Guide for Writing a Thesis

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THE CRAZIEST LANGUAGE

We'll begin with a box and the plural is boxes;
But the plural of ox should be oxen not oxes.

Then, one fowl is a goose, but two are called geese;
Yet, the plural of moose should never be meese.

You may find a lone mouse or a nest full of mice;
Yet, the plural of house is houses, not hice.

If the plural of man is always called men,
Why shouldn't the plural of pan be called pen?

If I speak of my foot and show you my feet,
and I give you a boot, would a pair be called beet?

If one is a tooth and a whole set are teeth,
Why shouldn't the plural of booth be called beeth?

Then, one may be that, and three would be those;
Yet, hat in the plural would never be hose;
As for cat in the plural, it's cats and not cose.

We speak of a brother and also of brethren,
But though we say mother, we never say methren.

Then, the masculine pronouns are he, his, and him;
Just imagine the feminine, she, shis, and shim.

So, English, I fancy you will agree,
is the craziest language you ever did see.

(Author unknown)

O B F U S C A T E

Work which is unintelligible will not necessarily be recognized as such. In some cases, the less intelligible a piece of prose, the greater the respect it could earn from its readers—or victims.

Take note, professional advancement is enhanced and colleagues are impressed by papers they cannot comprehend. Therefore, journals do not appreciate intelligible papers easy to review and understand, but prefer convoluted and long-winded papers, that appear to be so much more competent. Academic meetings frequently feature speakers who make little sense.

Compare: "*This paper concludes that to increase the probability of keeping a customer in queue, the server should attempt to influence the customer's initial as well as continued subjective estimate of the mean service time to ensure that the customer attains and then remains under the impression that it is small*". In a plain version, this reads: "*You are more likely to ensure that a customer stays put in a line-up if you can get that person to think that he will not have long to wait*".

If your objective of producing a thesis, writing a paper, or preparing a presentation is not to communicate, but to impress, read no more. You will probably all on your own succeed in presenting a rather incomprehensible work typical of people who may have something to say but who can express nothing. And in the not inconsiderate time you would have spent making your work easier to understand, you could be writing another incomprehensible *disquisition*.

On the other hand, if you desire to get your results truly considered your colleagues and fellow professionals, if you care about promoting the advancement of knowledge, and if you want to feel good about your thesis also in the future (there is a life also After-and-Beyond-the University), read on.

(Center paragraph is abbreviated and edited from an anonymous text)

FOREWORD

The thesis is for many students the very first “real” report a student will write. No wonder then that so many students can take months to produce the first draft. Yet, writing up a research work is not that difficult. It could be hard work, of course, but the format is straightforward and the language can be quite plain; should be plain, in fact. The intent of this Guide is to make the effort easier—for the student as well as for the supervisor who has to review the text. It is hoped that the Guide will let a thesis author avoid having to “reinvent the wheel” or depend on picking out the organization and format from an older thesis that may not be that great an example to follow, anyway. Frankly, using the Guide will simplify the writing task and the thesis will be better.

Start consulting the Guide when you write assignment report in the courses. Apart from your becoming familiar with the Guide, your reports will be better.

Soon after your have started your research and well before you have results to write up, read the Guide and think how you will present your work. Your first step is to state your **Problem**, formulate your **Objectives**, and plan your **Scope of Work**. And this you should do in writing as early as possible.

It is obvious for all that the format of a thesis has to be consistent. The Guide proposes a format that is logical and easy to follow. It is a simple format and devoid of the fancy stuff found in most word processors’ template.

The Guide organizes the thesis so that the text grows from Chapter 1 onward. No reference is made forward, that is, to a later chapter, only to material already presented earlier on in the thesis. All tables and figures are numbered according to the chapter in which they are first referred to. This way, tables and figures in a chapter can be added or deleted without affecting the numbering of tables and figures in other chapters.

When starting to write the thesis draft, begin with the introductory pages (“i-pages”) and proceed to Chapter 1. Then, discuss the draft Chapter 1 with your supervising professor, because you will need input on the Objectives and Outline very early in the work.

In the progress of your work, you will read many papers and reports on results of previous work in your field. Most of these will be summarized in your Theoretical Background chapter, or at least listed in your References chapter. The Guide offers time-saving advice on how to compile your references. Many of the pointers on grammar, style, and spelling are useful also for those with English as the first language.

As you proceed, collect your draft in a binder where you have separated the i-pages, the individual chapters, the tables, the figures, and the appendices with numbered separator sheets. As you complete the draft of each chapter, discuss it with your professor.

Good Luck!

Bengt H. Fellenius
(September 1999)

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GUIDE FOR WRITING A THESIS

Bengt H. Fellenius, Dr.Tech, P.Eng.

1. Introduction

A thesis is a formal presentation of a research topic having special requirements for organization, format, and style. This Guide contains the requirements of theses of the Geotechnical Group of the Department of Civil Engineering at the University of Ottawa. Some requirements are not rigid and will vary depending on capabilities of the word processor and printer used, as well as preferences of the author and the research supervisor.

Consult a grammar and writing handbook for preferred conventions. Note that style and grammar conventions differ from handbook to handbook. Choose one and stay with it. As to spelling convention, you are free to follow either of English or U.S. conventions, but you must be consistent.

A thesis consists of three main parts: the introductory material, the main body, and the reference material. Detailed instruction on each part is given in the following sections.

2. Format

The paper should be of white, good quality bond paper of size 216 mm by 279 mm (8.5 in by 11.0 in).

The following format will make your own editing easier as well as that of your supervisor. It will facilitate your supervisor's making editing suggestions and your revising the text:

- Use either Times Roman or Helvetica type and either 11 pt or 12 pt fonts.
- Use Line Spacing of 1.5 (rather than double spacing).
- Use at least 25 mm (1.0 inch) and no more than 30 mm (1.25 inch) left and right hand margins as well as 25 mm (1.0 inch) top and bottom margins.
- Make all text right justified and use no indents at the start of a paragraph.
- Separate the paragraphs by a blank line.
- Separate all heading lines and last heading line and first line of text with one blank line. The latter can be full height or closed-up a bit if you so prefer.
- Start the heading for the first section of a chapter one blank line below the chapter title with the section number flush with the left margin and with the section title starting after an about 10 mm (0.5 inch) tab.
- Avoid "widows and orphans", that is, avoid having the last line of a paragraph alone on top of a page or the first line of a paragraph alone on the bottom of a page, keeping at least two paragraph lines together. Most word processing programs include this aspect of editing as an automatic or optional feature.
- Place the page numbers at the top right-hand corner of the page.
- Use a top running head identifying the chapter to which the page belongs.
- Begin each chapter with "CHAPTER #" typed centered about 40 mm down from the top of the page (i.e., leave two blank lines below the top margin) and the capitalized title of the chapter written below with one blank line in between.

3. Organization of Introductory Material ("i-pages")

Organize the introductory material in the following manner:

(i) Title page
(ii) Certificate of examination or approval page
(iii) Dedication page (optional)
(iv) Acknowledgements
(v) Summary
(vi) Table of contents
(vii) List of tables
(viii) List of figures
(ix) List of appendices
(x) Glossary (optional)
(xi) Notations (optional)

3.1 Title Page

A specimen title page is given in the Appendix.

The thesis title should consist of about ten words or fewer. A subtitle may be used if necessary, to clarify the topic of the study, for example, to separate the thesis from another thesis of a similar topic.

In the title page, depending on the degree sought: Doctor of Philosophy (Ph.D.), Master of Applied Science (M.A.Sc.), Master of Engineering (M.Eng.), or Bachelor of Applied Science (B.A.Sc.). For an M.Eng. degree, the term "Report" is used instead of "Thesis".

The author's first name is always spelled out. An author's middle name is either spelled out or indicated by its initial.

The date at the right hand side of the bottom of the page is the date of the defense, or the date of the final submission of the thesis if more than minor amendments were requested at the defense.

