UNIVERSITY OF PRETORIA

DEPARTMENT OF CIVIL ENGINEERING

GUIDELINES FOR REPORTS, DISSERTATIONS AND THESES

JANUARY 2014

DEFINITIONS

PROJECT REPORT (Afr. “SKRIPSIEVERSLAG”)

A project is an investigation of a limited nature (± 350 hours). The project report is presented as part of the requirements for the BEng, MEng and MSc degrees.

DISSERTATION (Afr. “VERHANDELING”)

A dissertation is a report on an investigation of a major nature (± 1000 hours). It is presented as part of the requirements for the MEng and MSc degrees.

THESIS (Afr. “PROEFSKRIF”)

A thesis is a report on the research required for the PhD(Eng) or PhD degrees.

N ON BOOK EDGE

A

M

E

TITLE

OF REPORT

(ON BOOK COVER)

AB NAME

2

0

1

4 ON BOOK EDGE

TITLE

OF REPORT

FULL NAME OF AUTHOR

A project report/dissertation/thesis submitted in partial fulfilment of the requirements for the degree of

BACHELOR OF ENGINEERING (CIVIL ENGINEERING)

MASTER OF ENGINEERING (TRANSPORTATION ENGINEERING)

MASTER OF SCIENCE (TRANSPORTATION)

PHILOSOPHIAE DOCTOR (ENGINEERING)

In the

FACULTY OF ENGINEERING

UNIVERSITY OF PRETORIA

January 2014

TITEL

VAN VERSLAG

VOLLE NAAM VAN OUTEUR

'n Skripsieverslag/Verhandeling/Proefskrif voorgelê ter gedeeltelike vervulling van die vereistes vir die graad

BACCALAUREUS IN INGENIEURSWESE (SIVIELE INGENIEURSWESE)

MAGISTER IN INGENIEURSWESE (VERVOERINGENIEURSWESE)

MAGISTER SCIENTIAE (VERVOER)

PHILOSPHIAE DOCTOR (INGENIEURSWESE)

In die

FAKULTEIT INGENIEURSWESE

UNIVERSITEIT VAN PRETORIA

Januarie 2014

PROJECT REPORT/DISSERTATION/THESIS SUMMARY

TITLE OF REPORT

AB NAME

Supervisor: Professor Doctor AB Name

Co-Supervisor: Professor Doctor AB Name

Department: Civil Engineering

University: University of Pretoria

Degree: Bachelor of Engineering (Civil engineering)

Master of Engineering (Transportation engineering)

Master of Science (Transportation)

Philosophiae Doctor (Engineering)

The summary provides a brief description of the contents of the report bound into the report. The summary may ***not*** be longer than 500 words. The summary should contain a short but clear description of the problem, purpose of the study and the main conclusions reached during the study.

SAMEVATTING VAN

SKRIPSIEVERSLAG/VERHANDELING/PROEFSKRIF

AFRIKAANSE VERTALING VAN TITEL VAN VERSLAG

AB NAAM

Promotor:	Professor Doktor AB Naam
Medepromotor:	Professor Doktor AB Naam
Departement:	Siviele Ingenieurswese
Universiteit:	Universiteit van Pretoria
Graad:	Baccalaureus in Ingenieurswese (Siviele Ingenieurswese)
	Magister in Ingenieurswese (Vervoeringenieurswese)
	Magister Scientiae (Vervoer)
	Philosophiae Doctor (Ingenieurswese)

'n Afrikaanse vertaling van die opsomming moet in alle Suid-Afrikaanse verslae voorsien word. Die samevatting moet nie langer as 500 woorde wees nie. Dit moet 'n kort maar duidelike beskrywing gee van die probleem, doel van die studie en die belangrikste gevolgtrekkings wat gedurende die studie gemaak is.

ABSTRACT (ON SEPARATE PAGE)

(ONLY FOR DISSERTATIONS AND THESES)

Title:	Title of report
Author:	AB Name
Supervisor:	Professor Doctor AB Name
Co-Supervisor:	Professor Doctor AB Name
Department:	Civil Engineering
University:	University of Pretoria
Degree:	Master of Engineering (Transportation Engineering)
	Master of Science (Transportation)
	Philosophiae Doctor (Engineering)

An abstract in English containing a brief description of a dissertation or thesis must also be provided on a separate page (and not bound into the report). The abstract may not exceed 150 words for a dissertation and 350 words for a thesis. No abstract is required for project reports.

DECLARATION (VERKLARING)

I, the undersigned hereby declare that:

- I understand what plagiarism is and I am aware of the University's policy in this regard;
- The work contained in this thesis is my own original work;
- I did not refer to work of current or previous students, lecture notes, handbooks or any other study material without proper referencing;
- Where other people's work has been used this has been properly acknowledged and referenced;
- I have not allowed anyone to copy any part of my thesis;
- I have not previously in its entirety or in part submitted this thesis at any university for a degree.

DISCLAIMER:

The work presented in this report is that of the student alone. Students were encouraged to take ownership of their projects and to develop and execute their experiments with limited guidance and assistance. The content of the research does not necessarily represent the views of the supervisor or any staff member of the University of Pretoria, Department of Civil Engineering. The supervisor did not read or edit the final report and is not responsible for any technical inaccuracies, statements or errors. The conclusions and recommendations given in the report are also not necessarily that of the supervisor, sponsors or companies involved in the research.

Signature of student:

Name of student:

Student number:

Date:

Number of words in report: ______words

(NOTE: Final year project students will be penalised if their reports contain more than 15000 words.)

ACKNOWLEDGEMENT (ERKENNING)

I wish to express my appreciation to the following organisations and persons who made this project report/dissertation/thesis possible:

a) This project report/dissertation/thesis is based on a research project of ABC. Permission to use the material is gratefully acknowledged. The opinions expressed are those of the author and do not necessarily represent the policy of ABC.

b) The ABC organisation for financial support, the provision of data or the use of laboratory facilities during the course of the study.

c) The following persons are gratefully acknowledged for their assistance during the course of the study:

    i) Dr AB Name

d) Professor AB Name, my supervisor, and Professor AB Name, my co-supervisor for their guidance and support.

e) Miss AB Name for typing of the project report/dissertation/thesis.

f) My family for their encouragement and support during the study.

