3.2 THE PRESENT OCCUPATIONAL STRUCTURE

The response obtained from the 65 firms and seven public sector institutions is shown in Table 3.1.

Table 3.1 indicates that the occupational structures vary from group to group.

The consulting firms employed relatively more engineers (40 % of their labour force) than the construction firms. This difference was due to the difference in the main functions of the two groups. In Table 3.2, Table 3.1 is reduced to the number of engineers and qualified technicians employed. Certificated engineers were regarded as technicians as were draughtsmen.

Both Tables 3.1 and 3.2 show that the number of technicians with qualifications lower than NDT employed in consulting firms or the public sector was about as large as the number employed who had a qualification at NDT level or above. The construction firms employed relatively more technicians in qualification Groups 4 and 5.

TABLE 3.1

STRUCTURE OF TECHNICAL PERSONNEL

Occupation	Consulting firm						Construction firm		Public sector	
	Small		Medium		Large					
	N	%	N	%	N	%	N	%	N	%
Graduated engineer	165	41,3	239	43,2	783	45,1	409	29,2	231	39,3
Certificated engineer	15	3,8	11	2,0	66	3,8	70	5,0		
Other graduates	4	1,0	13	2,4	55	3,2	72	5,1	6	1,0
Draughtsmen with NDT	55	13,8	36	6,5	162	9,3	22	1,6	22	3,7
Draughtsmen lower than NDT	57	14,3	66	11,9	131	7,6	21	1,5	25	4,3
Pupil draughtsmen	19	4,8	21	3,8	93	5,4	28	2,0	21	3,6
Surveying technicians with NDT	10	2,5	3	0,5	16	0,9	68	4,9	39	6,6
Surveying technicians lower than NDT	16	4,0	10	1,8	9	0,5	24	1,7	15	2,6
Pupil surveying technicians	3	0,8	3	0,5	1	0,1	64	4,6	27	4,6
Other technicians with NDT	19	4,8	47	8,5	126	7,3	239	17,0	78	13,3
Other technicians (lower than NDT)	19	4,8	93	16,8	223	12,9	45	3,2	97	16,5
Other pupil technicians	18	4,5	11	2,0	70	4,0	340	24,3	27	4,6
TOTAL	400	100	553	100	1 735	100	1 402	100	588	100

TABLE 3.2

NUMBER OF ENGINEERS AND TECHNICIANS EMPLOYED

Occupation	Consulting firm						Construction firm		Public sector	
	Small		Medium		Large					
	N	%	N	%	N	%	N	%	N	%
Engineer	165	46,3	239	52,1	783	51,6	409	45,5	231	45,6
Technician (NDT and higher)	99	27,8	97	21,1	370	24,4	399	44,4	139	27,4
Technician (below NDT)	92	25,8	123	26,8	363	23,9	90	10,0	137	27,0
TOTAL	356	100	459	100	1 516	100	898	100	507	100

The number of "Other" pupil technicians (Table 3.1) in construction firms was high when compared to the other employer groups and was an indication of the future use construction firms will have to make of technicians. It is also an indication of the effect that the specific task of an organization has on its employment structure.

3.3 THE "IDEAL" RATIO

The ideal ratio was then calculated by using the data in Table 2.5. Table 2.5 shows for example that firms employing less than ten engineers (140 engineers in total) could save 37,89 man years of the available 140, which gives 27,1 %. Applying this percentage to the 165 engineers shown in Table 3.2 gives an answer of 45 engineers. Table 2.5 also gives the qualification structure. Of the 37,89 man years 40 % could be saved by having persons with qualifications below NDT doing the work. The 4,06 man years which have not been specified were divided *pro rata* between the "below NDT" and "NDT or higher" groups. The 45 persons were then classified according to qualification groups. The ratio for such firms thus became 120 : 124 : 112 (1 : 1 : 09) instead of the 165 : 99 : 92 (1 : 06 : 05) shown in Table 3.2. This exercise was then repeated for the other employer groups.

The results appear in Table 3.3.

TABLE 3.3

PRESENT AND IDEAL RATIO BETWEEN ENGINEERS AND QUALIFIED TECHNICIANS

Consulting firms		Engineers	Technicians NDT and +	Technicians NDT-
Small firms	Present ratio	165 (1)	99 (0,6)	92 (0,5)
	Ideal ratio	120 (1)	124 (1,0)	112 (0,9)
Medium firms	Present ratio	239 (1)	97 (0,4)	123 (0,5)
	Ideal ratio	184 (1)	132 (0,7)	143 (0,9)
Large firms	Present ratio	783 (1)	370 (0,5)	363 (0,5)
	Ideal ratio	588 (1)	474 (0,8)	455 (0,8)
Total consulting	Present	1187 (1)	566 (0,5)	578 (0,5)
	Ideal	892 (1)	730 (0,8)	710 (0,8)
Construction firms	Present ratio	409 (1)	399 (1)	90 (0,2)
	Ideal ratio	263 (1)	480 (1,8)	155 (0,6)

It will be noticed that no ratio was calculated for the public sector. The personnel in the public sector are part of a larger force which, in many cases, supply supporting services to those sections which deal more specifically with civil engineering tasks.

No single ratio was calculated for construction and consulting firms. Because of the difference in work content, the ratios for the two groups were clearly different. Although it could be expected that the survey groups from the consulting and construction sides would each reflect the situation in their own group, it could not be said that the survey group as a whole was representative of the civil engineering industry, as has already been explained.

Theoretically speaking, Table 3.3 indicates that much better use can be made of the available engineers by making use of technicians.

In the consulting groups half of these technicians (which included draughtsmen) need not have had a NDT. According to Table 3.3 the present ratio of 1 engineer to 1 techncian could be increased to 1 : 1,6. On the construction side the present ratio of 1 : 1,2 could theoretically be raised to 1 : 2,4. Most of these technicians, however, should be trained up to NDT level.

3.4 FACTORS INFLUENCING THE RATIO

3.4.1 *The availability of personnel*

The problem is whether something can be done about the situation. Respondents were asked to indicate the role played by five factors (Appendix A, Question 11) on a five point scale, for each job function where they indicated that time could be saved. These factors were:

(a) No suitable personnel available in the organization.
(b) Not enough suitable personnel available.
(c) Unpractical for another person to do part of the job.
(d) Person who could do the job cannot be kept fully occupied.
(e) Bad management.

If factors (c) and (d) play a very important causal role in determining the situation, very little can be done about it. One can hardly expect a firm to employ a person who cannot be kept fully occupied and it would also be unpractical for, say, two separate firms to share employees. According to Table 3.4 this is not a very important contributing factor. The averages given in Table 3.4 tend to be higher for the small firms, i.e. this factor (a) plays a slightly more important role in the small than in the large firm.