3.2 Certificate of Examination and Approval Page

Specimen certificate-of-examination and approval pages are given in the Appendix.

For Ph.D. and M.A.Sc. theses, a certificate-of-examination page is placed immediately after the title page. For M.Eng. reports and 4th Year theses, an approval page is used.

3.3 Dedication Page

A specimen dedication page is given in the Appendix.

Usually, the author singles out a spouse, parent(s), or other persons to whom the author has personal reason to give special recognition. The dedication is placed on a separate page with the dedication simply written at the middle or top of the page. First names only, or full names, may be used in the citation.

3.4 Acknowledgements

A specimen acknowledgement page is given in the Appendix.

Persons or institutions who have made a significant contribution to the thesis work in the form of financial support, material, advice, or moral support should be acknowledged with an indication of their type of support. Gratitude is not expressed to institutions, only to individuals. Note that the thesis supervisor is acknowledged on the title page and not under Acknowledgements.

Page numbering of the introductory material starts with the acknowledgement page using lower case Roman numerals.

3.5 Summary

A specimen summary is given in the Appendix to this guide.

The summary is essentially a short version of the thesis and is a very important parts of a thesis. It must not be a verbose outline of the thesis, nor read as a synopsis indicating what was done in qualitative terms, but be factual and quantitative. It should include an introduction on the background, objectives, and scope of the work. Mention of experimental procedures is minimal unless they form a substantial part of the thesis work. Most important, the summary must contain the main results and conclusions from the work.

Efforts should be directed toward keeping the summary short without turning it into an abstract. (An abstract contains only the scope, main findings, and conclusions. It is usually shorter than one page. In contrast, a summary should cover all aspects of the investigation and may extend to three or four pages).

The summary should not be written until the thesis draft has undergone two or three reviews and revisions, but before the manuscript has reached its final form.

Do not start the summary (nor the introduction or any other section, for that matter) with the hedging words "This thesis presents a study of ..." or some similar indirect approach. Start it with a direct approach. The Genesis, for example, did not start "***This book contains the spiritual background reference of one of the large religions ...***", but with a direct statement: "***In the beginning, God created. . . .***". If the thesis is about reducing settlement in clay by means of vippinzor treatment, start by "Vippinzor treatment of spurious clay soils is used to improve settlement behavior of conventional hexagonal footings. . . .".

The summary is often best <u>started</u> by going through the thesis manuscript taking at least a part of a sentence, usually a full sentence or parts from two, from <u>every paragraph</u> in the thesis with emphasis on the chapters presenting Results and Conclusions. The draft so produced is then edited with reference to the manuscript. (As a spin-off benefit, this manner of writing the summary will often indicate areas in the thesis in need of revision and clarification—indeed, useless portions that can be deleted will readily show up by their being irrelevant for the summary).

3.6 Table of Contents

A specimen page of table of contents is given in the Appendix to this guide.

Table of Contents begins on a new page. Pages containing the introductory material ("the i-pages"; the pages numbered with lower case Roman numerals) should be listed in the table of contents.

3.7 List of Tables

A specimen page of List of Tables is given in the Appendix to this guide.

List of Tables begins on a new page. Tables are numbered consecutively within each chapter. This eliminates the necessity of changing all table numbers that follow a new table inserted or deleted during the course of writing the thesis.

Tables in the appendices will not be included in the List of Tables, but may be listed in a separate list placed first in the thesis appendix section.

3.8 List of Figures

A specimen list of figures is given in the Appendix.

List of Figures begins on a new page. Figures are diagrams, photographs, maps—in fact, anything that is not a table. Figures are numbered consecutively within each chapter. This eliminates the necessity of changing all table numbers that follow a new figure inserted or deleted during the course of writing the thesis.

3.9 List of Appendices

List of Appendices begins on a new page. Appendices are separated by letters A, B, C, etc. Each appendix contains material of similar nature, such as raw data, detailed derivation of formulae, manuals, etc., which would be out of place in the main body of the thesis, but still belongs to the thesis work. If considered worthwhile, a detailed table of contents of an appendix may precede an appendix.

3.10 Glossary and Notations

Definition of all parameters used in the thesis should be compiled in a glossary. The symbols and notations listed in the Canadian Foundation Engineering Manual (1985, 1992) must be adhered to in all cases unless found unsuitable in a very special case. The units must be given in base SI-units. Imperial units may be given in parenthesis.

4. Organization of the Main Body of the Thesis

4.1 Chapter Heading and Reference

The main body of the thesis is divided into numbered chapters, each chapter headed by "CHAPTER #" with a capitalized title on the line below, and each beginning on a new page.

In the body of the thesis, when referring to a specific chapter, "Chapter" is written with an upper case "C", e. g., Chapter 3"; otherwise lower case "c" is used. "Chapter" is never abbreviated.

4.2 Subsections

The chapters are divided into sections as required and each section has a title. A section may be divided into subsections. Thus, the numbers "1.2.3" identify a text as the third subsection in Section 2 of Chapter 1. Do not use more than two subsection layers, i. e., 1.2.3.4.

The first word in a section heading—except prepositions and articles—is capitalized (the first letter is written using upper case). For subsection headings, only the first letter in the very first word is capitalized.

If subsections are used, it sometimes improves clarity, as well as ease of writing, to have the first subsection of the first subsection layer under the heading "General" or "Introduction", e. g., "2.3.1 General". No such introductory subsection should be used for the second layer, however.

In the body of the thesis, when referring to a specific section, "Section" is written with an upper case "S"; otherwise lower case "s" is used., e. g., Section 3.4. "Section" is never abbreviated.

4.3 Literature References

Literature references in the text are cited by the last name of the author(s) followed by the year of publication in parentheses. If more than two authors exist for a paper, use the first author's name followed by et al., which words stand for "et alii" (which means "and others"). Do not forget to include the period in "al.". When the reference is not a noun or an object in a sentence, both the name(s) and year(s) are placed in parentheses and separated by a comma.

If there is more than one paper cited within the parentheses, place the references in chronological order and separate them by semicolons.

When reference is made to more than one paper by the same author(s) published during the same year, separate the references by adding a letter after the year, e. g., 1984a, 1984b, etc. with "a", "b", etc. determined by alphabetical order from the first word in the title.

The following are examples of format references given in the text:

> Jones (1982) found the coefficient, C, to be equal to 1.403.
>
> The results presented by Plankare (1984) were in agreement with the findings of Herremann (1983), Gragossen et al. (1974), and Laurel and Hardy (1981).
>
> A number of researchers (Lillflickanovitz, 1932; Sellers, 1957, 1962; Raringen and Gosingen, 1974; Churchill et al., 1981; Zorrocz, 1981) have reported similar phenomena.
>
> There is substantial agreement between Fellenius (1980), Trak (1982), and Garga (1985) on this point.
>
> The findings reported by Wroom (1977, 1981) and Zolacion (1976a, 1976b) enabled Pzist and Topf (1983) to formulate the general theory of mudcake-activated communal swirls.
>
> Subsequently, the continued testing had to be significantly expanded to eliminate the consequence of elated shaft escitassion on the dynamically sensitive rackare and busar (Fint and Fult, 1982; Samt and Synnerligt, 1983).
>
> The Janbu method was introduced to North American geotechnical practice in 1985 by the Canadian Foundation Engineering Manual (Chapter 12 in CFEM 1985).

4.4 Tables and Figures

Place tables and figures together at the end of the main body of the thesis with the tables preceding the figures. (Note, inserting a figure or a table in the main text reduces thesis clarity and impedes the review process). In a table, separating lines must be used sparingly. Specimen of a table and a figure are given in the Appendix to this guide.

Place each table and figure on a separate page. However, figures that are intended to be studied together can be placed on the same page. Tables and figures which are too wide to fit down the page (portrait style) may be rotated 90° so that they are read from the right hand side (landscape style).