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A	Symbol A
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1 INTRODUCTION

1.1 BACKGROUND

Chapter 1 describes the reasons motivating the study, the purpose of the study as well as any restrictions on the scope of the study. It is more concerned with the study itself than with technical contents. Technical detail should, therefore, be kept to a minimum.

The background contains a brief history leading to and *motivating* the objectives of the study. The importance of the research topic must be stressed. The reader must be given a clear explanation on why the research is needed and what the implications of the research are.

1.2 OBJECTIVES OF THE STUDY

Describes the purpose and objectives of the study. Conclusions must be reached for each of the stated objectives (on a one-to-one basis).

1.3 SCOPE OF THE STUDY

Describes *limitations* of the research. Explain what has been investigated and what has not been covered. Explicitly states aspects that have not been covered during the study.

1.4 METHODOLOGY

Broadly describes the methodology followed during the research.

1.5 ORGANISATION OF THE REPORT

The report consists of the following chapters and appendices:

- Chapter 1 serves as introduction to the report.
- Chapter 2 normally contains a technical introduction based on a literature study.
- Chapter 3 usually describes the field observations undertaken during the study. It is important the experimental method should also be motivated.
- Chapter 4 describes the analysis of the field observations.
- Chapter 5 contains the conclusions and recommendations of the study.
- The list of references follows at the end of the report.
- Appendix A (and other) normally contains data obtained from field observations.

2 RESEARCH PROJECTS

2.1 INTRODUCTION

The purpose of a research project in the Department of Civil Engineering at the University of Pretoria is to provide an opportunity for students to develop the skills necessary for *independently* undertaking research in a chosen subject area. In formal subjects taken at the university, the student is normally given all the knowledge required to pass the subject. With the research project, however, the student is personally responsible for finding the necessary information to solve a problem. A study leader will advise the student on the research methodology that should be followed during the research.

Engineering research is normally directed towards the development of methods that can be applied generally to a class of problems. An existing method may be insufficient or inappropriate and improved methods needed. This is in contrast with normal engineering projects, which have the objective of finding a solution to one specific problem only.

2.2 IMPORTANCE OF RESEARCH

There are various reasons why students should gain experience in research. These include the following:

a) **Problem solving.** Research experience develops the ability of the student to apply a scientific approach to problems for which solutions are not readily available. These problems often occur in engineering practice and students should be aware of methods that can be followed in solving problems.

b) **Student evaluation.** It serves as a means of evaluating whether a student has successfully mastered the scientific research method and is capable of solving problems independently.

c) **Limitations of models.** It illustrates the process whereby methods and models in engineering have been and are being developed. Many students have the impression that engineering models are universally true and do not realise that models are only approximations of the real situation. Such models are then applied blindly without due consideration of the limitations of the models. Research has the advantage that it will illustrate the danger of such a viewpoint.

d) **Contribution.** The research may contribute significantly to the development and understanding of a subject area.

2.3 REQUIREMENTS

The following are the more important requirements of a university research project:

a) **Originality.** The main objective of university research at an undergraduate or master level is to provide *training* in the methodology of research and to evaluate whether a candidate has successfully mastered this methodology. Although it is preferable that research should be original, this is not a crucial requisite. It is only at the PhD level where the originality of the research is essential and where it is required that the project contributes significantly to the development of a subject area.

b) **Independent research.** A very high premium is placed on the requirement that students should be able to work *independently*. **The task of the study leader is only to provide advice on the methodology that should be followed during the study and *not* to undertake the research for the student.** The student is responsible for all technical aspects of the research, including experimental work, observations, analyses, modelling, deductions, finding solutions to problems and writing of the report. The student must, however, continually discuss the research with the study leader to ensure that appropriate approaches are being followed.

c) **Quality of research.** It is important that a topic should be selected which is not too extensive in scope. *Quality is more important that quantity*. It is advisable to investigate a smaller problem thoroughly rather than trying to solve an extensive problem superficially. A research report is similar to a mathematical proof - it must provide complete, logical, correct and incontrovertible evidence that the most appropriate solution has been found for a problem. If the time available for the research is limited, it is especially important that the scope of the study should be restricted and a simpler research topic selected.

d) **Balance.** Preference should be given to research topics that will provide a student with experience in most aspects of the research methodology. The important aspects are the *literature study*, *experimental work*, *analysis and report writing*. A good balance should be maintained between these aspects, and repetitive experimental work or observations should especially be kept to a minimum.

e) **Systems approach.** The student should give particular attention to applying the system approach to the problem being researched. It is particularly important that, not only pure technical aspects of a problem be considered, but also that a broader approach be followed in which the full socio-economic consequences of a problem are taken into consideration.

f) **Expert knowledge.** A research study can only be completed successfully when a comprehensive study was undertaken on the subject. On completion of the study, the student should have expert knowledge on the topic and its related aspects. An oral examination may be required on completion of the study to establish whether the student has indeed acquired such knowledge.

2.4 RESEARCH METHODOLOGY

It will be expected of students to work strictly according to a research programme and a timetable. Should the student be unable to comply with the programme for whatever reason, he or she should submit a written explanation to the study leader. The attitude of the student towards the research will be taken into account in the final evaluation of the research report or dissertation. Completing a task ahead of schedule will always give a more favourable impression of the student.

The following steps should be followed during a research study:

a) **Research topic.** Research topics are normally determined through consultation between the student and the study leader. In selecting the topic, it is important that the criteria for evaluating research reports should be taken into account. The selection of an appropriate topic could significantly affect the successful outcome of a research project.

b) **Problem definition.** The student should formulate a problem definition, research programme and timetable with the assistance of the study leader. Although it is preferable to establish the problem definition as final as possible at this stage, it may be necessary to change the definition during the study. Permission must, however, be obtained from the study leader for any such changes.

c) **Literature study.** The literature study is one of the most crucial steps in a research project. It is of extreme importance that the literature study is as extensive as possible, since it may critically affect the success of the research. The student should discuss the literature with the study leader. Study objectives can be reformulated on the basis of the literature study.

d) **Draft report (mini-thesis).** This step is recommended when the research topic is complex or when it is unclear which experimental work is required for the study. If the research project is relatively simple and no doubt exists on which experimental work is required, this step can be skipped. The step involves the writing of a first draft of the report based solely on the literature study. In this draft, information that needs to be collected is identified and research procedures established. It is important to make sure that all information that may be required is identified at this stage. The collection of information is very expensive and effort should not be wasted on unnecessary repetition of experimental work. Approval of the draft report must be obtained before the student may continue with the research.

e) **Experimental work and modelling.** A detailed experimental programme must be submitted to the study leader for approval. It is recommended that experiments are structured in such a way that the influence of only one variable is tested at a time.