The fact that it is unpractical for another person to do the job plays a more important role, in many cases reaching 3 although it varies from job function to job function.

Table 3.4 clearly indicates that the respondents felt that management played only a very minor contributory role. Factors (a) and (b) point towards a lack on the supply side. Factor (b) "not enough suitable personnel available in the organization" was generally given as the most important reason contributing towards the present situation. This applied to nearly all the job functions except managerial and administrative where "unpractical for other person to do the job" generally headed the list.

Employers were asked to indicate on a five point scale (1 = no problem to 5 = with great difficulty) the ease with which they could obtain the required personnel. Table 3.5 gives the analyses of the responses.

Table 3.5 reflects a very tight personnel situation as the bulk of the averages approaches 4, which means that the firms could only obtain personnel with difficulty. This applies to most of the already qualified categories: the firms felt that it was more difficult to obtain the technician at NDT level than at lower levels, and there was even a slight indication that it was more difficult to obtain NDT technicians than graduated engineers.

It is interesting to note that the firms felt that it was relatively easy to obtain pupil technicians (averages usually <3) which means that the training effort could be stepped up.

TABLE 3.4

RATING OF THE CONTRIBUTION OF CERTAIN FACTORS TOWARDS THE TIME DEVOTED TO TASKS WHICH OTHER PERSONS COULD PERFORM

(a) Consulting firms

Job function		Small firms			
		Engineers (professional and graduated)		Technicians (technologists, technicians and draughtsmen)	
		N	$\bar{X}$	N	$\bar{X}$
1 Preliminary investigation, e.g. planning and feasibility	(a)*	27	2,5		
	(b)	24	2,8		
	(c)	29	3,2		
	(d)	23	1,8		
	(e)	23	1,3		
2 Development of design e.g. calculations and creation of rough or sketch drawings	(a)	40	2,6	11	1,4
	(b)	45	3,0	12	1,9
	(c)	35	2,5	11	3,4
	(d)	36	2,1	10	1,5
	(e)	34	1,3	10	1,0
3 Detail design,e.g. calculation of components	(a)	49	2,5	12	2,3
	(b)	60	3,6	12	2,0
	(c)	49	2,3	11	2,8
	(d)	43	1,6	10	1,0
	(e)	43	1,3	10	1,0
4 Detail documentation,e.g. preparation of final drawings, detailing etc.	(a)	50	2,1	18	2,0
	(b)	59	3,6	24	2,3
	(c)	48	2,2	18	2,5
	(d)	46	1,6	16	1,3
	(e)	43	1,3	17	1,3
5 Technical writing,e.g. specification and report writing, developing schedules of quantities	(a)	26	2,4		
	(b)	29	3,1		
	(c)	24	2,9		
	(d)	27	1,9		
	(e)	23	1,2		
6 Measurement, estimating, budgets, e.g. measuring quantities, estimating, tender preparation	(a)	43	1,9		
	(b)	46	3,0		
	(c)	43	2,6		
	(d)	44	2,0		
	(e)	42	1,4		
7 Project management,e.g. construction management, contract supervision and procurement	(a)	48	2,4		
	(b)	52	2,9		
	(c)	51	3,1		
	(d)	46	1,7		
	(e)	44	1,4		
8 Investigation and testing, e.g. materials and soils investigation and testing	(a)	13	2,5		
	(b)	15	2,7		
	(c)	13	2,5		
	(d)	14	2,1		
	(e)	12	1,1		
9 Surveying, e.g. land and engineering surveys, traffic counts, general inspection	(a)	12	2,0		
	(b)	12	2,7		
	(c)	11	2,4		
	(d)	12	2,3		
	(e)	10	1,3		
10 Control of companies as a client,e.g. of consultants	(a)				
	(b)				
	(c)				
	(d)				
	(e)				
11 Managerial and administrative,e.g. supervision of personnel, completion of returns	(a)	40	2,8		
	(b)	39	2,2		
	(c)	43,	2,7		
	(d)	41	2,1		
	(e)	38	1,4		

*(a) No suitable personnel available in organization (continued)
(b) Not enough suitable personnel available in organization
(c) Unpractical for another person to do part of job
(d) Person who could do the job cannot be kept fully occupied in the organization
(e) Bad management

(a) Consulting firms (continued)

Job function		Medium firms			
		Engineers (professional and graduated)		Technicians (technologists, technicians and draughtsmen)	
		N	$\bar{X}$	N	$\bar{X}$
1 Preliminary investigation, e.g. planning and feasibility	(a)	34	2,3	11	1,3
	(b)	34	3,3	11	1,8
	(c)	34	2,4	12	2,6
	(d)	34	1,8	11	1,5
	(e)	34	1,4	11	1,3
2 Development of design, e.g. calculations and creation of rough or sketch drawings	(a)	46	1,9	17	1,5
	(b)	46	1,9	17	2,6
	(c)	46	2,2	18	2,3
	(d)	47	1,7	17	1,4
	(e)	46	1,2	17	1,4
3 Detail design, e.g. calculation of components	(a)	60	1,9	18	1,3
	(b)	63	3,0	18	2,4
	(c)	63	2,4	18	2,5
	(d)	60	1,7	19	1,5
	(e)	60	1,4	18	1,3
4 Detail documentation, e.g. preparation of final drawings, detailing etc.	(a)	46	1,8	17	1,4
	(b)	48	3,6	17	2,3
	(c)	46	2,0	18	2,7
	(d)	46	1,6	17	1,2
	(e)	46	1,4	17	1,3
5 Technical writing, e.g. specification and report writing, developing schedules of quantities	(a)	41	2,2		
	(b)	41	3,3		
	(c)	41	2,6		
	(d)	41	1,5		
	(e)	40	1,3		
6 Measurement, estimating, budgets, e.g. measuring quantities, estimating, tender preparation	(a)	57	1,8	15	2,3
	(b)	58	3,3	15	2,3
	(c)	59	2,1	15	2,2
	(d)	59	1,6	15	1,3
	(e)	57	1,2	15	1,3
7 Project management, e.g. construction management, contract supervision and procurement	(a)	49	1,9		
	(b)	48	3,1		
	(c)	49	2,7		
	(d)	48	1,4		
	(e)	48	1,2		
8 Investigation and testing, e.g. materials and soils investigation and testing	(a)	21	2,6		
	(b)	21	2,9		
	(c)	23	2,5		
	(d)	21	2,2		
	(e)	21	1,2		
9 Surveying, e.g. land and engineering surveys, traffic counts, general inspection	(a)	17	2,1		
	(b)	17	2,5		
	(c)	18	2,6		
	(d)	18	2,8		
	(e)	17	1,2		
10 Control of companies as a client, e.g. of consultants	(a)				
	(b)				
	(c)				
	(d)				
	(e)				
11 Managerial and administrative, e.g. supervision of personnel, completion of returns	(a)	46	2,4	10	1,8
	(b)	46	2,1	10	1,6
	(c)	46	3,1	11	2,3
	(d)	46	2,8	10	1,6
	(e)	46	1,5	10	1,1