In the text, when referring to specific tables or figures, always write “Table 2.6”, “Tables 2.6 and 4.7, or Tables 3.1 - 3.7. Similarly, "Fig. 2.5", Figs. 3.6 and 7.6", and Figs. 8 - 12. When referring to a figure without giving its number, write "figure". Example: "The preceding figures and Fig. 1.4 verify the assumption". Write either "Fig." or "Figure, but be consistent.

Figures can be drawn in black-and-white or color. If in color, pick shades that will print well in black-and-white, e.g., photocopies must be legible. Make all lines thick (heavy; wide) and the lines in the graph about twice as thick as the width used for the axes in the diagram. Connect data points with straight lines and avoid using graphics program that creates curved lines between points. If data represent a curved line, draw the line by some curve fitting approach (to be described in your thesis text), but , usually, the connecting lines should be kept.

Figure texts often become too small to be read. To determine the proper height of a letter, imagine a rectangle around the figure and never use any main lettering smaller than 2 percent of the longest side of that rectangle. For secondary texts, subscripts, and symbols, do not use a size smaller than 1 percent of the diagonal length.

4.5 Equations

Similar to the numbering of tables and figures, equations are numbered according to the chapter in which they first appear. Symbols and notations are only defined when they first appear (and in Notations).

When an equation is cited from a reference using symbols and notations deviating from those of the thesis, the equation should be rewritten into the convention of the thesis.

When referring to specific equation(s), for a reference to a single equation write, say, "Eq. 2.5", for a reference to two equations write "Eqs. 3.6 and 3.8", and for a reference to three or more equations, write Eqs. 4.2 - 4.6". When referring to an equation without giving its number, write out the entire word "equation".

Use the math or equation option of your word processor program to obtain clear equations rather than trying to type an equation.

4.6 Units and Terms

When written out, SI-units, e.g., metre, newton, pascal. etc., are not capitalized and do not take plural ending. Plural endings should also be omitted for all other units in the SI-System, including for the unit "hour", which nobody would write "hs", of course, but writing "hr" or "hrs" is equally wrong. (Similarly, if you include conversion to English units, do not write "lbs". The spelling is "lb". The "lb" stands for "libra" which is a plural form already).

Moreover, numbers are brought to more useful size by means of multipliers or prefixes, which for combined units can only be in the nominator (above the line), never in the denominator (below the line). Never write "MN/mm^2", but "N/m2". Note that the unit "kg/cm^2" is not an SI unit and should be converted to "100 kPa". Do not use the units "bar" and "at" (as an aside, the unit “bar” is equal to 100 kPa and the unit “at" is equal to 98 kPa).

For linear measurements, do not use "cm", use only "mm" and "m" (linear measurement is always multiples of 1,000 of "m", "metre"). Sometimes, the centimetre unit can be used for volume, as in "cm^3". For area, square centimetre (cm^2) can be used when alone. However, never in combined terms, such as when indicating stress . The unit for stress is multiple of newton/square metre or pascal (N/m^2 or Pa). Combination units such as N/mm^2 and MN/cm^2 violate the principle of the International System (SI) and can be the cause of errors of calculation. That is, prefixes such as "M" (million = 10^6) and "m" (milli = 10^{-3}) must only be used in the numerator never in the denominator.

Avoid using "mass" which has the unit "**kg**". "Weight" has the unit "**N**" (newton) can normally be used instead with very little change of wording. However, if "mass" is the most fitting term, never use the unit "**Mg** (megagramme)" to mean "1,000 kg", the unit gramme, “g”, is not a base SI-unit. On occasion, the term "tonne" can be used for the mass of 1,000 kg, but it is clumsy. It is better to convert to weight and express the value in with prefixes indicating multiples of the base unit for force "newton", "N". Suitable prefixes are "MN", "GN", etc. Also note that all units originating from names, e.g., N, J, etc., take the letter in upper case, but when the unit is written out, all letters are in lower case, e.g., newton, joule, etc.. Note that the letter symbol for the unit pascal is "Pa".

It is acceptable, indeed preferable, to capitalize the prefix in "KPa", "KN", etc., instead of writing "kPa", "kN", but be consistent. Notice, "kg" should be considered as a single symbol and requires lower case "k". (“K” is an increasing multiple and as such it should take upper case letter similarly to the multiples “G”, and “M”).

It is not correct to use formulae or equations requiring insertion of parameters in dimensions other than the base units. The multiples, such as M (mega = $1 \bullet 10^6$), G (giga = $1 \bullet 10^9$), m (milli = $1 \bullet 10^{-3}$), etc. are to be considered to be numbers multiplying the base unit input in the equation.

When quoting data in originally in English units, make sure that soft conversion is used and avoid writing "30.48 metre", when the original measure was "100 feet", or maybe even "about 100 feet". Similarly "about one inch" is "about 25 mm", while the conversion of "2.27 inches" is "57.7 mm". Notice, the unit for "second" is "s", not "sec"!

Using the word "centigrade" to mean the unit for temperature is a far too common mistake. The correct term is "degree celsius" or just "celsius", abbreviated "°C", as in "a soil temperature of 14 °C".

I find consistency and logics in the use of terms very important. For example, I prefer to use the terms "**shaft resistance**" and "**toe resistance**" and abhor terms such as skin friction" and "end resistance" My dog has a skin, but a pile does not, and "end" resistance" has a connotation of time. My preferred term for the "upper end" of a pile is "pile head". Some use the term "top", but if you deal with wood piles, the "top" of the tree does not become the pile head. And, as to the term "pile tip" (used in the sense of "pile toe"), consider that "tip" is only a typo away from "top" (which typo has appeared in a major publication). "Pile point" is not a good term either. Sometimes, you need to attach a pile point (a rock shoe or similar) to a pile toe, and attaching a point to a point would sound strange. Recently, I saw a paper referring to the "tip end capacity"! I am not sure if I know what was meant. If you do not have a strong own preference, I suggest you use the terms "pile head", "pile toe", "pile shaft", "shaft resistance", "toe resistance". Limit the "end" to uses such as "end of driving", "lower end", "upper end", and reflect on how if in the following "end" would replace "toe": "*toward the end of the driving (the test, etc.), the toe resistance was* ...). Above all, do not employ several terms for one and the same aspect.

Frequently, "**settlement**" is let to mean "movement", "deformation", or "deflection"—a gaffe recurrently found in piling papers. For example, load-transfer effects cause movement, not settlement. Settlement is usually time-dependent and is caused by compression of the soil for a single load and not by load-transfer of a series of increasing loads. In fact, we must distinguish between three different types of deformation: "movement" which is deformation caused by increasing total stress; "settlement" which is deformation under constant total stress, but increasing effective stress; and "creep" which is deformation occurring under constant effective stress. A static loading test produces "movement", not "settlement". (Of course, load-movement results, such as from a static loading test, can be a great assistance to calculating the settlement of a foundation supported by piles. However the movement of the pile in the test is not a direct measurement of the settlement of the structure to be supported by the pile).

Many theses and papers include results from **static loading tests**. although the term used is mostly "load test". However, I have often met non-geotechnical professionals who believe the term means a test of the particular loads to be applied to the pile by the structure to be supported irrespective of the soil and pile conditions and who do not realize that the term refers to testing the response of the soil and pile to load from the structure. (Note, "test loading" is not a good substitute for "loading test"). Similarly, I prefer to write "piled foundation" as opposed to "pile foundation". We are not referring to the foundation of a pile, but a foundation placed on piles. A parallel case is that we say "iced tea", and not "ice tea". Well, one can carry the approach too far, we also say "ice cream" not "iced cream".

The term "**ultimate capacity**" is a tautology similar to "warm heat", "cold chill". The tautology comes from a concoction with "**ultimate resistance**", a term that has the same meaning as "capacity", and one that cannot be misunderstood or in combination with a modifier or adjective be misleading.