Results of experiments or observations should be analysed using appropriate statistical methods. It is especially important that attention be given to the statistical reliability of samples.

A research project may depend more on the use of a model than on experimental work. When such a model is used or developed, it is extremely important that attention should be given to the realism of the model and to ensure that the model is a true reflection of the real world situation.

f) **Final report.** The report must meet requirements of technical report writing. Ensure absolute technical and language correctness. A single error will require correction and could even be viewed negatively. If you doubt your language abilities, it is permissible to obtain assistance from a competent linguist. *Do not expect your study leader to correct your language or check the technical correctness of the report.*

2.5 WRITING OF THE REPORT

Research reports in the Department of Civil Engineering may be written in either Afrikaans or English. The following steps should be followed when writing the report:

a) **Table of contents.** The table of contents must be drawn up and submitted to the study leader for approval. This should be undertaken before commencing with writing of the report. Careful planning is required at this stage.

b) **Chapter 1.** The first chapter of the report normally contains a general technical introduction based on a literature study of the research topic. The title of the chapter is often related to (but not the same) the main title of the report. This chapter must first be completed to the satisfaction of the study leader before commencing with subsequent chapters.

c) **Subsequent chapters.** The second and subsequent chapters normally contain details of the experimental work undertaken during the study and the analysis thereof. Conclusions and recommendations are given in the final chapter. References follow at the end of the report. Appendices may also be added to provide information that does not require the immediate attention of the reader.

d) **Submission of the report.** The report is submitted in stages as given below. The required number of copies of the report is given in Table 2.1. Prescribed colours of report covers are given in Table 2.2.

   i) **Preliminary copy.** A ring-bound preliminary copy of the report is submitted to the study leader for comments. The student should improve the report on the basis of the comments.

   ii) **Examination copies.** Ring-bound copies of the report are submitted for examination purpose. The study leader and external examiners may require further revisions of the report.

   iii) **Final copies.** The report must first be submitted to the study leader for final approval before final copies are made.

   iv) **Master copies.** A master unbound copy of the report is also required for master's dissertations and PhD theses only.

Table 2.1: Required number of copies of the report

Copy	Binding method	Required number of copies			
		BEng Essay	MEng Essay	MEng Dissertation	PhD Thesis
Preliminary copy	Ring	1	1	1	1
Examination copy	Ring				
Study leader		1	1	1	1
External examiner(s)		1	1	1	2
Internal examiner		1	1	1	1
Total		3	3	3	4
Final copy	Hard				
Univ. Administration				1	1
Departmental archives		1*	1	1	1
Study leader		1*	1	1	1
External examiner(s)			1	1	2
Total		2*	3	4	5
Master copy	Unbound				
Univ. Administration				1	1
Total				1	1

* Ring-bound copies.

Table 2.2: Required colour of the cover of the report (at post-graduate level only)

Division	Colour
Materials	Claret red
Geo-technical engineering	Red
Structural engineering	Green
Transportation engineering	Black
Environmental Engineering	Brown
Water resources engineering	Blue

2.6 EVALUATION

The research report will be evaluated on the basis of the evaluation criteria listed below. A minimum standard must be achieved in each of the criteria before the report will be accepted. The evaluation will only consider the personal contribution of the student and is not a reflection of the capabilities of the study leader.

a) **Work method.** Students will be evaluated for their general attitude towards the research, adherence to the timetable, personal contributions and **ability to work independently**.

b) **Literature study.** The literature study forms an important component of a research report. The report will therefore be evaluated for the completeness, quality and applicability of the literature study. It is also extremely important that the literature should be critically evaluated, discussed and interpreted in the report.

c) **Experimental work and modelling.** Experimental work, observations and analysis will be evaluated for quality and appropriateness. It is extremely important that the experimental method should be well motivated. Different alternative experimental methods should be discussed and reasons given for the selection of a specific method. Attention must also be given to statistical techniques and confidence intervals. It is particularly important to discuss whether samples are representative of the real world population.

A research project may depend more on modelling than on experimental work. In such cases, it is important that some experimental work should be undertaken to calibrate the model and to evaluate the model for realism. It is extremely important to establish whether the model is a true reflection of the real world situation.

d) **Systems approach.** The research will be evaluated for the degree to which the systems approach was applied. Particularly important are the problem definition and objectives, development and evaluation of alternative solutions, motivations and scientific proofs, own conclusions and recommendations.

e) **Writing style.** Correctness of language and terminology as well as style of writing is an extremely important factor in the evaluation of a report.

f) **Oral examination.** During the oral examination the student will be evaluated for his or her knowledge of the research topic. The student must also be able to defend the research report and show that he or she has become an expert in the particular field (as well as related aspects).

If the student should fail in any of the above aspects, no supplementary examination will be given. The student will then not be allowed to resubmit the same report and will be required to start with a completely different research topic. It is therefore in the own interest of the student to ensure that he or she has reached the required standards as set out in this document.

3 REPORT WRITING

3.1 INTRODUCTION

Each chapter of the report should preferably start with an introduction that serves to explain the following:

a) The theme and objectives of the chapter (indicating *what* is discussed).

b) A motivation *why* it is necessary to include the chapter in the report.

3.2 TYPING CONVENTIONS

Reports should be typed in 1½ line spacing. Only one space must be left between the headings and text and between paragraphs. Two spaces must follow a table or figure.

Use margins of 25 - 30 mm on all four sides of the page. The page number must be typed within the top margin. It is difficult to read a wide column of text, especially with proportional fonts, and the width of the text should therefore not exceed 125 mm.

A typing font that is either too small or too large is difficult to read. The *Times New Roman 10 or 11 point* font is normally recommended for text while an *Arial 11 or 12 point* font is recommended for headings.