(continued)

(a) Consulting firms (continued)

Job function		Large firms			
		Engineers (professional and graduated)		Technicians (technologists, technicians and draughtsmen)	
		N	$\bar{X}$	N	$\bar{X}$
1 Preliminary investigation, e.g. planning and feasibility	(a)	100	1,8	20	1,6
	(b)	100	2,8	20	2,8
	(c)	100	3,0	20	3,3
	(d)	98	1,6	20	1,8
	(e)	98	1,3	20	1,6
2 Development of design, e.g. calculations and creation of rough or sketch drawings	(a)	141	1,7	35	1,9
	(b)	142	3,1	35	3,1
	(c)	140	2,7	35	2,8
	(d)	139	1,5	35	1,3
	(e)	138	1,3	35	1,5
3 Detail design, e.g. calculation of components	(a)	149	1,7	34	1,7
	(b)	153	3,2	34	2,8
	(c)	150	2,5	35	2,4
	(d)	148	1,4	34	1,2
	(e)	148	1,5	34	1,3
4 Detail documentation, e.g. preparation of final drawings, detailing,etc.	(a)	120	1,5	56	1,8
	(b)	124	3,1	57	3,3
	(c)	123	2,3	59	2,5
	(d)	120	1,4	54	1,4
	(e)	120	1,5	54	1,3
5 Technical writing, e.g. specification and report writing, developing schedules of quantities	(a)	132	1,8	24	1,8
	(b)	133	2,9	24	2,8
	(c)	136	2,9	25	3,1
	(d)	132	1,6	24	1,2
	(e)	132	1,3	24	1,3
6 Measurement, estimating, budgets,e.g. measuring quantities, estimating, tender preparation	(a)	138	1,7	29	1,8
	(b)	139	3,1	29	3,0
	(c)	142	2,3	29	2,3
	(d)	138	1,6	30	1,6
	(e)	138	1,4	29	1,4
7 Project management, e.g. construction management, contract supervision and procurement	(a)	129	1,8	26	1,6
	(b)	129	2,9	26	2,4
	(c)	131	2,6	26	3,4
	(d)	128	1,6	26	1,5
	(e)	128	1,4	26	1,0
8 Investigation and testing, e.g. materials and soils investigation and testing	(a)	31	1,5		
	(b)	30	2,9		
	(c)	34	2,4		
	(d)	31	1,8		
	(e)	30	1,2		
9 Surveying, e.g. land and engineering surveys, traffic counts, general inspection	(a)	39	1,5	18	1,8
	(b)	39	2,4	18	2,8
	(c)	40	2,8	18	2,2
	(d)	39	2,2	18	1,9
	(e)	39	1,2	18	1,0
10 Control of companies as a client,e.g. of consultants	(a)				
	(b)				
	(c)				
	(d)				
	(e)				
11 Managerial and administrative,e.g. supervision of personnel, completion of returns	(a)	120	2,0	23	1,5
	(b)	119	2,2	23	2,7
	(c)	121	2,7	23	2,8
	(d)	119	2,1	23	1,9
	(e)	117	1,6	23	1,3

(continued)

(b) Construction firms

Job function		Construction firms			
		Engineers (professional and graduated)		Technicians (technologists, technicians and draughtsmen)	
		N	$\bar{X}$	N	$\bar{X}$
1 Preliminary investigation, e.g. planning and feasibility	(a)	62	2,2	26	1,3
	(b)	63	2,4	26	2,5
	(c)	62	2,5	26	2,9
	(d)	62	1,8	26	1,7
	(e)	62	1,4	26	1,2
2 Development of design, e.g. calculations and creation of rough or sketch drawings	(a)	46	1,8	12	1,7
	(b)	47	2,6	12	1,7
	(c)	46	2,6	12	2,1
	(d)	46	1,7	12	1,6
	(e)	46	1,3	12	1,2
3 Detail design, e.g. calculation of components	(a)	28	1,6		
	(b)	28	2,9		
	(c)	28	2,3		
	(d)	28	1,6		
	(e)	28	1,6		
4 Detail documentation, e.g. preparation of final drawings, detailing etc.	(a)	20	2,1	11	2,2
	(b)	20	2,4	11	2,2
	(c)	20	1,7	11	2,6
	(d)	20	2,1	11	1,7
	(e)	20	1,6	11	1,8
5 Technical writing, e.g. specification and report writing, developing schedules of quantities	(a)	45	1,7	23	1,9
	(b)	45	2,5	23	2,6
	(c)	45	2,7	23	2,5
	(d)	45	2,0	23	1,9
	(e)	45	1,1	23	1,3
6 Measurement, estimating, budgets, e.g. measuring quantities, estimating, tender preparation	(a)	85	1,8	38	1,7
	(b)	86	2,5	38	1,7
	(c)	85	2,6	38	2,7
	(d)	85	1,8	38	2,7
	(e)	85	1,3	38	1,3
7 Project management, e.g. construction management, contract supervision and procurement	(a)	90	2,0	25	1,8
	(b)	91	2,8	25	2,9
	(c)	90	2,4	25	2,5
	(d)	90	1,6	25	1,4
	(e)	90	1,4	25	1,4
8 Investigation and testing, e.g. materials and soils investigation and testing	(a)	17	2,2	16	1,7
	(b)	17	2,2	16	2,6
	(c)	17	2,1	16	1,8
	(d)	17	2,6	16	1,6
	(e)	17	1,3	16	1,1
9 Surveying, e.g. land and engineering surveys, traffic counts, general inspection	(a)	31	1,7	18	1,7
	(b)	31	3,0	18	2,7
	(c)	31	2,2	18	1,9
	(d)	32	1,8	18	1,9
	(e)	31	1,3	18	1,0
10 Control of companies as a client, e.g. of consultants	(a)	23	1,5		
	(b)	23	2,1		
	(c)	23	2,3		
	(d)	23	1,9		
	(e)	23	1,4		
11 Managerial and administrative, e.g. supervision of personnel, completion of returns	(a)	103	1,9	29	1,7
	(b)	104	2,4	29	2,8
	(c)	104	2,5	29	2,3
	(d)	103	1,7	29	1,6
	(e)	103	1,5	29	1,6

(continued)