Generally, modifying "capacity" to, for example, "**load capacity**", "**allowable capacity**", and "**design capacity**" opens up confusions and errors. The terms might be intended to mean, say, "design load", "allowable load", "factored resistance", respectively, but the intent aside, different engineers interpret the meaning of each term differently to that interpreted by another engineer. The three examples of modified "capacity" are very confusing and misleading and must not be used. The word "capacity" is best used alone, and when meaning "design load", "allowable load", "factored resistance", use those very terms.

Do not abuse the term "**prediction**". It is not a synonym to "calculation", and the verb "predict" is not synonymous with the words "calculate", "determine", or "compute". If you really intend to refer to a true prediction, that is, a calculation made before an observation has been made and then compared to that observation, fine, but if the paper presents calculations made after the measured values are known, this is not a "prediction", and the word to use is "calculation, "analysis", etc. Do a "search-and-replace" to surely weed out this abuse. For example, a capacity determined in a CAPWAP analysis can never be a predicted value.

The term "**batter**" is an absolutely needless jargon term. It adds nothing to the message what the common word "inclined" conveys. "Batter" is simply one of the jargon terms many add, mostly without thinking, in order to sound more knowledgeable and advanced than they are. Laymen (read: lawyers and judges) cannot understand the term, so the author must be good, eh? Use "inclined" to indicate that a pile is not vertical.

A less common mistake for reference to an inclined pile is the term "**raker**". It is a term referring to support of retaining walls. A raker is an inclined beam between the ground (usually placed on a foundation pad or similar support) rising to a "whaler" (a beam parallel to the wall that distributes the force over the wall and into the retained soil). There is a bit of a 'cross-pollination' between "raker" and "batter"; I have seen the term "batter raker" used! Again, to proper way to state that a pile is inclined is to use the word "inclined".

The term "moisture content" in lieu of "**water content**" is spot on example of an obfuscating jargon term to avoid. Note, a layman can understand what "water content" means, as well as the terms “moisture” and “content”, when encountered separately, but understanding the meaning of the combination of the latter words requires geotechnical training. Jargon that has no other purpose than to make the subject matter incomprehensible for the uninitiated makes bad technical writing. Perhaps "moisture content" is used because it is perceived to make the author appear refined and a true expert. Would someone writing "humidity content" then look even more refined? Or, could perhaps "wetness content" be better, or the even more 'refinedly' sounding: "wetness quotient". Please, the word to use is "water"!

The term "specific weight" was abandoned as a technical terms long ago. It used to define the weight of material for a unit volume. However, the proper term is "**unit weight**" (units of measure are force/volume; "density" has units of mass/volume).

Also the term "specific gravity" is still in common use despite being a discarded term internationally. It is used to mean the dimensionless ratio of the density of the material over the density of water. The internationally assigned term to use for this ratio is "**relative density**", which term, unfortunately, conflicts with the North American geotechnical meaning of the term "relative density" referring to SPT N-indices, alternatively as a classification of soil density with respect to its maximum and minimum density. For the latter, however, the internationally assigned term is "**density index**". Avoid using the "specific gravity term; it is not that hard to do.

The term "**bearing**", usually means "ultimate toe resistance" or "actually applied toe load", but also other meanings prevail. It is often found combined as in "end bearing", but while "toe bearing" is a less clumsy alternative, the meaning of neither term is clear and "bearing" is best avoided.

Pile driving is terminated on satisfying a "**termination criterion**". Some will use the word "refusal" to indicate this, as in "the pile reached refusal". However, the all important laymen will take the words to mean that the pile cannot or could not be driven deeper by any means available. "The pile driving just had to stop". It is not understood that the word "refusal" is not used in an absolute sense, but that the driving simply met the criterion assigned to the project. It is ridiculous to talk about or specify a "refusal" as 8 blows to the inch! The words "practical refusal" tries to bring the use of "refusal" into agreement with the layman's concept, but this only emphasizes the confusion. Use expressions such as "termination criterion", "the pile could not be driven deeper, because ...", etc.

The number of blows is often counted — mechanically or by a device. The number of blows counted over a certain time or, more commonly, over a certain length of pile penetration, say, number of blows over 200 mm, one inch, or one foot, is called "blow-count", sometimes, expressed as number of blows per time, e.g., one minute. Note, use of the words "**blow-count**" should be limited to when referring to the actual count. That is, if the penetration of the pile for 10 blows is 15 mm, and the termination criterion refers to number of blows per 25 mm, then, the blow-count is not 17 bl/25 mm, it is still 10 bl/15 mm, but the "equivalent penetration resistance" is 17 bl/25 mm (Don't use the term "equivalent blow-count"; it would be utterly confusing). Always make clear if referring to an actual number of blows (impacts) counted (give the actual number and length measured) or the value is in the units of the assigned termination criterion.

Personally, I prefer to avoid using blow-count altogether and use the term "**penetration resistance**" instead. Because the capacity the hammer-pile-soil system has to overcome is rarely equal to the ultimate resistance of the pile at some later moment, a term for soil resistance to the driving, "**driving resistance**", for short, can be useful. Some may interpret the term "penetration resistance" to imply force, that is, understand it as a synonym to "driving resistance". Adding the units of the term to the value resolves that conflict.

An abuse of terms that has cost considerable money in litigation is using the abbreviation "**set**" to mean "termination criterion". The words "set" is a short for "'settlement". For example, a "small set" is where the penetration is small. However, "small set" is thought by some to mean a "small number of blows" per one inch (or other penetration length), which essentially is the inverse of the 'correct' meaning. Don't ever use the term 'set" in any circumstance!

The term for describing the effect of resistance increase with time after driving is “**set-up**” (soil set-up; "set" has nothing to do with abbreviating "settlement" here). Do not use the term “freeze” (soil freeze), as this term has a different meaning for persons working in cold regions of the world.

Bored piles can be constructed with the hole kept open using a temporary casing or a slurry mix if the hole does not stay open. The hole can be wet (filled with water) or dry (no water in the hole). The term "**dry hole**" means exactly that and not that no slurry was used. Similarly, placing of concrete (grouting the pile) can be through an "elephant trunk" hose or through a tremie pipe. But note that use of a "**tremie pipe**" does not mean that the hole was filled with water or slurry before grouting. So, to make the actual conditions clear, you need to emphasize that you are using the terms in the correct context, that is, make clear whether or not water was present in the hole.

Piled foundations can be placed on driven piles or **bored piles**. In North America, the latter type are often called **drilled shaft**, which is acceptable, but use one or the other, not both. When using "drilled-shaft" make sure that it cannot be confused with the pile shaft as opposed to the pile toe. The old term "caisson" should not be used as it is often confused with the term cofferdam.

4.7 Quotations

Quotations are discouraged. However, when text is quoted from a source it must verbatim and it should be placed within quotations marks. Alternatively, relatively long quotes may be placed in a separate paragraph indented from each side and the quotation marks dropped. To provide an additional visual separation from the thesis text, quotations may be written in italics.

4.8 Writing Tense

Normally, past tense should be used for all verbs throughout the text. Present tense should be limited to what is actually shown in figures and tables. For example: "The results were in agreement with the findings of Kunnig (1983)", and "Fig. 4.2. presents a selection of the results”.

4.9 Writing Style

Do not extend the thesis unnecessarily. Be positive in your presentation. The thesis is not about what you did not do. Certainly, it will be necessary to qualify the scope of your work and present some reasons for your choice, which may leave some phenomena unexplained. Nevertheless, keep comments on aspects beyond the scope of the thesis to a minimum.

Limit each paragraph to a single message. Short paragraphs focus the reader’s attention and assist understanding.

Avoid long sentences. While occasionally a long sentence may yet be suitable, two or more long sentences in sequence must be avoided. Most word-processing programs include the options of grammar checking and sentence word count (in addition to the spell checker). Make frequent use of these options and, in particular, before and each time the thesis draft is submitted to your supervising professor for review.