Do not <u>underline</u> important words. *Italics may be used to draw attention to important words or passages.*

3.3 SECTION HEADINGS

3.3.1 Paragraph headings

The use of paragraph headings (third level) should be restricted to a minimum. Four or more levels are unacceptable and should be avoided where possible.

Do not use headings longer than one line. Restrict the use of verbs to a minimum in headings. Do not use headings as part of the contents of a document or expect the reader to read headings consciously. The very first sentence of a section should describe the contents of the section. The exact wording of the heading can even be repeated in the first sentence.

3.4 MATHEMATICAL EQUATIONS

Type mathematical equations left justified as follows:

$Y = e^{X.t}$

Where:

X = Description of X variable.

Y = Description of Y variable

3.5 TABLES AND FIGURES

Tables and figures should be used as often as possible, because they are easier to follow than long strings of sentences. A short description and interpretation of each table and figure must, however, be given in the document. If the table or figure is unworthy of comment, then it should not be in the report at all. Do not expect the reader to derive his own conclusions from a table or a figure.

Refer to tables and figures in the text as Tables 3.1 and 3.2 or Figure 3.1. The table and figure must be given as soon as possible *after* being referred to in the text but should never precede the reference. When it is necessary to include a large number of tables and figures in the report itself, however, it may be advisable to group the tables and figures together at the end of each chapter.

The following are a number of guidelines that should be considered when drawing up a table:

a) Try to make columns of a table equally spaced.

b) Put units with the headings, not in the body of the table.

c) Avoid using too many vertical lines in table.

d) Break up long columns of figures by inserting a blank row every fifth line.

e) Round numbers to the minimum required (usually the first 2 that change).

f) Provide totals where appropriate (especially 100% with percentages).

g) Add footnotes to clarify data where necessary.

h) Quote the source of the information (usually in table heading).

The following are a number of guidelines that should be considered when developing a figure:

a) Avoid too much information on a figure (preferably not more than 3 graphs per figure).

b) Use linear scales where possible - be especially careful of using logarithmic scales.

c) Try to avoid using false origins - it is preferable to use a zero origin.

d) Use the x-axis for the independent variable, y-axis for the dependent variable.

e) Use different line types for different graphs.

Table 3.1: Example of a narrow table

Type table over width of text

Table 3.2: Example of a wide table

Type table over full width of page

Figure 3.1: Example of a figure

3.6 NOTES ON REPORT WRITING

The following guidelines should be applied when writing scientific reports:

f) **Report layout.** Be systematic and logical in the formulation of the contents. Take care of the following:

  i) Use a logical system of headings and subheadings. Use a hierarchical report structure, but be careful that this will not cause the report to become unwieldy. Be especially careful of using multiple levels of paragraphs and sub-paragraphs. The hierarchical approach can then lead to extremely long chapters. In such cases, a non-hierarchical system could result in a report that is easier to read.

  ii) Keep chapters short, preferably not longer than 10 pages, so that the reader does not lose track of the purpose of the chapter. This will often only be possible if a non-hierarchical approach is followed.

  iii) Use at least one, but preferably two, headings per page.

  iv) Where possible, place long lists of facts in tables rather than in the text.

g) **Comprehensiveness.** The report must be comprehensive, providing all conclusions of importance (including negative results). However, trivial findings should be omitted, but judgement must be exercised to decide which results are insignificant.

h) **Plagiarism.** Take extreme care not to commit plagiarism under any circumstances. Always acknowledge the work of somebody else. Your report will be rejected if you commit plagiarism.

i) **Scientific proof.** Provide scientific arguments and ***motivate every single statement*** (or at least provide a reference to the required motivation). Contents must be free of any unfounded assumptions and must be objective. Never base arguments on "engineering judgement". Never give unfounded opinions. Be exact, correct and clear in all motivations. Be especially cautious not to give the perception of preconceived conclusions (that you wanted to "prove" something).

j) **Accuracy.** Check the accuracy of technical information and data, not only for errors, but also that conclusions are given without bias or wrong emphasis.

k) **Style.** Write the report in the passive form (never refer to the first and second person, e.g. you or I). The past tense must be used to describe work that was performed (e.g. "speeds were measured"). The present tense is used for the discussion of results and conclusions (e.g. "it is therefore concluded").

l) **Readability.** Ensure that the reader for whom it is intended will easily understand the report. The meaning of each sentence must be immediately apparent. Do not expect the reader to read through the remainder of a paragraph to understand an earlier sentence.

m) **Language.** Use a very formal academic (and not a popular), crisp and to the point style of language. Vary the length of sentences, but avoid unnecessary long sentences. One-sentence paragraphs are not acceptable. Do not include information unless it is essential to the topic - do not "pad". Use an absolute minimum of words, but do not omit any essential information. However, be careful of not being too blunt - always use complete sentences. Use UK English as the default language for the document (NOT US English or South African English)

n) **Paragraph structure.** Start each paragraph with one sentence describing the theme of the paragraph. Remaining sentences in the paragraph must provide technical detail. Each sentence should only convey one element of this detail. Where appropriate, end the paragraph with a summary sentence. *Do not describe more than one important concept or give more than one fact per paragraph*. The reader may miss an important concept hidden away in such a paragraph, while he may be confused by a multiplicity of information. More than one fact must be given point by point or in tables.

o) **Grammar.** Check language and terminology. Check for appropriateness of every single word and sentence. Check each word to ensure that the correct word is used in the right place. Be specific with no possibility of misinterpretation. Use the same terminology throughout a document. Do not use colloquial language, slang or emotive words. Avoid the following:

  i) Ambiguity such as "more rugged vehicles" (a larger number of the same strength? the same number but stronger?).

  ii) Do not endow objects with human attributes, as in "the equipment refused to operate".

  iii) Vague expressions and clichés such as "it would seem" and "it is clear".

A number of common English and Afrikaans language errors are given in Tables 3.3 and 3.4 respectively.

Table 3.3: Common errors in English.