(c) Government sector

Job function		Government sector			
		Engineers (professional and graduated		Technicians (technologists, technicians and draughtsmen)	
		N	$\bar{X}$	N	$\bar{X}$
1 Preliminary investigation, e.g. planning and feasibility	(a)	97	2,4	26	2,4
	(b)	98	3,4	26	3,0
	(c)	97	2,3	26	2,1
	(d)	97	1,3	26	1,4
	(e)	97	1,6	26	1,6
2 Development of design, e.g. calculations and creation of rough or sketch drawings	(a)	74	2,3	23	2,3
	(b)	74	3,4	23	3,7
	(c)	74	2,1	23	2,3
	(d)	74	1,3	23	1,3
	(e)	73	1,5	23	1,3
3 Detail design,e.g. calculation of components	(a)	54	1,9	11	2,9
	(b)	55	3,4	11	3,9
	(c)	54	2,0	11	2,2
	(d)	54	1,3	11	1,0
	(e)	54	1,5	11	1,2
4 Detail documentation, e.g. preparation of final drawings, detailing etc.	(a)	57	2,1	23	2,6
	(b)	58	3,9	24	3,0
	(c)	57	1,4	23	2,0
	(d)	57	1,3	23	1,5
	(e)	57	1,8	23	1,3
5 Technical writing, e.g. specification and report writing, developing schedules of quantities	(a)	131	2,1	35	2,5
	(b)	132	3,3	35	2,8
	(c)	131	2,4	35	2,3
	(d)	131	1,5	35	1,4
	(e)	131	1,4	35	1,5
6 Measurement, estimating budgets,e.g. measuring quantities, estimating, tender preparation	(a)	98	2,0	20	2,5
	(b)	99	3,3	20	2,8
	(c)	99	1,9	20	2,3
	(d)	99	1,4	20	1,7
	(e)	99	1,4	20	1,3
7 Project management, e.g. construction management, contract supervision and procurement	(a)	73	2,0	17	2,6
	(b)	74	3,3	17	3,3
	(c)	73	2,4	17	2,4
	(d)	73	1,4	17	1,5
	(e)	73	1,3	17	1,5
8 Investigation and testing, e.g. materials and soils investigation and testing	(a)	31	1,8	18	2,7
	(b)	32	3,8	18	3,6
	(c)	31	2,2	18	1,0
	(d)	31	1,3	18	1,0
	(e)	31	1,4	18	1,2
9 Surveying, e.g. land and engineering surveys, traffic counts, general inspection	(a)	62	2,2	31	2,2
	(b)	62	3,3	31	3,4
	(c)	62	2,0	31	2,1
	(d)	62	1,3	31	1,3
	(e)	62	1,3	31	1,4
10 Control of companies as a client,e.g. of consultants	(a)	34	2,3		
	(b)	35	3,3		
	(c)	34	2,7		
	(d)	34	1,4		
	(e)	34	1,8		
11 Managerial and administrative,e.g. supervision of personnel, completion of returns	(a)	137	2,2	43	2,4
	(b)	139	3,0	43	3,0
	(c)	137	2,0	43	2,1
	(d)	138	1,5	43	1,4
	(e)	138	1,7	43	1,7

TABLE 3.5

EASE WITH WHICH EMPLOYERS CAN OBTAIN THE PERSONNEL THEY REQUIRE

Employment category	Consult. group 1		Consult. group 2		Consult. group 3		Public sector		Construct-ion firms	
	N	$\bar{X}$ [1)]	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
1 Engineers with university degrees	30	3,8	12	3,6	12	4,1	6	4,0	17	3,6
2 Certificated engineers	12	3,8	3	4,0	7	3,6	1	1,0	11	3,7
3 Other graduates	8	3,9	4	3,5	9	2,9	3	1,7	14	4,2
4 Draughtsmen with NDT	26	4,7	12	4,7	10	4,2	6	4,3	5	2,4
5 Draughtsmen (lower than NDT)	23	4,0	12	4,2	10	3,4	4	4,3	5	2,2
6 Pupil draughtsmen	18	3,1	10	2,6	10	2,1	5	3,8	5	2,0
7 Surveying technicians with NDT	12	4,5	6	4,0	6	3,5	8	4,8	13	4,5
8 Surveying technicians (lower than NDT)	9	3,7	6	3,2	6	3,0	3	4,0	11	3,9
9 Pupil surveying technicians	10	3,7	2	2,5	5	2,0	4	4,0	12	3,3
10 Other technicians with NDT	18	4,3	9	3,9	11	4,1	6	4,8	13	3,8
11 Other technicians (lower than NDT)	15	3,9	8	3,0	8	3,1	3	4,3	10	2,9
12 Other pupil technicians	14	3,2	5	2,4	10	2,3	5	3,6	16	2,8

1) 1 = No problem

5 = With great difficulty

3.4.2 *Wage differentials*

The labour market is well known for its imperfections and for the fact that supply and demand in this market are not wholly influenced by the price paid for labour. In spite of these imperfections, wages still play an important part in the allocation of labour especially in the private sector. Table 3.5 indicates the median income for engineers and technicians by age group for the private sector. Draughtsmen were not taken into consideration because of their small numbers.

To get a better indication of wage differentials a second-degree function was applied to the data in Table 3.6 by the usual least-squares' method and the working life income calculated. Table 3.7 shows the calculated flow and the total sum the average engineer or technician can expect to earn in his working life at present income levels.

TABLE 3.6

MEDIAN ANNUAL INCOME OF ENGINEERS AND TECHNICIANS BY AGE (PRIVATE SECTOR)

Age	Engineers				Technicians (excluding draughtsmen)			
	Partner		Employee		NDT or higher		Lower than NDT	
	N	R.p.a.	N	R.p.a.	N	R.p.a.	N	R.p.a.
20 - 24		11 000*	32	11 000	9	11 000	20	5 400
25 - 29	1	18 000	184	14 950	57	12 600	18	9 750
30 - 34	27	30 000	160	19 840	44	15 665	32	14 335
35 - 39	48	36 000	93	22 000	30	16 848	26	16 000
40 - 44	60	35 500	46	24 000	11	19 175	20	18 120
45 - 49	39	36 000	26	26 450	5	18 000	17	17 160
50 - 54	43	40 000	17	24 000	4	17 450	13	15 000
55 - 59	20	35 000	18	24 475		17 450	6	15 660
60 - 64	10	27 500	14	23 000		17 450		15 660

*Figures blocked indicate an age group for which no median wage is available and for which an estimate had to be made.