5. Chapter Organization

5.1 General

The most common chapter organization is Introduction, Literature Review, Theoretical Background, Experimental Approach, Results, Discussion, and Conclusions. In some instances, deviations from this standard organization are reasonable, but they should be discussed with your supervisor. Notice, do not write a discussion and/or conclusion at the end of each chapter. This makes the thesis convoluted and repetitious.

5.2 Introduction

An Introduction chapter is always included. Organized in separate sections, it should make a statement of the problem studied, give the objectives of the study, indicate the scope of the work, and provide an outline of the thesis. Thus, it **must** have the following five section headings:

1.1 Introduction
1.2 Statement of the Problem
1.3 Objectives
1.4 Scope of Work
1.5 Outline of the Thesis

Many are confused about what separates Sections 1.2, 1.3, and 1.4. Experience has shown that for many these sections are very hard to write. Before the are completed, however, not much purpose is served by writing anything else of the thesis.

5.3 Literature Review and Theory

The literature review is as long as necessary, citing the appropriate background information and references needed to fully develop the topic and analysis. In many instances, it is logical to follow this chapter with a separate chapter entitled "Theory", or "Theoretical background", to cover extensive theoretical development pertinent to the work.

The review chapter is the chapter spelling the difference between a M.A.Sc. Thesis and an M.Eng. Report. Whereas the Report limits the literature review to what is necessary in order to understand the analysis made later on in the Report, the Thesis requires a much more elaborate and comprehensive survey of the literature that aims to put the study into its proper context. (Furthermore, in the chapter on Discussion, the Thesis is expected to critically examine the results in the light of results from other studies, presented in the literature review. This discussion can be shortened in the case of a Report).

When reading papers which may have a bearing on your thesis work, note all the particulars of the reference on an index card—hard copy or virtual card. The top of the card should contain a complete and formally correct reference to the paper as used in the Reference section of the thesis. The rest of the card may be used for a few notes on the contents of the paper. Then, when writing your thesis draft, the papers to be referenced in the thesis can be easily selected and the proper texts for the References taken directly from the cards. Properly kept up, this system will save you days of work.

5.4 Experimental Approach

The chapter presenting the experimental approach to the study must include all details of the experimental plan, procedures, and equipment used in the research. The information must be sufficient to allow anyone to fully reproduce the experiments. Standard procedures need not be described in detail, but you must give full reference to the particular standard. If a deviation from the procedures outlined in a given reference was employed, it must be fully explained. Photographs of the experimental setup, samples, etc. will enhance the presentation.

5.5 Results

The chapter giving the results of the work should list the observations from the experiments in a logical fashion. The raw data are not necessarily included in this chapter, but the results of standard manipulation (reduction) of the raw data must be presented. Sometimes, an example calculation should be given, possibly appended. Data are reduced, tabulated, and presented on graphs (figures), but the chapter does not include a discussion of the data. Trends drawn from the data in diagrams should be supported by the appropriate statistics.

In case of extensive data sets, the raw data are best given in appendices and only the plotted data included in the tables of the thesis. Always, all of the raw data must be present in the thesis, either in the main body or appended, to ensure the usefulness of the thesis work for future analysis.

5.6 Discussion and Conclusions

The discussion analyzes the results to finally prove the arguments made or stated hypotheses. The results are interpreted and explained, data from different tests are compared and related to the findings of others (which must have been included in the chapter on literature review and theory), and the data are critically reviewed with comments on the reliability of the data and results. The discussion leads up to the conclusions of the thesis work. The Conclusions chapter is a vital component of the thesis and deserves a careful consideration. It is often worthwhile to have one chapter on Discussion and one on Conclusions.

5.7 References

References are placed immediately after the last numbered chapter of the thesis. The format must follow the convention of the Canadian Geotechnical Journal. Give the references alphabetically and without any abbreviations and do not number them. The Appendix contains two specimen pages. (Notice the different formats of making the ASCE Journal references).

5.8 Appendices

The appendices contain information which, although essential to the thesis, is routine in nature, or highly detailed. Tables containing the raw data of an investigation should be placed in an appendix. It is a good rule to also append important working tables and figures and routine calculations. Computer program listings (codes) may be incorporated directly in the appendices placing only a flow chart of the program in the main body of the thesis.

The appendices should be numbered A, B, C, etc. In conformity with the organization of tables and figures in the main body, A1, A2, A3, etc. identify tables and figures in the Appendix.

6. Spelling Rules and Special Aspects of Style

Use either English or U.S. spelling: for example, English spelling includes the letter "u" in words such as "behaviour", "colour", "favour", "harbour", "labour", "rumour", "neighbouring", "remould", "gauge" and doubles the consonant in words such as "modelling", "travelling", "controlled", "labelling", "omitted", "focussing", and "referring", "preferred", and "occurring", (but "offered" and "offering", because the stress is on the first syllable). American spelling omits the “u” and does not double the consonant in these words. (“occurring” and “occurred”, however, are written the same way by both conventions).

Write "z" instead of "s" in "analyze", "analyzing, and in "analyzer", and in "organize", "organizing", and "organizer", as well as in "capitalize", "horizontal", "idealize", "rationalize", "realize", "specialize", and "summarize".

Use the spelling "to advise" and "to practise" and "the advice" and "the practice" (verb versus noun), and omit "e" before "able" in "arguable", "drivability", "desirable", "lovable", etc. However, the "e" is retained in "serviceability" and "noticeable" (to separate the consonant “c” from the vowel “a”). Notice also the spelling of words such as "mileage". Similarly, use “i before e unless after c”, e.g., “receive”, or when the vowels "ei" sound like “a”, as in neighbor or weigh, or weight.

A simple and useful distinction of meanings can be made by writing "metre" for distance and "meter" when referring to a measuring device. Similarly, the spelling "programme" as in "testing programme" keeps the meaning apart from "program" as in a "computer program".

When using the verbs "centre" (English) or "center" (U.S.), use the correct tense forms: "centred" and "centered", respectively.

Do not use loose contractions such as "don't" or "can't". Write "do not" and "cannot". Also, write "it is", not "it's" or "its". Besides, "its" is a possessive pronoun not to be written "it's".

Capitalize all months, days, and seasons.

Do not overuse nouns as adjectives. Four nouns in a row is an abomination. For instance, "the concrete pile toe capacity", which reads much better if changed to "the toe capacity of the concrete pile". In general emphasizing adjectives “much”, “very”, etc. are redundant, and “extremely”, “absolutely” have no place in a thesis. If something is larger than something else, better than to say “much larger”, quantify it and let the reader judge from the numbers.

Avoid "there are " constructions; write "two critical points are shown. . . ", not "there are two critical points shown...".

Avoid also the "of the"-phrases. Thus, write "the page length should be 100 mm" rather than "the length <u>of the</u> page should be 100 mm".

The first time a noun, e.g. "test", "measurement", "borehole", etc., is mentioned, avoid using definite article (i.e., "the"). Often, the text flows better is an indefinite article is used, i.e., "a", or no article.

Use plain English and common words rather than fancy ones, and be concise (on account of that sesquipedality does not result in perspicacity). Use short sentences and avoid lengthy or awkward constructions. If a sentence comes out to use more than three lines, it is usually better to split it into two.

Think of the literal meaning of words and expressions and avoid 'ear-sores' such as "up to a depth of …”.

It adds to clarity to separate sentences by making two space bar depressions after each end-of-sentence period.

Take care (proof read) not to leave a number alone at line end with its units at the next line, e.g., "16 MPa". Use a non-break space command between numerals and units for getting "16 MPa" to always be on the same line. Similarly, use the non break command to prevent a number from starting a line, i.e. the word immediately before the number should stay with the number.

When writing "Fig. 5", "Author B. C.", "i. e.", "e. g.", and other words using an abbreviation period, the automatic justification of the lines may result in too wide a space after the period, e. g., Fig.   5", "e.   g., and Author B.   C.". To avoid this, always follow such a period with a no-break-space command, or do not use a space. For names shown as only the a first letter followed by a period, the space after the period between a series of such letters can be omitted.