GENERAL	
Do not use an American dictionary to spell-check a document. Use the "-ise" spelling instead of "-ize". Use the following word order: subject - verb - indirect object - direct object.	
ARTICLES	
An: Words beginning with a e i o u - silent h - single letters: a e f h i l m n o r s x A : Words beginning with other letters - single letters: b c d g j k p q t u v w y z	
CONCORD (AGREEMENT OF SUBJECT AND VERB)	
I: am/was/have/shall You: are/were/have/will He, she, it: is/was/has/will	We: are/were/have/shall You: are/were/have/will They: are/were/have/will
Noun nearest to the verb counts: Neither ... or Neither ... nor Not ... but Not only ... but also Example: Neither the lecturer nor the students *are*	The first noun is the one that counts: With Together ... with As well as Including Example: The lecturer as well as the students *is*
Quantities and collectives take the singular verb "is": x tons, x litres, x metres, R 2000 series, public, furniture, news, mathematics	
SINGULAR NOUNS	**PLURAL NOUNS**
Criterion Datum Stratum The number of	Criteria Data Strata A number of
PREPOSITIONS	
aim *at* *under* the circumstances Complain *of* compliment *on* different *from* disqualified *from* divide *by/into* exception *to* exchange an - *for* a - *in* front *of*	move *into* multiply *by* *within* a time period *for* a period of time place *onto* reaction *to* *in* respect *of* Succeeded *in* Surprised *at* *too* many
VOCABULARY	
Affected by, the effect of Extent of, extend the (extent is a noun, extend a verb) Fewer numbers but less quantity Owing to means because of, due to means caused by	
USE THE FOLLOWING:	**RATHER THAN:**
Percentage Performed, investigated Researchers, professionals Several, various X metres long	Percent Done Persons A number of X metres in length

Table 3.4: Common errors in Afrikaans.

<table>
<tr><th colspan="2">ALGEMEEN</th></tr>
<tr><td colspan="2">Plaas werkwoorde so na as moontlik aan die einde van 'n sin, maar nie teen elke prys nie.
Gebuik noord, oos, suid en wes met klein letters.</td></tr>
<tr><th colspan="2">SPELLING</th></tr>
<tr><td colspan="2">Beïnvloed, gereelde, reëlings
Definieer (nie defineer nie)
Finansieel – finansiële
Gruispad (nie gryspad nie)
Offisieel – offisiële (gebruik eerder amptelik)
Oorskry (nie oorskrei nie)
Opdraand (nie opdraend nie)
Parkering (nie parkeering nie)
Suid-Afrika, Oos-Transvaal, Aliwal-Noord
Wêreld, brûe</td></tr>
<tr><th colspan="2">VOORSETSELS</th></tr>
<tr><td colspan="2">In antwoord op
Benadering van (nie tot nie)
Daar word aangeneem dat (nie dit nie)
Dit wil voorkom of (nie dat nie)
Dit blyk dat (nie of nie)
Nog of verdere besonderhede (nie meer nie)
Dit wil voorkom asof (nie of nie)
Vergesel van (nie deur nie)</td></tr>
<tr><th colspan="2">WOORDESKAT</th></tr>
<tr><td colspan="2">afdoende = deurslaggewend; voldoende = toereikend
bevind = weloorwoë beoordeling; gevind = momentele oordele</td></tr>
<tr><th>GEBRUIK DIE VOLGENDE:</th><th>IN PLAAS VAN:</th></tr>
<tr><td>Bylae
Nóg ... nóg / nié ... óf
Oponthoud
Openbare vervoer
Sowel A as B
Uitvoer
Verdeling
Verstadig</td><td>Bylaag
Nog ... of
Vertraging
Publieke vervoer
Beide A en B / A sowel as B
Doen
Verspreiding
Vertraag</td></tr>
</table>

4 SYSTEMS APPROACH

4.1 INTRODUCTION

Engineers must cope with a variety of problems that vary enormously in scope and complexity. Some problems are relatively simple and the solutions are obvious. Other problems are more formidable and the best solutions are not readily apparent. Such problems require a structured approach to identify the most appropriate solution. The systems approach provides a *general* framework for handling such complex problems. In essence, it is a *broad-based philosophy* that may be used to formulate or structure problems and to *rationally* and *systematically* search for the *best* or *optimum* solutions to problems. The approach can be used for many types of problems, but is especially applicable to problems typically encountered by engineers and planners.

Although it is tempting to state that the systems approach is a *problem-solving method*, it is in fact not - for the following reasons:

a) The problem is often unclear and it is difficult to determine what is expected from a solution.

b) The systems approach is a *general* approach or framework and not an *exact* or definite method consisting of precise steps to be followed in solving problems. The systems approach does not provide quick answers to problems - it does not even guarantee that solutions will be found.

c) Not all problems can be *solved* as mathematical problems may be calculated and solved. Many problems (particularly engineering problems) have several alternative solutions, each consisting of both good and bad features. Some solutions may do more good than harm, but some solutions can also cause more problems or difficulties. The best that can be expected in such situations is a most appropriate or *optimum* solution. However, even such an optimum can be suspect because a solution which may be an optimum for one person can be a disaster for another. For example, a road bypassing a small town may be beneficial to long distance travellers, but could lead to the demise of the town. Building a new dam can bring wealth to a few industrialists and farmers, but could lead to the death of a valley.

In spite of its many limitations and shortcomings, the systems approach remains an excellent procedure that should be adopted as a basic philosophy by all engineers and planners. The approach is the epitome of *common sense*, providing guidance to rational arguments, and will result in solutions that are at least no worse than solutions found without the approach. More often it would lead to better solutions, even if the solutions are not necessarily the best. At least, it will indicate the many dilemmas and pitfalls which exist in finding solutions.

4.2 SYSTEMS

One of the most important features of the system approach is that problems should not be considered in an isolated or fragmented context, but that a broad, holistic approach should be adopted in which the problem is viewed in its totality. Many problems, even problems that may not be considered as complex, can have far-reaching effects, with consequences that bear little direct relation to the original problem. Such problems require a comprehensive understanding of the problem, whereby the underlying causes of the problem are ascertained, and all possible consequences fully determined.

Civil engineering problems are typically very large in magnitude and can have far-reaching effects, especially on the socio-economic well being of people as well as the natural environment. Building a new road or construction a new dam can, for example, lead to developments far beyond the mere transportation or water-supply functions. Engineers should especially ensure that a holistic approach is taken and problems considered in the broadest systems context.

4.3 SYSTEMS APPROACH

The systems approach is a procedure that will assist the engineer or planner in finding the optimum solutions. The approach consists of the following steps:

a) Problem definition.

b) Define system constraints.

c) Define goals and objectives.

d) Establish measures of effectiveness.

e) Develop a model for evaluation.

f) Develop alternative solutions.

g) Evaluate alternative solutions using the model.

h) Decision-taking.