Technicians with NDT or higher can expect to earn R704 000 over working life (20-64 years) as against the R621 000 of technicians with qualifications below NDT. This gives a difference of about R160 a month. The engineer employee earns about R420 a month more than the technician at NDT level. The salary of the NDT technician compares very well with the salary that males with a B.A. as only and highest qualification can expect to earn (Goosen 1982). For example Table 3.7 shows that the NDT technician at 30 years can expect to earn R14 400 and Goosen gives a salary of R11 600 for the B.A. graduate of the same age. At 40 years the salaries are R17 431 and R16 700 and at 50 R18 427 and R18 402. The income of the NDT technician is, however, appreciably lower than that of the B.Com. or B.Sc. graduate.

TABLE 3.7

CALCULATED INCOME (R p.a) BY AGE

Age	Engineers		Technicians *	
	Director/ partner	Employee	NDT plus	Below NDT
22	10093	10293	10535	5618
23	11330	11330	11090	6503
24	12329	12329	11625	7354
25	15583	13291	12140	8171
26	17578	14217	12634	8954
27	19482	15105	13108	9703
28	21296	15957	13562	10418
29	23019	16771	13996	11099
30	24652	17549	14409	11745
31	26194	18290	14803	12356
32	27646	18994	15176	12937
33	29008	19661	15528	13482
34	30279	20291	15861	13992
35	31459	20884	16173	14469
36	32549	21440	16465	14911
37	33548	21960	16737	15320
38	34458	22442	16988	15694
39	35276	22887	17220	16033
40	36004	23296	17431	16341
41	36642	23668	17621	16613
42	37189	24002	17792	16852
43	37646	24300	17942	17056
44	38012	24561	18072	17226
45	38288	24785	18182	17362
46	38473	24972	18271	17464
47	38568	25122	18341	17532
48	38572	25236	18390	17566
49	38486	25312	18418	17566
50	38309	25351	18427	17532
51	38042	25354	18415	17464
52	37684	25319	18383	17361
53	37236	25248	18331	17225
54	36698	25140	18258	17055
55	36068	24994	18165	16850
56	35349	24812	18052	16612
57	34539	24593	17919	16340
58	33638	24337	17766	16033
59	32648	24044	17592	15692
60	31566	23715	17398	15318
61	30394	23348	17184	14909
62	29132	22944	16949	14466
63	27779	22504	16694	13990
64	26336	22026	16419	13479
TOTAL	1319276	922674	704452	620676

* Excludes draughtmen

Whether the present differentials will provide enough incentive to draw larger numbers of pupil technicians to the technikons is an open question. Table 3.6 also indicates that firms are beginning to realise the value of technicians with the NDT qualification. The wage differentials for technicians younger than 29 years is much higher than is the case for the older groups.

3.4.3 *Technology*

The increased use of technology in various forms is also a method of saving time. A question in this regard was asked and it was concerned, not with any future developments but with the use of technology which is presently commercially available but is not available to the respondents. The results on this question appear in Table 3.8.

It is apparent from Table 3.8 that only a few respondents in the total survey group indicated that time could be saved by making use of technology not presently available to them. Therefore no attempt was made to do the intricate calculation of man years saved by the use of these types of technology. Most of the responses dealt with detail documentation, detail design and measurement, and estimating and budgeting. The type of technology most frequently mentioned was computer draughting and plotting equipment, minicomputers and computer facilities. Computerized administrative systems were also mentioned and it is interesting to note that these systems were mentioned in connection with most of the job functions.

It can be deduced from Table 3.8 that the engineer : technician ratio would be only slightly affected by the increased use of available technology.

3.5 THE REALISM OF THE "IDEAL" RATIOS AS TRAINING TARGET

Cambell Pitt wrote that "from time to time an attempt has been made to estimate the desired ratio of technicians to professional engineers. I find this an unprofitable task because there are so many factors that influence the ratio" (Cambell Pitt 1970). His remarks are still valid in as far as the factors which influence the ratio are numerable and to a great

TABLE 3.8

USE OF AVAILABLE TECHNOLOGY

	Job function	Type of technology: Word processor, memory typewriter (1+3)		Comp. draughting, plotting or related equipment (2)		Minicomputer (4)		Comp. facilities (5)		Computerized administrative systems (7)		Other (9)		Total number of responses	
		N[1]	%[2]	N	%	N	%	N	%	N	%	N	%	N	%[3]
1	Preliminary investigation	2	46,5	6	28,7	14	19,2	10	31,7	8	18,1			40	4,4
2	Development of design			8	27,5	21	35,3	10	31,5	6	43,3			45	4,6
3	Detail design			12	36,9	56	31,1	32	39,8	13	26,8	1	10,0	114	15,6
4	Detail documentation	5	39,2	67	32,4	3	15,0	3	5,0	2	47,5	5	13,8	85	13,5
5	Technical writing	15	23,6	4	30,0	6	33,3	3	15,0	5	46,0	5	23,6	38	4,1
6	Measurement, estimating, budgets	2	25,0	6	23,5	42	30,3	27	37,8	14	34,1	1	20,0	92	10,0
7	Project management	2	25,0			16	14,0	9	24,4	4	22,5	2	10,0	33	4,1
8	Investigation and testing					2	25,0	1	15,0	1	50,0	11	31,1	15	3,9
9	Surveying			4	42,5	2	32,5	2	3,5	2	27,5	5	48,8	15	3,7
10	Control of co. as a client					1	33,0	1	50,0					2	1,0
11	Managerial and administration	4	23,8	2	3,0	26	25,5	11	29,8	9	41,6	3	31,7	55	6,3
12	Travel											4	24,5	4	0,5
13	Education & training							1	85,0			1	30,0	2	<1
	TOTAL	30	27,94	109	31,59	189	28,06	110	33,55	64	33,2	38	27,53	540	

1 N - Number of times mentioned.

2 % - % time spent on function that could be saved.

3 Indicated as percentage of survey group who indicated time spent on function on average.

extent unquantifiable. The previous paragraphs dealt with some of these factors and only indicated the direction in which the ratios could be influenced, without any attempt to quantify the influence. Yet efforts in calculating the ratios are not without merit even if they only highlight practices which are undesirable in present circumstances.

Determining whether the "ideal" ratios as calculated in this study can be regarded as realistic training targets, cannot be achieved by precise quantification.

It is apparent from the analysis presented thus far that the engineers felt that an appreciable amount of their working time was spent on tasks that persons with lower qualifications could do just as efficiently. In all, 1 161 engineers indicated that a certain amount of time could be saved. These 1 161 engineers indicated that 308,73 man years were used on such tasks.

This is of course a purely hypothetical figure as respondents were asked not to take the practical situation in their organizations into account. It is also clear, however, that better use of engineers' time will have an influence on the present ratio between engineers and technicians.

Because of the differences in the tasks of consulting and construction firms there can hardly be one ideal ratio for the whole civil engineering industry and these two groups will therefore be discussed separately.