Numerical values consisting of four or more digits can be difficult to read. Then, to improve clarity, separate each set of three digits with a comma, e.g., 7,312,940. (This is North American practice. European practice of separating the digits with a space for every digits is less clear and can lead to mistakes in understanding).

Work on the interpunctuation and, in particular, the use of the comma. Commas are important for the understanding of the text and must not be neglected. Always place a comma before a conjunction introducing an independent clause. For example: “always remember, commas enhance the reader’s understanding of the message”. Also, ponder why the following two sentences have different meanings: “Also the professor may need assistance with regard to commas.” “Also, the professor may need assistance with regard to commas." (Either meaning may require a bit of diplomacy in rendering the assistance). Finally, consider the life and death importance of whether Caesar's order about your execution or liberation reads "Execute, not liberate" or "Execute not, liberate".

Use always the convention of the "serial comma". Thus, write "red, white, and blue" with a comma separating each item in the series (of three or more items). That is, place a comma before the "and", as well as before the "or" in a series of alternatives.

When the subject is the same for both sentence clauses and the connective is "but", a comma should be used after the word preceding "but". Note, when the subject is the same for both clauses and the connective is "and", the comma should be omitted.

Notice that there is often a difference between similar words. For example, "alternate" and "alternative", where "alternate" refers to every second in a series, and "alternative" is one of two possibilities. "Alternate", but not "alternative" can sometimes mean "substitute". The word "substitute" is then preferred. Do not confuse the meaning of the words "objective" and "object"—a common mistake.

You may want to indicate that a particular observation or item is more important than others, starting the sentence making this point as "*More important, the measurements show that ...*". Do not write "importantly". The adverb of important, "importantly", is a synonym to "pompously". Similarly, when presenting items in order of importance, preferring to avoid a bulleted or numbered list, do not write, "Firstly", "Secondly", "Thirdly", etc. Remove the "-ly" and write "First", "Second", "Third", etc.

Many times, the words "precision" and "accuracy" are improperly used. An example of "precision" is the reading precision of a gage, that is, the number of decimals given in the gage reading. "Accuracy" considers errors in the gage and in a combination of measurements and calculations. The following is a common error: "the accuracy of the prediction of capacity was 3 percent". The text actually means to refer to an "agreement" between values. Besides, accuracy in prediction of pile capacity can never be as good as 3 percent!

Notice that a verbal message can be spoken or written, heard, or read. If you want to say that the message is spoken as opposed to written, say "oral". A non-verbal message is not necessarily non-spoken, but one not conveyed by words, for example, by grunts and gestures.

The word "anybody" means "anyone". "Any body" means "any corpse". Similarly, "any one" means "any single person".

The word "data" is a plural word and takes plural verbs. So are and do the words "criteria", "formulae", "media", "memoranda", "phenomena", as well as "strata". Therefore, the appertained verb must be in plural form. The corresponding singular words are "datum", "criterion", "formula", "medium", "memorandum", "phenomenon", and "stratum".

Words such as "usage", "finalized", etc. may look refined, but are examples of convoluted style. Use the simple versions: "use", or "final or finished", etc. Note, "utilization" refers to the manner or "using", and "utilize" is not a refined synonym to the word "use".

The words "order of magnitude" imply a relation of ten! Usually, the intended meaning is better expressed by plain "magnitude" or "size".

Puristically, "in-situ" should be written in italics, but hyphenating it provides sufficient distinction. Do not write "insitu", or "in situ".

The word "less" is overused. Whenever possible, replace it by its various equivalents, such as "fewer", "smaller", "lighter", "lower", "poorer", etc.

Do not use the ampersand symbol, "&", write "and".

Prefixes such as "pre-" are often unnecessary. For example, the word "predominant" can often be written "dominant" (and preferably be replaced by words such as "governing", "principal", "leading", etc.).

Limit each paragraph to a single message. Short paragraphs focus the reader's attention and assist understanding.

8. Visuals

Do not use tables in a visual. Most material contained in a table is much more informative if shown in a diagram. When a table just has to be shown, limit the number of lines to 5 and the number of columns to 4.

Good visuals can rarely be made from the figures used in a paper, because most such figures have too much detail and too small lettering and letters and numbers. For a visual, the ideal minimum text size (height of a letter) for a visual is 3 percent of the graph diagonal. If you intend to use a figure from the thesis or paper as a visual, therefore, you most likely will have to redraw it to do the audience and the paper—as well as yourself—full justice. When preparing the visual, eliminate all extraneous text, such as captions and literature references.

Do not use serif type fonts in a visual, e.g., Times Roman, but use a non-serif type, e. g., Arial or Helvetica. The former are easier to follow on a running text as in a thesis or a paper, but the texts inside a figure or along a diagram axis are more legible in non-serif fonts.

For curves, use wide (heavy; thick) lines and use large symbols to indicate all plotted points.

Use bright and sharp colors. Remember, you would surely like to reach also those in the audience who have a visual deficiency with regard to color. And they are not that few.

When using computer graphics, e. g., Power Point, avoid fancy backgrounds, or the visual will be not be easy to read and it will require more time to absorb. Use colors that are sharp and somewhat on the dark side rather than those diffuse and pale. Pale yellow color may be used on a background shading, but never for points, text, or lines.

APPENDIX

EXAMPLES

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Certificate of Examination (M.A.Sc.)
M.Eng. Approval Page
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"Chapter 1. Introduction"
Beginning of "Chapter 2, Theory"
"References"

TABLES AND FIGURES

Example of a Page Ph.D.

REVISCILATATION OF HEXAGONAL STRIP FOOTINGS

JOHN B. SNUBBLARE, M.A.Sc.

A Thesis

Submitted under the supervision of

Dr. Sanguine K. Vasare

in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Department of Civil Engineering
Faculty of Engineering
University of Ottawa
Ottawa, Canada

April 31, 1999

UNIVERSITY OF OTTAWA
FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

Example of a Page M.A.Sc.

POST-DYNAMIC QUASI-TREPIDATIONS IN SEISMIC REVOCATIONS

FLITIG GOSSE, B.A.Sc., P.Eng.

A Thesis

Submitted under the supervision of

Dr. Fler Ordig, P.Eng.
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in partial fulfillment
of the requirements for the degree of
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April 31, 1999

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UNIVERSITY OF OTTAWA - SCHOOL OF GRADUATE STUDIES

C E R T I F I C A T E O F E X A M I N A T I O N

The Thesis by

JOHN B. SNUBBLARE, B.A.Sc.

entitled

REVISCILATATION OF HEXAGONAL STRIP FOOTINGS

is accepted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Civil Engineering

April 31, 1999

Examining Board:

Dr. TROR P. ALLT

Dr. SOVER MEST

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Supervising Professor:

Dr. SANGUINE K. VASARE

Certificate Page M.Eng. of B.A.Sc.

UNIVERSITY OF OTTAWA
FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

C E R T I F I C A T E O F A P P R O V A L

The Engineering Report by

SOPASS O. KUNNIG

entitled

Use of Bull Feathers for Soil Reinforcement

is accepted in partial fulfillment
of the requirements for the degree of
Master of Engineering

July 1, 1996

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SUMMARY[1]

A full-scale laboratory testing study has been conducted on premanufactured bandshaped drains (wick drains) of four different geometrical designs. The objectives of the study were to measure the efficiency of the drains in terms of achieved degree of consolidation and to determine their relative equivalent cylinder diameter.

The theory behind calculation of the time necessary for dissipation of pore pressures in fine-grained soils by means of vertical drains builds on Terzaghi's consolidation theory as adapted by Barron (1947) and Kjellman (1948). The theory makes use of radial and horizontal flow toward a small cylindrical drain in the center of a large cylinder of soil. Bandshaped drains are treated as cylindrical drains with a certain equivalent diameter (Hansbo, 1979). However, the references do not show agreement on how to determine the equivalent cylinder diameter of a bandshaped drain.