It is essential that earlier steps in the procedure should continually be revised, as more information becomes available during a study. The problem may, for example, become clearer during the development of the model or another completely different problem may even become apparent. An iterative process should then be followed in which the problem is redefined and subsequent steps adjusted accordingly, until a decision can finally be made.

4.4 PROBLEM DEFINITION

Engineers and planners are continuously involved in the scanning of the socio-economic environment in order to identify deficiencies and needs. In this, reliance is often placed on *management information systems* in which information is collected and analysed on a regular basis to ensure that problems are promptly uncovered.

A major emphasis of the systems approach involves the development of a clear *problem statement*. Although it is an obvious step in the process, the attainment of a clear problem definition can easily be neglected or overlooked. An inappropriate identification of a problem can lead to an unsatisfactory solution of the problem, and could result in a complete waste of effort and resources.

Inappropriate problem definitions often occur when a problem is under-emphasised in order not to cause embarrassment. Other pitfalls are:

a) Failure to distinguish between the actual cause of a problem and *symptoms* of an underlying cause.

b) The tendency to immediately pose *solutions* before establishing the exact nature and extent of the problem.

The following are a number of examples of these pitfalls:

Symptoms of problems	**Solutions to problems**	**Actual problems**
The road is cracked	The road needs a new seal	Inadequate drainage
Congested roads	Build a new road	Inadequate public transport
Water shortage	Enlarge reservoir	Leaking pipes

If a problem is extensive or complex, the problem can be subdivided into smaller sub-problems that are more manageable. The sub-problem then becomes a problem statement in itself, which again can be subdivided into a *hierarchy* of smaller sub-problems.

4.5 SYSTEM CONSTRAINTS

The search for a solution to a problem is often restricted by *system constrains* which place limitations on the type of solutions that may be considered for the problem. The most important constraint is that of the law - unlawful solutions will not often be considered, nor solutions which are immoral or unethical. Another important constraint is affordability - only solutions for which sufficient finances can be found should be considered. Even if the solution can be justified economically, there is little advantage in selecting such a solution if it can not be afforded or financed. Other constraints include the natural environment and locations of historical significance.

4.6 GOALS AND OBJECTIVES

The establishment *goals* and *objectives* represents one of the crucial steps of the systems approach. Goals and objectives are basically statements of "why" one alternative solution is more suitable or more optimum than another, or why something should be done. Alternative solutions are evaluated to determine which of the solutions most closely fulfils the stated goals and objectives.

Engineers and planners have historically been plagued with the difficulty of defining meaningful goals and objectives. This is particularly true when dealing with complex problems typically encountered by civil engineers. Such problems involve social considerations that tend to be abstract or intangible and lack definitive meaning.

A goal is usually a general statement of the end result that is to be achieved, while objectives are more detailed statements of the purpose of the analysis. Few objectives can, however, fully address this purpose and can only provide partial answers to the "why". For example, two important objectives in engineering are economics and safety - but it can always be questioned why these objectives should be considered? There must therefore be a greater objective or goal that can answer the "why". Goals and objectives thus have a hierarchical structure, each objective having a greater objective or goal.

A possible *end goal* for engineers and planners is to maximise socio-economic improvement and quality of life for all. The perception of quality of life varies from person to person, but for most individuals it probably implies *health*, *wealth* and *happiness*. These goals, however, are difficult, if not impossible to attain, because it is hardly possible to achieve development without some damage, especially to the natural environment. Although it may be possible to improve the quality of life for the majority of inhabitants, others may suffer some loss.

Perhaps engineers should add the reservation that inhabitants gaining from a development should compensate others for their losses through corrective (or affirmative) actions.

A further problem is that it is probably impossible to achieve an *absolute* quality of life. Health does not mean a total absence of pain or suffering. Wealth is also rarely enough, especially when compared to a neighbour. Happiness is even more illusive and virtually impossible to quantify. This problem is further aggravated by the fact that people tend to be confusing, unpredictable and conflicting in their values. The trouble with people is that they tend to be human!

Although it is apparent that it is impossible to state goals or objectives which are universally true, no solution will be found unless a pragmatic approach is followed and objectives selected which will at least point in the direction where quality of life is likely to be improved. The following are examples of objectives that are often applied in engineering projects:

- **Economic objectives**
  - Economic development
    - Economic growth, business creation
    - Equal opportunities, extended ownership base, fair and open participation
    - Employment, labour intensive methods
    - Promotion of local technology
  - Economic efficiency
    - Institutional costs
    - Capital costs (constructability)
    - Maintenance costs (durability, maintainability)
    - Operating costs
- **Social objectives**
  - Time
  - Aesthetics, visual intrusion
  - Noise, pollution
  - Safety and security
  - Comfort and convenience
  - Mobility and accessibility
  - Recreation
  - Freedom, choices
  - Natural environment
- **Strategic objectives**
  - Resources
  - Defence and national security

Many of the above objectives are contradictory - some objectives can only be reached to the detriment of others. Is it possible to develop and save the environment at the same time? Can travel time be reduced on a road and safety be improved as well? These questions indicate the difficulties that exist in drawing up a set of objectives and attaching weights to each objective. Different communities will also have different preferences - the needs of the third world are very different to those of the first world. When establishing goals and objectives, it is therefore important that the *socio-economic environment* of the community should be taken into account.

The uncertainties that exist in establishing goals and objectives often mean that *politics* become an important factor. Many engineers do not view politicians favourably and view their decisions as biased or uninformed. This may be true in some instances, but most politicians are guided by the wishes of the community, which is perhaps the best approach that can be followed in establishing objectives. The democratic process is perhaps also better served by introducing "public participation" in which not only the politicians, but also the community itself can have direct input in determining objectives.

Although it may be the right of the community, directly or indirectly through their elected officials, to establish goals and objectives, it remains the task of the engineer and planner to point out all possible consequences. The community is not always correct in their perceptions, especially if the community depends on information from a biased media. There is also the problem of the "tyranny" of the majority, where the minority is forced to lead a life that is decided upon by the rest of the population. In this, the engineer or planner can make a valuable contribution by making the decision-taker aware of all possible consequences and thus reduce the effects of biased decisions.