Firms were asked to indicate the number of workers in a category that could be employed in addition to the number employed at the time of the survey (Appendix B, Question 1, Column B). The results are shown in Table 3.7. In public sector terms these could be referred to as "vacant posts".

A few general trends are noticeable from Table 3.9.

(a) The number of vacant posts in the public sector is high.

(b) In all employer groups the vacancy rate for support personnel is usually appreciably higher than it is for engineers.

(c) The vacancy rate for technicians at NDT level is usually higher than it is for the group with lower qualifications.

TABLE 3.9

NUMBER OF WORKERS THAT CAN IMMEDIATELY BE ADDITIONALLY EMPLOYED

	Consulting firms		Construction firms		Public firms	
	N	%*	N	%	N	%
Graduate engineers	151	11,3	82	16,7	74	24,3
Certificated engineers	23	20,0	19	21,3	-	
Other graduates	17	19,1	24	25,0	-	
Draughtsmen (with NDT)	80	24,0	4	15,4	31	58,5
Draughtsmen (lower than NDT)	44	14,8	4	16,0	-	
Pupil draughtsmen	30	18,4	4	12,5	12	36,4
Surveying technicians (with NDT)	9	23,7	18	20,9	35	47,3
Surveying technicians (lower than NDT)	8	18,6	1	4,0	1	6,3
Pupil surveying technicians	8	53,3	13	16,9	9	25,0
Other technicians (with NDT)	51	21,0	79	24,8	74	48,7
Other technicians (lower than NDT)	35	9,5	6	11,8	-	
Other pupil technicians	15	13,2	83	19,6	8	22,9

* Expressed as % of job opportunities

TABLE 3.10

RATIO BETWEEN ENGINEERS AND QUALIFIED TECHNICIANS, VACANT POSTS INCLUDED

	Consulting firm	Construction firm
Engineers	1 338 (1)	491 (1)
Technicians (NDT+)	729 (0,5)	519 (1,1)
Technicians (NDT-)	711 (0,5)	101 (0,2)

One would therefore expect that the ratios between qualified technicians and engineers, taking vacancies into account, would be different from those shown in Table 3.3 These ratios are shown in Table 3.10. Worked to the first decimal these ratios only change slightly in the case of construct ion firms, i.e. from 1 : 1,2 to 1 : 1,3. For the consulting firms the ratio remains the same at only 1 : 1.

A very important point which has not been discussed up to now is the number of pupil technicians and the vacancies which exist for these pupils. Table 3.11 shows the available job opportunies in the firms surveyed, i.e. in public sector terms filled posts plus vacancies.

TABLE 3.11

JOB OPPORTUNITIES FOR TECHNICAL PERSONNEL

Occupation	Consulting firms		Construction firms	
	N	%	N	%
Graduated engineers	1338	42,4	491	28,2
Certificated engineers	115	3,6	89	5,1
Other graduates	89	2,8	96	5,5
Draughtsmen (with NDT)	333	10,5	26	1,5
Draughtsmen (lower than NDT)	298	9,4	25	1,4
Pupil draughtsmen	163	5,2	32	1,8
Surveying technicians (NDT)	38	1,2	86	4,9
Surveying technicians (lower than NDT)	43	1,4	25	1,4
Pupil surveying technicians	15	0,5	77	4,4
Other technicians (with NDT)	243	7,7	318	18,3
Other technicians (lower than NDT)	370	11,7	51	2,9
Other pupil technicians	114	3,6	423	24,3
TOTAL	3159	100	1739	100

Analysis of the above table indicates that the construction firms are really trying to change the present ratio of engineers to technicians. Of the total number of posts that were available, the construction firms reserved 24,3 % for other pupil technicians as against the 3,6 % of the consulting firms.

In the interpretation of the data in Table 3.11 it should be taken into consideration that even pupil technicians trained at a technikon are available for production work for some time, and that many others are trained in-house. The pupil technicians therefore have an influence on the availability of support services and the engineers surely took this into account when giving an indication of time saved.

Leaving other graduates out of consideration, the ratios between engineers and all technicians (including pupils) were the following:

Consulting firms 1 : 1,3
Construction firms 1 : 2,4

As has been shown, the increased use of technology can also save some engineering time and the hypothetical ratios based on the initial calculations are perhaps not an unrealistic training target, especially as firms indicated that it was not very difficult to recruit pupil technicians.

3.6 RECOMMENDATIONS

The engineers clearly felt that they were spending time on functions that could be performed efficiently by persons with lower qualifications. They indicated that the non-availability of such personnel was an important contributory factor towards this situation. Firms should therefore try to increase the training of technicians. It is also clear that not all these technicians need to be trained to NDT level and that there is scope for those with lower qualifications. Firms should also note that both technicians and engineers undergo relatively long training periods. The civil engineering industry is rather sensitive to fluctuations in economic activity and state expenditure. Because of the curtailment of bursaries in difficult times and the usual student reaction to market forces, the intake of first-year students during such times tends to become smaller. Because of the long training period this often results in a small supply precisely at the time economic activity peaks. Supply and demand are therefore often out of phase. Firms should therefore think twice about curtailing training schemes during periods of low economic activity.

Although the respondents felt that management did not play an important role in contributing towards underutilization, management should nevertheless take a careful look at the way they use their scarce human resources.

APPENDIX A

HUMAN SCIENCES RESEARCH COUNCIL

SOUTH AFRICAN INSTITUTE FOR MANPOWER RESEARCH

SKILL MIX IN THE CIVIL ENGINEERING INDUSTRY

Rec. No.

Office use

Answer by [√] where possible in the appropriate block [ ][ ][ ][ ][ ] 1 - 5

1 Please indicate which category describes your present position in your organisation the best:

Professional engineer	1
Graduated engineer	2
Technologist	3
Technician	4
Learner technician	5
Draughtsman	6
Learner draughtsman	7
Other (Please specify)	8

.....

..... [ ] 6

2 If you have indicated [5] or [7] in 1, supply the qualification for which you are studying at the moment

..... [ ] 7

3 Status in the organisation:

Director/Partner	1
Employee	2

[ ] 8

4 Highest qualification you possess at the present moment (Please consult the list of qualifications on page 6 & 7).

Qualification group

1	2	3	4	5	6	7

[ ] 9

Office use

5 Year of birth 19 ☐☐ ☐☐ 10 - 11

6 Length of average working week ☐☐☐ hours ☐☐ 12 - 13

7 How many weeks on average do you devote to your work per year?

☐☐☐ weeks ☐☐ 14 - 15

8 Male 1 ☐

Female 2 ☐ ☐ 16

9 What is your gross annual salary/income from the work done at this organisation?

R ☐☐☐☐☐☐☐ ☐☐☐☐☐☐ 17 - 21

10 THIS QUESTION IS THE FOCUS OF THE SURVEY! !
PLEASE READ THE INSTRUCTIONS CAREFULLY! !

The question is divided into 5 blocks, A to E.