To achieve the above objectives, two full-scale test series were performed in the laboratory. Each test series consisted of loading four cylindrical containers filled with remolded soil. A consolidation process was started in the soil by loading the soil surface with weights. The consolidation process was monitored by means of specially developed and manufactured settlement gages and piezometers. In three of the four containers, a bandshaped drain was installed to accelerate the consolidation by means of horizontal drainage. The fourth container determined vertical consolidation, only, and served as reference for a separation of horizontal and vertical consolidation.

The first test series made use of natural clay soil, while the second used a natural silty and sandy soil. The soils were remolded and mixed with water to achieve isotropic soil conditions and placed in a 1.0-m diameter steel cylinder to a depth of 1.0 metre.

The drains included in the study were a 100 mm wide studded drain (Drain A; Alidrain), a 100 mm wide grooved drain (Drain G), a 100 mm wide drain studded on one side and flat on the other (Drain S; Alidrain S), and, for reference, a half-width studded drain (Drain M). All drains were equipped with the same type of filter envelope.

The instruments used to monitor pore pressure and settlement consisted of hydraulic pore pressure gages and settlement gages developed and fabricated in the laboratory for the purpose of this study. Both types of gages had a reading precision of 2 mm. The accuracy of the gage readings was 5 mm, considering the influence of reading precision, capillary effect, and temperature variation.

The analysis performed for the Clay Series indicated that the results of estimating the final settlement by the method proposed by Asaoka (1983) agreed well between the test containers

[1] This text is taken with some abbreviation and editing changes from a M.A.Sc. Thesis presented in 1985 by Normand G. Castonguay.

(approximately the same final settlement was calculated). For Series Three, calculations according to the Asaoka method gave values of final settlement which agreed with the values obtained by means of conventional methods.

Oedometer test performed on soil samples obtained from the soil mixtures prior to and at the completion of the tests indicated that isotropic soil conditions were obtained and, specifically, the coefficients of consolidation due to vertical and horizontal drainage, c_v and c_h, were about equal and in the range of $1 \cdot 10^{-8}$ m^2/s through $10 \cdot 10^{-8}$ m^2/s for both test series. The evaluation of the settlement measured in the No-Drain containers resulted in c_v-values in both series equal to approximately $4 \cdot 10^{-8}$ m^2/s.

The observations indicated that the drains accelerated the consolidation process by means of horizontal drainage. Drain A achieved a faster development of settlement and a faster dissipation of pore pressures than that achieved by Drains G, M, and S.

The vertical and horizontal consolidations were separated by means of the Carrillo relation (Carrillo, 1942), and the effect of the horizontal degree of consolidation achieved by Drains G and S was about equal and 80 % of that of Drain A.

By using the fact that Drain A is exactly twice the width of Drain M and identical in all other respects, and, therefore, the equivalent cylinder diameter of Drain A is twice that of Drain M, the horizontal coefficient of consolidation, c_h, was determined to be $3 \cdot 10^{-8}$ m^2/s and $1 \cdot 10^{-8}$ m^2/s for the Clay and Silt Series, respectively. In the same analysis, the diameter ratio for Drain G to Drain A was determined to be about 0.6 and for Drain S to Drain A the diameter ratio was found to be about 0.8.

The different diameter ratios evaluated for Drains G and S to Drain A were used to calculate the ratio of time required for achieving 80 % consolidation to the time for Drain A at equal spacing, which was about 150 % for Drain G and about 130 % for Drain S. The ratio of volume of drains necessary to achieve the 80 % consolidation in equal time (requires the less efficient drain to be installed at a closer spacing) was, again, about 150 % for Drain G and about 130 % for Drain S.

The calculations are very sensitive to minor variations in the input data. However, the main results are definite: Drain A was more efficient that the other drains and Drain G and A are approximately equal with, perhaps, a slight edge for Drain S.

The efficiency differences found are considered due to two factors: the different free surface area of the drains of equal total surface area, and the observed microfolding of the drains, which increases the well resistance in the grooved drain, but does not affect the well resistance of the studded drain.

T A B L E O F C O N T E N T S

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CHAPTER 1*)

INTRODUCTION

1.1 General

Starting some 60 years ago, the draining of water in fine-grained soils from deep below the ground surface was achieved through vertical sand drains installed by means of punching or drilling a hole in the ground and filling it up with free-draining sand (Porter 1936, 1938). The sand drains could greatly accelerate the settlements in a local area and allow a road or a building to be finished much sooner than otherwise would have been possible. However, they were expensive and their installation sometimes so disturbed the soil that the final results were no improvement over the original conditions (Casagrande and Poulos 1969).

About 40 years ago, premanufactured bandshaped drains (wick drains) were developed that eliminated much of the disadvantages associated with the sand drains (Kjellman 1948). The bandshaped drain consists in principle of a filter surrounding a core that is studded or grooved. The filter gives free passage to water, but retains the soil particles. Once in the core, the water can travel freely in the channels created between the studs or grooves.

The first bandshaped drain—the Kjellman wick—was made of arsenic-impregnated cardboard and had the dimensions 100 mm by 3 mm. Due to its low efficiency and obvious environmental hazards, the Kjellman wick was abandoned. It was not until the late sixties that the modern bandshaped drain was invented consisting of a plastic core and a separate filter. At first, the filter was made of paper. Soon, however, the paper was discarded for synthetic material being more pervious, stronger, and durable.

The premanufactured bandshaped drain very quickly became accepted as replacement for vertical sand drains. Today, there are several competing bandshaped drains in the international market. Most of them are based on the original Kjellman concept of a 100 mm wide strip with an outside filter and an inside core.

1.2 Statement of the Problem

The theoretical model normally used for the design of drain projects builds on theories developed by Barron (1947) and Kjellman (1948) which say that the time for reaching a certain degree of consolidation, i.e., settlement or pore pressure dissipation, is a function of the equivalent cylinder diameter of the bandshaped drain among other factors (Hansbo 1979). The theory makes use of radial and horizontal flow toward a small cylindrical drain in the centre of a cylinder of soil and builds on the Terzaghi general consolidation theory. However, it is not clear how to determine the diameter of the cylinder representing the bandshaped drain.

The literature does not contain any reference to factual studies of the equivalent cylinder diameter of the bandshaped drain. This means that there is a lack of reliable input for use in the

*) This text is taken with some abbreviation and editing changes from a M.A.Sc. Thesis presented in 1985 by Normand G. Castonguay.

design of projects on bandshaped drains in general, because the different approaches give different values of equivalent diameter for commercially available drains.

1.3 Objectives of the Investigation

The objectives of this study were to measure the efficiency of four premanufactured bandshaped drains in terms of achieved degree of consolidation and to determine their relative equivalent cylinder diameter.

1.4 Scope of the Investigation

The four types of bandshaped drains investigated were the Alidrain (Drain A), a drain with a ratio of free surface over closed surface of about 10; a grooved drain (Drain G), a drain with a free surface ratio of about 1; the Alidrain S, a drain with one side equal to the standard Alidrain and the other side smooth with openings into the studded side; and a half width Alidrain (Drain M) included as a special drain with a gross free surface equal to that of the grooved drain and a free surface ratio equal to that of the Alidrain (Drain A). All drains were wrapped with the same filter.

The investigation reported herein consisted of two test series. In the first, the "Clay Series", natural Champlain clay obtained from a local site was used. This was remolded with addition of water to make it more compressible. Natural soil was also used in the second test series. This time, the soil was silty and sandy, the "Silt Series".

The tests were at full scale and were carried out in the laboratory by placing the soil in large cylindrical containers and subjecting it to a uniform surcharge. The surcharge induced excess pore pressures in the soil matrix. The subsequent dissipation of the pore pressures and compression (volume loss) resulting from the drainage of the water were measured by means of piezometers and settlement gauges, which were specially developed and manufactured for the project.

In each test series, four containers were used, three of which had one of the drains placed in its centre. The fourth container served as reference for vertical drainage to enable the results of the other three tests to be adjusted to consider the effect of horizontal drainage, only.