4.7 MEASURES OF EFFECTIVENESS

Goals and objectives are broad criteria for the evaluation of alternatives. It is, however, difficult to evaluate alternatives objectively, unless some scale exists that can be applied to measure the degree to which an alternative fulfils a particular objective. These scales are called *measures of effectiveness*.

Measures of effectiveness should, where possible, be based on an objective numeric scale, but a subjective scale is also acceptable. In fact, subjective scales may in some instances be more preferable, because it may be difficult to obtain numeric measurements.

The following are examples of measures of effectiveness:

Objective	Measure of effectiveness
Economic growth	Growth rate
Employment	Number of jobs
Costs	Monetary units
Safety	Number of accidents per annum
Convenience	Number of buses per hour
Comfort	Level of service
Mobility	Person-kilometre

4.8 MODELLING

Models are required to obtain measurements of measures of effectiveness in order to find the best or optimum solution. Although the measurements can be obtained from observations of the real-life situation, this is seldom feasible, because of the need to implement alternative solutions before their consequences can be observed.

Most models in civil engineering are one of the following types:

a) Symbolic: Mathematical, statistical or simulation.

b) Physical: Scaled physical representations.

A model should be capable of not only producing the *average* or most likely consequence, but also an indication of a *range* of possible consequences together with the probabilities that the consequences will occur. It is rarely possible to state that a certain action will result in one particular consequence, and it is more likely that an action can have different consequences, some of which are more likely to occur than others. When an alternative solution is evaluated, it is important that all possible consequences and their likelihood should be taken into account.

All models have the disadvantage that they are only *approximate* representations of real-life situations and therefore not accurately reflect true consequences. Many models, and especially mathematical models, give the impression that they are precise, but it is exactly these types of models that require the most simplifying assumptions in order to provide tractable solutions.

Although models are very important in engineering, it is crucial that engineers should understand the limitations of the models. It is equally as important to have a proper understanding of the limitations of the model than the model itself. Many engineers have a dislike in the word "assumption" and some even question the need to state such assumptions. This is perhaps one of the greatest shortcomings of many engineers - their blind trust in models as black boxes. Some engineers also hide behind models and are unwilling to consider other issues which may be intractable. Models are elevated to a god-like status, while they are only one of the steps in the systems approach, and perhaps even a minor step. The argument can even be made that a model is of no use, unless it is capable of addressing the real issues.

One way of improving trust in a model, is to *calibrate* the model, using an existing real-life situation. The model can then be trusted as long as the difference between the alternative solutions and the real-life situation is not extensive. Care should, however, be taken in extrapolating the results of a model to situations where the model may not be applicable.

4.9 ALTERNATIVE SOLUTIONS

The success of applying the systems approach depends greatly on the ability of the engineer or planner to develop *alternative solutions*. The best solution is only the best of alternatives that were thought of, and is not necessarily the best solution available. A broad-minded approach, imagination and creativity are required in the development of alternatives.

In designing alternative solutions, it is unnecessary to consider all possible solutions. Those solutions that are obviously inappropriate can be disregarded very early in the process. The engineer or planner should, however, have sufficient judgement and experience to recognise such alternatives, and not disregard alternatives that may indeed be good solutions.

Engineers develop alternative solutions by using one or more of the following approaches:

a) **Design standards.** Design standards are used when the same problem occurs at different locations. This approach has the advantage that it reduces the possibility of making a serious error, but the risk exists that it could lead to inflexibility. Standards should not be applied blindly, and judgement should always be exercised to determine whether standards are applicable to a particular situation.

b) **Design guidelines.** Design guidelines are more flexible than design standards and can be of great value in developing an optimum solution.

c) **Examples.** Existing solutions to problems similar to the problem being investigated can provide valuable ideas.

d) **Analogue solutions.** In some instances it is possible to acquire a solution from another class of problems which, at first glance, may appear unrelated to the problem.

An example of this approach is found in traffic engineering where traffic flow is often handled analogously to the flow of water.

e) **Model optimisers.** Some models have the ability to automatically search for an optimum solution. These models are, however, fairly restricted in their scope and can generally only be applied to highly technical aspects of a problem.

f) **Systematic searches.** An excellent method for finding solutions is to systematically search through all combinations of variables influencing a solution. Values of variables are changed in a systematic way in order to generate a variety of solutions.

g) **Intuition.** Most complex problems rely on the intuition and imagination of the engineer or planner to find solutions. A multidisciplinary approach can often provide valuable contributions and should be adopted where possible.

4.10 EVALUATION

Alternative solutions are *evaluated* using the model to estimate values for the different measures of effectiveness. This is usually a fairly straightforward step if a simple model is available. The evaluation can, however, become highly complex if an elaborate model is used.

The evaluation of alternatives only results in values of the different measures of effectiveness and is not in the final answer. The best solution is only determined in the next step, namely decision taking.

4.11 DECISION TAKING

The decision-taker should consider all possible likely consequences of alternative solutions, as well as the likelihood of the consequences. Solution may sometimes appear obvious, but more often solutions can be highly controversial, requiring careful deliberation. The decision-taking process can, however, be enhanced if the engineer or planner has approached a problem in sufficient width and depth in order that all consequences have properly been quantified and all possible alternative solutions considered.

The systems approach will fail if the decision-taker remains inflexible in the face of evidence presented. Adherence to cherished beliefs or prejudice can also adversely influence results. It is of utmost importance that objectivity should be maintained and consideration be given to all consequences.

4.12 CONCLUSIONS

Although the systems approach is not a panacea for solving problems, it does provide a framework in which problems can be approached systematically and rationally. It reduces the impact of emotional arguments and is especially effective in countering inflexibility and prejudice. It encourages broad-mindedness in the sense that all viewpoints are accommodated. Hopefully, this would lead to better solutions that will improve the quality of life for all (and to a better research report!).

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

A summary of the results of the research must be provided in the last chapter, together with a conclusion for each of the study objectives. There must be a one-to-one relationship between the conclusions and the study objectives. One conclusion (or set of conclusions) must be given for each objective, in the same order as given in Chapter 1 of the report.

The conclusions must be related to the contents of the report and no new information should be introduced. Make sure that conclusions are valid and supported by the study.