Please answer the question block by block after *reading through all the job functions first.*

Block A: How much time (in %) do you spend *on average* on the job functions listed? (Total 100%)

Block B: Use your *last two working weeks as reference,* indicate how your working time was distributed according to the listed job functions. (total 100%)

Block C: *Think only about the job you had to do, as indicated in block B.* Give no attention to the *practical staff situation in your organisation* (i.e. the availability of support personnel.)

What % of the time indicated in block B, for each job function, could have been performed just as efficiently by a person with other qualifications than yours.

Block D: Indicate if the training of the imaginary person must be mainly technical (T) or administrative/clerical (A)

Block E: Please consult the list of qualifications and indicate the qualification group of the imaginary person you have in mind.

	Job Function	A % of average working time spent on each job function	B % of working time distribution on each job function during last two weeks	C % of time as indicated in B that a person with other qualifications could do. Practical situation *excluded*	D Required training of person mentioned in C. Indicate category by ✓ A = Administrative T = Technical	E Qualification group of person mentioned in C and D. Indicate with ✓ at appropriate group	Office use
1	**Preliminary investigation** e.g. planning and feasibility studies, contract planning programming				A T	1 2 3 4 5 6 7	22 · 32
2	**Development of design** e.g. calculations and creation of rough or sketch drawings				A T	1 2 3 4 5 6 7	33 · 43
3	**Detail design** e.g. calculation of components				A T	1 2 3 4 5 6 7	44 · 54
4	**Detail documentation** e.g. preparation of final drawings, detailing etc.				A T	1 2 3 4 5 6 7	55 · 65
							1 76 M-147 (77 · 80) 1 · 5
5	**Technical writing** e.g. report writing, specification, developing schedules of quantities				A T	1 2 3 4 5 6 7	6 · 16
6	**Measurement, estimating, budgets** e.g. measuring quantities, estimating, tender preparation				A T	1 2 3 4 5 6 7	17 · 27
7	**Project management** e.g. construction management, contract supervision and procurement				A T	1 2 3 4 5 6 7	28 · 38
8	**Investigation and testing** e.g. materials and soils investigation and testing				A T	1 2 3 4 5 6 7	39 · 49
9	**Surveying** e.g. land and engineering surveys, traffic counts, general inspection				A T	1 2 3 4 5 6 7	50 · 60
10	**Control of companies as a client** e.g. of consultants or contractors				A T	1 2 3 4 5 6 7	61 · 71
							2 76 M-147 (77 · 80) 1 · 5
11	**Managerial and administrative** e.g. supervision of personnel, completion of returns				A T	1 2 3 4 5 6 7	6 · 16
12	**Travel**						17 · 20
13	**Education and Training** (a) Giving training/lecturing (b) Receiving training (c) Research						21 · 24 25 · 28 29 · 32
14	**Other**						
		100 %	100 %				

Quest. 11 If you have indicated any percentage in block C, (Question 10, page 3) against any job function, indicate *to what extent* the following has contributed to the situation

	Job function				Office use	
1	**Preliminary investigation** e.g. planning and feasibility	(a)	No suitable personnel available in organisation	Much 5 4 3 2 1 None		33
		(b)	Not enough suitable personnel available in organisation	Much 5 4 3 2 1 None		34
		(c)	Unpractical for another person to do part of job	Much 5 4 3 2 1 None		35
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much 5 4 3 2 1 None		36
		(e)	Bad management	Much 5 4 3 2 1 None		37
2	**Development of design** e.g. calculations and creation of rough or sketch drawings	(a)	No suitable personnel available in organisation	Much 5 4 3 2 1 None		38
		(b)	Not enough suitable personnel available in organisation	Much 5 4 3 2 1 None		39
		(c)	Unpractical for another person to do part of job	Much 5 4 3 2 1 None		40
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much 5 4 3 2 1 None		41
		(e)	Bad management	Much 5 4 3 2 1 None		42
3	**Detail design** e.g. calculation of components	(a)	No suitable personnel available in organisation	Much 5 4 3 2 1 None		43
		(b)	Not enough suitable personnel available in organisation	Much 5 4 3 2 1 None		44
		(c)	Unpractical for another person to do part of job	Much 5 4 3 2 1 None		45
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much 5 4 3 2 1 None		46
		(e)	Bad management	Much 5 4 3 2 1 None		47
4	**Detail documentation** e.g. preparation of final drawings, detailing etc.	(a)	No suitable personnel available in organisation	Much 5 4 3 2 1 None		48
		(b)	Not enough suitable personnel available in organisation	Much 5 4 3 2 1 None		49
		(c)	Unpractical for another person to do part of job	Much 5 4 3 2 1 None		50
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much 5 4 3 2 1 None		51
		(e)	Bad management	Much 5 4 3 2 1 None		52
5	**Technical writing** e.g. specification and report writing, developing schedules of quantities	(a)	No suitable personnel available in organisation	Much 5 4 3 2 1 None		53
		(b)	Not enough suitable personnel available in organisation	Much 5 4 3 2 1 None		54
		(c)	Unpractical for another person to do part of job	Much 5 4 3 2 1 None		55
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much 5 4 3 2 1 None		56
		(e)	Bad management	Much 5 4 3 2 1 None		57
6	**Measurement, estimating, budgets** e.g. measuring quantities, estimating, tender preparation	(a)	No suitable personnel available in organisation	Much 5 4 3 2 1 None		58
		(b)	Not enough suitable personnel available in organisation	Much 5 4 3 2 1 None		59
		(c)	Unpractical for another person to do part of job	Much 5 4 3 2 1 None		60
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much 5 4 3 2 1 None		61
		(e)	Bad management	Much 5 4 3 2 1 None		62

7	**Project management** e.g. construction management, contract supervision and procurement	(a)	No suitable personnel available in organisation	Much	5	4	3	2	1	None		63
		(b)	Not enough suitable personnel available in organisation	Much	5	4	3	2	1	None		64
		(c)	Unpractical for another person to do part of job	Much	5	4	3	2	1	None		65
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much	5	4	3	2	1	None		66
		(e)	Bad management	Much	5	4	3	2	1	None		67
8	**Investigation and testing** e.g. materials and soils investigation and testing	(a)	No suitable personnel available in organisation	Much	5	4	3	2	1	None		68
		(b)	Not enough suitable personnel available in organisation	Much	5	4	3	2	1	None		69
		(c)	Unpractical for another person to do part of job	Much	5	4	3	2	1	None		70
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much	5	4	3	2	1	None		71
		(e)	Bad management	Much	5	4	3	2	1	None		72
												73
											3	76
											M-147 (77-80)	
												1-5
9	**Surveying** e.g. land and engineering surveys, traffic counts, general inspection	(a)	No suitable personnel available in organisation	Much	5	4	3	2	1	None		6
		(b)	Not enough suitable personnel available in organisation	Much	5	4	3	2	1	None		7
		(c)	Unpractical for another person to do part of job	Much	5	4	3	2	1	None		8
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much	5	4	3	2	1	None		9
		(e)	Bad management	Much	5	4	3	2	1	None		10
10	**Control of companies as a client** e.g. of consultants	(a)	No suitable personnel available in organisation	Much	5	4	3	2	1	None		11
		(b)	Not enough suitable personnel available in organisation	Much	5	4	3	2	1	None		12
		(c)	Unpractical for another person to do part of job	Much	5	4	3	2	1	None		13
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much	5	4	3	2	1	None		14
		(e)	Bad management	Much	5	4	3	2	1	None		15
11	**Managerial and administrative** e.g. supervision of personnel, completion of returns	(a)	No suitable personnel available in organisation	Much	5	4	3	2	1	None		16
		(b)	Not enough suitable personnel available in organisation	Much	5	4	3	2	1	None		17
		(c)	Unpractical for another person to do part of job	Much	5	4	3	2	1	None		18
		(d)	Person who could do the job cannot be kept fully occupied in the organisation	Much	5	4	3	2	1	None		19
		(e)	Bad management	Much	5	4	3	2	1	None		20

Office use

12 Technology

Refer back to the working time distribution supplied in Block C (question 10). Indicate below if working time could be saved by making use of technology that is commercially available but to which you personally have no access.

No. of job function	% of working time that could be saved	Indicate the kind of technology e.g. mini computer, computer draughting, etc.	
			21 - 25
			26 - 30
			31 - 35
			36 - 40
			41 - 45
			46 - 50

4 76

M-147 (77 - 80)

EDUCATIONAL QUALIFICATIONS

Group 1

Std 10, NTC III

Group 2

RSA-Qualifications

National Technical Certificate (NTC IV & V)
Advanced Technical Certificate (ATC I and II)
National Certificate for Technicians (NCT)
Intermediate Diploma for Technicians (IDT)
National Teaching Diploma (technical)
Certificate of Competency as Telecommunications Technicians (Post Office)
Typing Diploma – 2 years post matriculation training
Secretarial Training – 2 years post matriculation training

Other

"B"-certificate with specialisation (Belguim)
Meisterprüfung (Germany)
Ordinary National Certificate (ONC-Britain)
City and Guilds of London Institute (CGLI),
Final Technical Course (Britain)
Engineering Certificate (Victoria, Australia)

Group 3

RSA-Qualification
National Technical Diploma (NTD)
National Engineering Diploma
Higher National Certificate for Technicians (HNCT)

Other
Staatlich Geprüfter Techniker (Germany)
Middelbare Technische School (MTS-Netherland)
Uitgebreid Technische School (UTS-Netherland)
Higher National Certificate (HNC-Britain)
CGLI Full Technical Course (Britain)
Engineering Diploma (Australia)
Diploma for Electronic Technicians (Bulgaria)
General Mechanical Technician Diploma (Hungary)
Technical Diploma (Poland)
National Technical Certificate (Switzerland)
Technical Diploma (Czechoslovakia)

Group 4

National Diploma for Technicians (NDT)
Higher National Diploma for Technicians (HNDT)
Government Certificate of Competency
Certificate as Mine Surveyor

Group 5

Hogere Technische School (HTS-Netherland)
Government Certificate (Rhodesia)
Chartered Engineer (CE-Britain)
Diplom HTL (Switzerland)
Technische Ingineer with Specialisation "A_2" (Belguim)
Technische Ingineer with Specialisation "A_3" (Belgium)
B. Tech. (Australia)
Dip. Tech. (Britain)
Higher National Diploma (HND-Britain)
Technische Ingineer "A" (Belguim)
Ing-Grad (Germany)

Group 6

Bachelors degree in Engineering

Group 7

Honours and higher degrees

APPENDIX B

SKILL MIX IN THE CIVIL ENGINEERING INDUSTRY

ORGANISATION QUESTIONNAIRE

Office use

Rec.No. 1-3

1 Please indicate the number of persons at present employed in your organisation in column A. In column B please indicate the number of persons who could at present be immediately employed in addition to those mentioned in column A

	Category of employee	Column A	Column B	
1.1	Engineers with university degrees			4-8
1.2	Certificated engineers			9-13
1.3	Other graduates (e.g. land and quantity surveyors)			14-18
1.4	Draughtsmen with NDT			19-23
1.5	Draughtsmen (lower than NDT)			24-28
1.6	Pupil draughtsmen			29-33
1.7	Surveying technicians with NDT			34-38
1.8	Surveying technicians (lower than NDT)			39-43
1.9	Pupil surveying technicians			44-48
1.10	Other technicians with NDT			49-53
1.11	Other technicians (lower than NDT)			54-58
1.12	Other pupil technicians			59-63
1.13	Tracers			64-68
1.14	Clerical personnel and typists			69-73

1 76

M-147 (77-80)

2 Please rate the present supply position in the categories of personnel mentioned in question 1 in terms of the ease with which your organisation can obtain the personnel it requires.

		No problem				with great difficulty	Office use	
								1-3
2.1	Engineers with university degrees	1	2	3	4	5		4
2.2	Certificated engineers	1	2	3	4	5		5
2.3	Other graduates (e.g. land and quantity surveyors)	1	2	3	4	5		6
2.4	Draughtsmen with NDT	1	2	3	4	5		7
2.5	Draughtsmen (lower than NDT)	1	2	3	4	5		8
2.6	Pupil draughtsmen	1	2	3	4	5		9
2.7	Surveying technicians with NDT	1	2	3	4	5		10
2.8	Surveying technicians (lower than NDT)	1	2	3	4	5		11
2.9	Pupil surveying technicians	1	2	3	4	5		12
2.10	Other technicians with NDT	1	2	3	4	5		13
2.11	Other technicians (lower than NDT)	1	2	3	4	5		14
2.12	Other pupil technicians	1	2	3	4	5		15
2.13	Tracers	1	2	3	4	5		16
2.14	Clerical personnel and typists	1	2	3	4	5		17

3 How many of your pupil technicians are attending courses at a technikon at the present moment?

		18-19
	2	76

M-147 (77-80)

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