1.5 Outline of the Thesis

(*Not included*)

CHAPTER 2*)

THEORY OF CONSOLIDATION BY VERTICAL DRAINS

2.1 Introduction

Theoretical design procedures were not available when sand drains were first used and the early installations were designed on an empirical basis. Theoretical design procedures based on Terzaghi's theory of consolidation of compressible soils were developed by Barron (1947). The customary Terzaghi from for expressing the differential equation for one-dimensional consolidation is as follows.

$$\frac{\partial u}{\partial t} = c_v \frac{\partial^2 u}{\partial z^2} \tag{2.1}$$

where
- c_v = coefficient of consolidation
- u = excess pore pressure
- t = time for dissipation of excess pore pressure
- z = depth coordinate

The solution to the differential equation is

$$t = T_v \frac{H^2}{c_v} \tag{2.2}$$

where
- T_v = -0.1 - 1g(1 - U_v) (2.3)
- H = length of drainage path
- U_v = average degree of vertical consolidation

The coefficient of consolidation, c_v, determined by Eq. 2.2. The equivalent horizontal coefficient for horizontal drainage is c_h. The coefficients are assumed constant over the usual loading range.

The equation for consolidation by three-dimensional flow expressed in cylindrical coordinates is:

$$\frac{\partial u}{\partial t} = c_h \left(\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r}\right) + c_v \frac{\partial^2 u}{\partial z^2} \tag{2.4}$$

*) This text is taken with some abbreviation and editing changes from a M.A.Sc. Thesis presented in 1985 by Normand G. Castonguay.

For two and three dimensional flow, the assumptions are also made that the load distribution on the soil layer is unaffected by the consolidation process, and that change in strain does not affect change in stress.

Consolidation by vertical flow alone involves only two variables, time, t, and depth, z. For consolidation by two-dimensional flow, the variables are x, y, and t, while for three-dimensional flow, they are x, y, z, and t. The general solution for consolidation by two- and three-dimensional flow for a given set of boundary conditions may be obtained by . . . . .

(*Example text is cut here*)

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Table 4.1 Site Information

No.	Depth (m)	Description	Water Content (%)	CPTu Data q_t (MPa)	f_s (KPa)	U2 (KPa)
Evanston, IL (Groundwater table at 4.5 m)						
1	1.5	SAND, Fine to medium, trace gravel	29	25.08	191.5	49.8
2	3.4	SAND, Medium, trace gravel	16	3.48	47.9	-16.0
3	6.7	SAND, Fine, trace silt, organics	26	32.03	162.8	111.7
4	8.5	Silty CLAY, trace sand	28	0.51	21.1	306.4
5	9.5	Silty CLAY, some gravel	22	0.99	57.5	39.6
6	12.8	Silty CLAY, some gravel	23	0.69	19.2	383.0
7	16.5	Silty CLAY, some gravel	24	0.77	17.2	427.1
Vancouver, BC (Groundwater table at 3.5 m)						
1	3.7	CLAY to Clayey SILT	52	0.27	16.1	82.5
2	5.8	Clayey SILT to SILT	34	1.74	20.0	177.1
3	10.2	Silty CLAY	47	1.03	13.4	183.5
4	14.3	Silty CLAY	40	4.53	60.2	54.3
5	17.5	Silty SAND	25	10.22	77.8	118.5

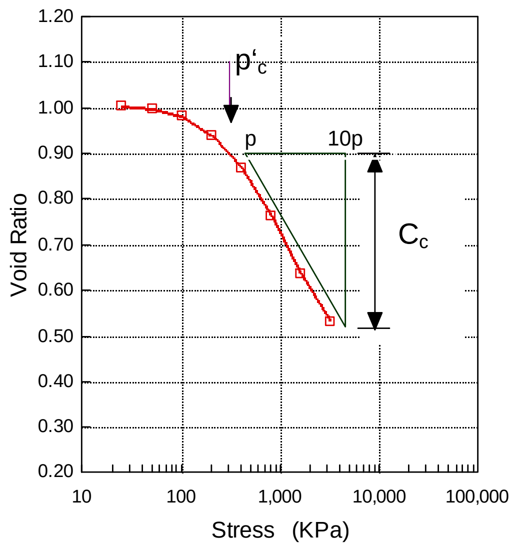

Fig. 3.1A Conventional presentation of results

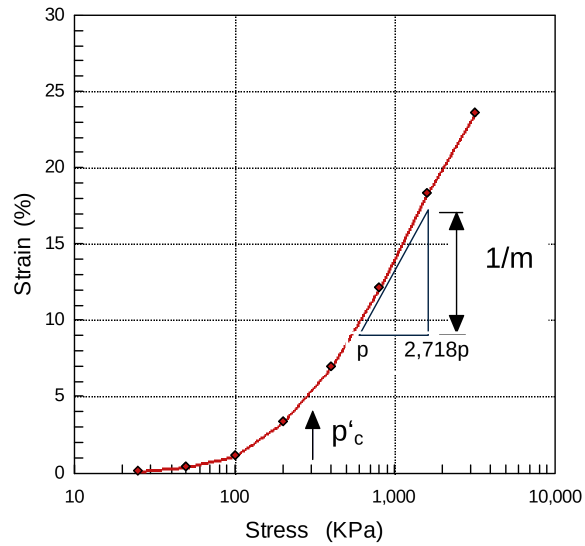

Fig. 3.1 B Plot in stress-strain

(*Figure excerpt from Fellenius, 1999*)

The two diagrams are related and therefore placed together on the page. Note that placed alone, the axis texts and numbers are sized to be just about within 2 % of the about 100-mm diagram diagonals. When placed together, however, the two diagrams must be considered one diagram. The diagram diagonal is then about 180 mm and **the letters and numbers are too small**.

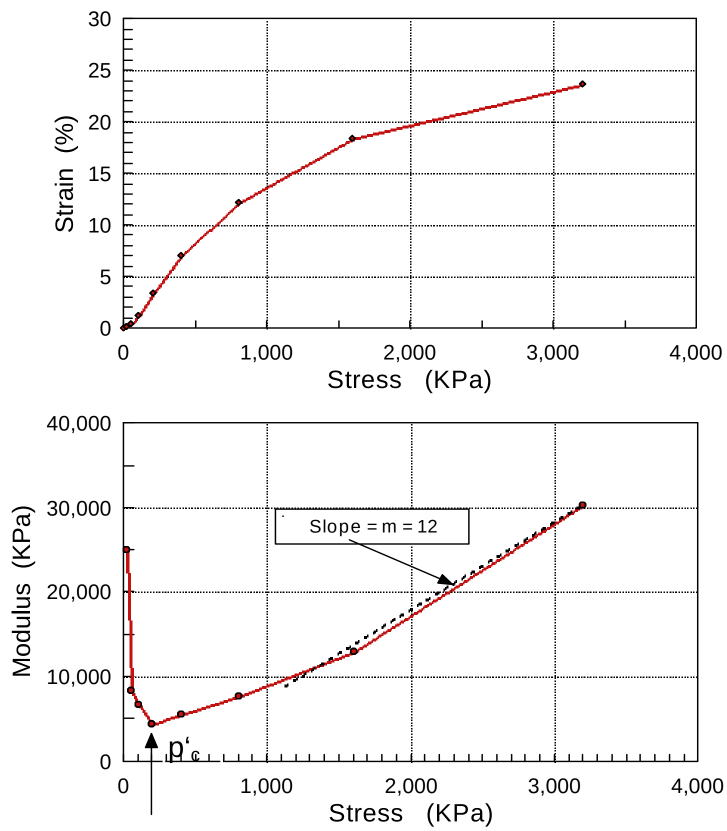

Fig. 3.2 Oedometer results plotted in arithmetic scale

The lines are too thin and, again, **the letters and numbers are too small**
(*Figure excerpt from Fellenius, 1999*)