Preface

Why This Book?

It is my hope that the present book is the final edition of my lecture notes *Elementary Continuum Mechanics for Everyone*. The very first edition was written in connection with my teaching a first course on continuum mechanics at the Technical University of Denmark. I tried to find a text that would suit my intentions, but found that the books on the market either were filled with tensor analysis, including e.g. *curvilinear coordinates* and *Christoffel Symbols*, or they were of the old mechanics traditions, meaning that every new example was treated separately with the result that universally valid principles, such as the *Principle of Virtual Work*,[P.1] never appeared. In my opinion, if teaching continuum mechanics at any level is justified it must contain a strong element of general statements. Then, of course, there is the risk that the treatment becomes mathematically so difficult that it cannot serve as an introduction to the subject. Therefore, this book contains an elementary, but quite general, exposition of the subject, and it is my sincere expectation that most students—*with some effort, of course*—should be able to get a feel for the important concepts of *(generalized) strains*, *(generalized) stresses*, and the *Principle of Virtual Work*. Judging from the experience of many of my predecessors I may have set too high a goal, but still I shall try to reach it.

I feel that a solid understanding of almost any subject may only be obtained through examples, and this is one of the reasons why I have included Parts II–V, which may be viewed as applications of the theory of Part I. Of course, I consider the topics of Parts II–V to be important by themselves, but in the present context it is just as pertinent that they may be based on and illustrate concepts from Part I. Thus, an essential idea behind this book is to present continuum mechanics, not only as a valuable subject in its own right, but as the foundation for all our theories and methods governing the behavior of solids and structures. Although I endorse the use of examples it has been my experience that they tend to obscure the real subject by their sheer number and length. Therefore, I have limited the number of worked examples, except in Part III because there the examples provide useful information about properties of a number of cross-sections. I hope that I have found a reasonable balance in this regard.

[P.1] Later, we shall see that there are more than just one principle of virtual work, but at this point this is not important.

Who Should Read this Book?

The present book is meant as an introduction to continuum mechanics with applications in solid and structural mechanics and, obviously, engineering students are potential readers. It is, however, my hope that engineers who would like to achieve a better understanding of the theories they apply will appreciate this book.

Other Possible Topics

As regards topics not treated here there is a couple that I would have liked very much to include. An important one is *Elastic Fracture Mechanics*. The reason why I have left it out is that in order to do the job right one has to introduce solutions to some fundamental elasticity problems, which can almost only be found by use of complex functional analysis. If I were to introduce the methods of Muskhelishvili (1963) that particular subject would have taken up much more space than I consider feasible in the present context. The possibility of presenting the solutions without proof and then utilizing them as a basis for the theory of linear fracture mechanics may be justified under other circumstances, but not here, where the emphasis is different, namely on full derivations of all[P.2] formulas.

Another subject which might have been covered is perfect plasticity because results from computations by hand based on this assumption have been used over and over during the past sixty years or so. However, with few exceptions, computer analyses that consider the more realistic case of strain hardening have been made possible due to the small cost of personal computers and have therefore made the older methods redundant. In my opinion, today the most important application of perfect plasticity is *Johansen's Yield Line Theory*,[P.3] see e.g. (Johansen 1963) and (Johansen 1972). The beauty of his theory is that it may provide useful results with only a limited effort, even for rather complicated situations. On the other hand, derivation of the Yield Line Theory would take up more space than I consider reasonable in the present context.

My Writing Style

Readers of this book will soon discover that its style is somewhat unusual—probably an older reader will find it appalling, see also the Introduction, but I have my reasons for writing the way I do. I have tried to write in an informal style without sacrificing accuracy. A main idea behind my

[P.2] There is one exception to this, namely the formulas for imperfection sensitivity in Chapter 20. The reason for this is that the formulas by themselves are short, while their derivation is long and very complicated, see e.g. (Budiansky 1974) or (Christensen & Byskov 2010).

[P.3] Johansen himself never acknowledged that his yield line theory actually could be viewed as an example of upper bound solutions of the more general theory of perfect plasticity.

writing is that I attempt not to introduce any concept without first giving a motivation for its usefulness and relevance. I may not have succeeded, but this was my goal.

Many years ago when I was an undergraduate at the Technical University of Denmark I encountered the subject of mechanics in a physics course. It was never explained to us why the subject as a whole was important, and in particular there never was an indication of the reason behind the way the different topics were dealt with—other than the comment: "If you don't understand this, you don't belong here." In my case they may have been right, but at that time I did not feel that a statement like that showed much insight into how the human mind works, and today I think that teachers like that should not have been allowed to stand in front of a class. I intend to avoid such arrogance, but caution that the consequence in some cases is that the presentation will seem unnecessarily lengthy to some readers.

You might say that my ambition has been to explain "why—not just how."

In all probability it is not necessary to mention that English is not my mother tongue, but hopefully the meaning of my efforts is clear in spite of that.

If, on the other hand, the language of this book bears some resemblance to (American) English, my wonderful secretary at Aalborg University, Kirsten Aakjær, who has read all the pages[P.4] of a shorter, previous edition and has suggested many substantial improvements to my writing, deserves to be mentioned. Kirsten Aakjær favors British English, and many times she tried to convert every phrase into that language. Over the years, we have had discussions about the virtues of these two kinds of English, but have never obtained a complete agreement—only a friendly ceasefire.[P.5]

It is also worth mentioning that Kirsten Aakjær in many cases suggested more fundamental improvements to my writing, such as telling me that a particular example had a too abrupt ending.

Being a very stubborn person, I have sometimes chosen to follow my own instincts in spite of the advice by Kirsten Aakjær, so blame me—not her—for the errors.

As you will see later, in order that you may have a quick view of the topics I have put a lot of gray boxes in the margin.

Many gray boxes in margin

[P.4] It must have been a boring job considering the fact that the contents must have been alien to Kirsten Aakjær.

[P.5] In the mid-Seventies my family and I stayed in Massachusetts on a sabbatical leave at Harvard University. My son, Torben, who was five or six years old at that time, once proclaimed: "British English is bad English," which is a statement that I have often quoted since.

To be fair, our year in Massachusetts was the Bicentennial year, and the British were always the bad guys when the kindergarten kids played.

Open Source Programs

I could not have written this book without the use of open source and free programs such as LaTeX 2ε, BibTeX, makeindex, texindy,[P.6] gnuplot, maxima, Octave, xfig, gcc, and g++.

Possible Errors in This Book

I am sure that there must be some errors even in this edition. There is, unfortunately, nobody else but myself to blame: I have pressed the keys on the keyboard, I have moved and clicked the mouse, I have written the text, and I have drawn all figures and produced all the plots.

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[P.6] Just the thought of using one of the WYSIWIG, sometimes called WYSIAIG for "What You See Is All You Get," text editing programs brings sweat to my face.

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