5.2 RECOMMENDATIONS

Provide recommendations on the *application* of the results of the research, based on the conclusions. Recommendations for future research should only be provided when significant. It is also advisable to mention possible consequences if the recommendations are not followed.

6 REFERENCES

The Harvard method must be used to refer indirectly (Author, 1994; Author1 and Author2, 1994; Author *et al.*, 1994) or directly to Author (1994). The list of references is given alphabetically in the following format ***(The headings given above are used only for clarification purposes and should not be included in the list. Provide only one single list of publications, sorted alphabetically.)***:

References to books

Author, A.B. 1994. *Name of book*. 2nd ed. Publisher, Place of publication.

References to articles in books

Author, A.B. and Author, A.B. 1994. Title of article in book. *Name of book*. Ed A.B. Name. 2nd ed. Publisher, Place of publication, pp 243-212.

References to articles in journals

Author, A.B. Author, A.B. and Author, A.B. 1994. Title of article. *Name of journal*, Vol 130, No 1, Month, pp 123-124.

References to newspapers

Newspaper. Day Month 1994. *Title of article*.

References to reports

Author, A.B. Author, A.B. and Author, A.B. 1994. *Title of report*. Organisation. Type of report and report number. Place.

References to theses

Author, A.B. 1994. *Title of theses*. PhD thesis. University.

References to unpublished publications

Author, A.B. 1994. *Personal correspondence or communication*.

References to reputable websites (only if no other way of referencing is possible)

Author (person or organisation), Year (site created or revised). *Name (and place if applicable) of sponsor of the site*, date of viewing the site (date month year), <URL>.

APPENDIX A

NOTES ON APPENDICES

APPENDIX A NOTES ON APPENDICES

A.1 INTRODUCTION

The structure of an appendix should closely follow the structure of an ordinary chapter. The same type of headings should preferably be used.

A.2 CONTENTS OF APPENDICES

Appendices should contain detailed data and graphs that are referred to in the document. The following are a number of examples of such data:

a) Derivation of formulae.

b) Examples of questionnaires.

c) Maps.

d) Brochures.

e) Computer printouts

f) Survey results.

Appendices should not be used to 'pad' a report.

APPENDIX B

EVALUATION FOR

UNIVERSITEIT VAN PRETORIA
DEPARTEMENT SIVIELE INGENIEURSWESE
PUNTETOEKENNING - VOORGRAADSE SKRIPSIES

Student:

❑

Minimum vereistes – die projek sal nie aanvaar word as dit nie aan die volgende tien vereistes voldoen nie:			
Die student het 'n probleem geïdentifiseer, geassesseer, geformuleer en opgelos (ECSA ELO1)		Die verslag is professioneel op standaard (ECSA EO6)	
Die student het fundamentele kennis gebruik om 'n ingenieursprobleem op te los (ECSA ELO2)		Die student is bewus van die impak van ingenieursaktiwiteite op die omgewing en samelewing (ECSA ELO7)	
Die student het die probleem sistematies opgelos (ECSA ELO3)		Die student het onafhanlik en selfstandig 'n unieke navorsingsprojek uitgevoer (ECSA ELO9)	
Die student het data ge-analiseer en geïnterpreteer (ECSA ELO4)		Die projek is ingehandig teen die gegewe inhandigingsdatum (ECSA ELO 10)	
Die student het toepaslike metodes en rekenaartegnologie gebruik om die probleem op te los (ECSA ELO5)		Projek is meestal die student se eie werk. Student moet duidelik aandui wat sy/haar eie werk is. (ECSA ELO10)	

❑

❑ **Punte**					
❑ 30% Baie Swak	❑ 45% Swak	❑ 55% Aanvaarbaar	❑ 65% Goed	❑ 75% Onderskeiding	❑ 90% Uitstekend

Beskrywing van aspekte wat in ag geneem word:		**MAKSIMUM PUNT**	**PUNT**
1	Probleemstelling		
2	Literatuurstudie (relevant, volledig, krities beoordeel)		
3	Ontwerp van eksperiment		
4	Uitvoer van eksperiment		
5	Aanbied van resultate		
6	Analise van resultate		
7	Evaluering van resultate		
8	Gevolgtrekking		
9	Aanbevelings		
10	Tegniese inhoud		
11	Uitleg van verslag		
12	Skryfstyl		
13	Oorspronklikheid		
14	Moeilikheidsgraad		
15	Netheid van verslag		
16	Algehele indruk		
Finale punt		100	

KOMMENTAAR

Eksaminator: **Datum:**

UNIVERSITY OF PRETORIA
DEPARTMENT OF CIVIL ENGINEERING
MARKING SHEET FOR UNDERGRADUATE RESEARCH PROJECT REPORTS

Student:

Minimum requirements – the project report will be referred back if it does not meet the following requirements:			
The student identified, assessed, formulated and solved a problem (ECSA ELO1)		The report is of a professional quality and appearance (ECSA ELO6)	
The student applied fundamental knowledge to solve an engineering problem (ECSA ELO2)		The student is aware of the impact of engineering activities on the environment and the community (ECSA ELO7)	
The student solved the problem systematically (ECSA ELO3)		The student worked independently to submit a unique research report (ECSA ELO9)	
The student analysed, interpreted and derived information from data (ECSA ELO4)		Project is largely the students own work. Student should clearly indicate his/her own work. (ECSA ELO10)	
The student used appropriate methods and computer technology to solve the problem (ECSA ELO5)		The report is submitted by the specified date. (ECSA ELO10)	

❑

❑ **Marks**					
❑ 30% Very Bad	❑ 45% Bad	❑ 55% Acceptable	❑ 65% Good	❑ 75% Distinction	❑ 90% Exceptional

Factors taken into account during evaluation:		**MAXIMUM MARKS**	**MARKS**
1	Problem definition		
2	Literature review (relevance, completeness, critical evaluation)		
3	Design of experiment		
4	Execution of experiment		
5	Presentation of results		
6	Analysis of results		
7	Evaluation of results		
8	Conclusions		
9	Recommendations		
10	Technical content		
11	Layout of report		
12	Style of writing		
13	Originality		
14	Level of difficulty		
15	Neatness of report		
16	General impression		
Final mark		100	

COMMENTS

Examiner: Date: