Objectives of an Assistant Professor

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The application procedure for a position of assistant professor at Delft University of Technology requires that the candidate writes an essay on his or her objectives. This is such an essay for a position in the Structural Mechanics Section of the Department of Civil Engineering and Geosciences. It presents my expectations for the future of structural engineering and explains how I wish to contribute to this development. Three subjects are considered, teaching, science and technology.

Teaching

The major challenge for a teacher is to be crystal clear.

Despite the fast development in information and communication technology I do not expect dramatic changes in university education. At the moment the WWW is frequently used to communicate course schedules, to register for exams and to report grades. Professor Verruijt has explored other options like e-books, interactive exercises and tests on the WWW [2]. Others have published course notes on the WWW [for example 3] or developed interactive CD-ROMs [4]. Some of these applications take much developing effort but most are relatively easy to produce and maintain. I plan to apply this technology where it is convenient for both students and teacher.

Short video demonstrations can be very efficient in explaining lecture material, for example the simulated motion of a building model in an earthquake. One minute of video explains more than a thousand words. However, producing and editing video material on a personal computer is still a cumbersome task. Far easier to develop are animations using the program PowerPoint. Animations are efficient to explain changes in time, for example the construction stages of a suspension bridge. Videos and animations used in a lecture should afterwards be distributed on CD-ROM or be available on the WWW for future reference.

At Delft University the teachers have time to write tailor-made lecture notes and exercises for the students. This is a privileged situation compared to many other universities. However, should the number of graduate students drop significantly, we perhaps need to adopt standard textbooks for some of the courses. Excellent books are available for many courses in structural engineering. A book usually includes much more than needs to be covered in the course. Therefore, a study guide needs to accompany the book. A disadvantage is that most books are more expensive than lecture notes.

University education is not only for acquiring understanding. The students also need to learn basic engineering skills, such as using finite element software. For this it is not sufficient to include software demonstrations in a lecture. In my experience students are only interested in programs they can use by themselves. Therefore, some universities have adopted a practical approach to teaching finite element analysis to undergraduate students [5]. During such a course the students work on computers to solve a series of problems that demonstrate the importance of meshing, element selection, manual checks and so forth. Theory is only introduced when necessary to a correct understanding of applying the method. At Delft University we should consider such an approach because at present many graduate students are not confident that they can do finite element analyses.

Because the computer takes over ever more engineers tasks, the need for studying applied mechanics may become less obvious. Clearly, specialised structural engineers will always be needed for maintaining existing analysis software and developing special-purpose programs. We need to show potential graduate students that this line of work can be a very good start of a successful career.

Science

Scientific research pursues knowledge without a clear application in mind. This knowledge may be applied in the future but this is not relevant to a scientist. He or she attempts to explain observations with a simple theory or elegant mathematics. Beforehand it is not known whether such an explanation will be found or even whether it exists.

However, when asked, leading scientists in structural and material engineering often answer that they do not know of recent important discoveries in their field. Instead a gradual development is perceived. An explanation may be that structural and material behaviour is of such complexity that simple truths do not exist. My view is that scientific discoveries in this field are still possible. We need to continue looking for them, not only in personal research but also in the work of others.

My contribution to scientific research will mainly be on computational modelling of structures, structural optimisation and structural reliability. Aspects of these have not been investigated thoroughly and further research can provide interesting insights.

Unfortunately the key research areas of Delft University do not include structural analysis or structural design (Appendix 1). Apparently, safe and efficient structures are taken for granted. More than ever we need to advocate that in-depth knowledge of structural behaviour is essential to support change and challenges in the Dutch construction industry.

Technology

Designing better products in less time is an important objective of the construction industry. The productivity of structural engineers can be increased by good software. Initial designs will probably always be made with just a pencil, paper and a few formulae. But all subsequent structural design work can and should be computer supported.

Design graphs are very convenient for structural engineers. However, the provided information could also be obtained with a special purpose computer program in the same time as is needed to read the graphs. The program can include finite element technology because a model with a thousand degrees of freedom can often be computed in less than a second on a modern personal computer. The advantages of such a program are higher accuracy, more options and a wider range of parameters. Despite these advantages there are many obstacles for special purpose programs. Specialised knowledge is needed to produce and maintain the program. Moreover, code committees might not yet have approved the state of the art knowledge that needs to be included.

Structural analysis programs have gradually adopted much of the functionality of general-purpose finite element programs. To date, the latter are almost exclusively used when volume elements are needed, for example to study soil structure interaction and reinforced concrete beam column joints.

Most structural analysis programs and finite element analysis programs present beautiful plots of moments, stresses, force flow and so forth. However, often a structural engineer just wants to know whether a design suffices. If not, he or she quickly makes a few changes and the program checks the design again. Performance checking will soon become very easy in structural analysis programs. I expect that in the near future most designs will be made by just trial-and-error, thereby ignoring the graphical output altogether.

Optimisation has been introduced in some finite element programs [6]. Among other applications, it is being used for shape optimisation of mechanical components. Optimisation has not yet been introduced in common structural analysis programs. If introduced, I expect it would not be successful. The problem is that any structure has many unique constraints, which the designer would need to formulate and enter before the optimisation can start. It is probably faster to vary some dimensions manually. However, optimisation can be successful in special purpose programs.

Reliability analysis has also been introduced in some finite element analysis programs [7] but not yet in the common structural analysis programs. Reliability analysis will give a considerable reduction of structural costs because it is quite accurate compared to the conservative safety factors and load combinations. To date, reliability computations are mainly carried out on structural components. This is related to the computational speed of modern computers. Reliability analysis can be introduced in practice as soon as computers are sufficiently powerful to process complete structural models. Reliability-based design may differ considerably from a conventional design process. In my research I plan to investigate design procedures based on reliability analysis.

The Dutch construction industry cannot afford to fall behind in adopting new technology. This danger is not just imaginary because there is little communication between Dutch structural designers and designers in countries like the USA, Japan or even Germany. Therefore, International comparison of design methods and software is essential. A personal objective is to find, study and keep track of new software that can be used in structural design. Next to the American and Japanese programs special attention will be given to German software, which particularly show promising innovations (Appendix 2).

Planning

Table 1 shows the planned teaching and research targets for the period of 1 October 2002 to 30 September 2006. The footnotes below the table explain the presented data.

Targets per year	Costs per year	Gain per year [2]	Gain / Costs
1.5 papers in international reviewed journals	0.40 fte (714 hours)	7 pts (€ 21000)	29 € / hour
2 papers in international conferences	0.11 fte (196 hours) [1] + € 3000	6 pts (€ 18000)	77
Co-author of 1 paper	10 hours	4 pts (€ 12000) [3]	1200
Teaching 2 courses a year	0.10 fte (178 hours)	3 pts (€ 9000) [4]	50
Direct supervision of 2 M.Sc. projects	0.10 fte (178 hours)	0.55 pts (€ 1650) [5]	9
Committee member in 2 M.Sc. projects	0.02 fte (36 hours)	0.23 pts (€ 690) [6]	19
Consultancy	0.02 fte (36 hours)		
Supporting colleagues	0.03 fte (54 hours)		
Planning, bureaucracy and administrative meetings	0.02 fte (36 hours)		
Writing 2 Ph.D. projects (STW, etc.)	0.10 fte (178 hours)	€ 250000 [7]	1400
Supporting 1 Ph.D. student	0.10 fte (178 hours)	0.4 pts (€ 1200) [8]	7
Total	1.00 fte (1784 hours) + € 3000	21.18 pts (€ 63400) + € 250000	174

Table 1. Annual planning for teaching and research

1. It takes 3 weeks to write a paper and 1 week to visit a conference. A paper may be used for a second conference, which would take another week. In total this is 200 hours.
2. In 2001 a point yielded fl 6600.00 (allocatiemodel). This value is used for the planning period.
3. It is assumed that the other authors are not from the same department.
4. It is assumed that 25 students in a course will pass the exam. The courses yield 2 credits (studiepunten). For 1 credit we receive 0.03 pts. 2 * 25 * 2 * 0.03 = 3 pts.
5. A graduation project yields 26 credits (studiepunten). For 1 credit we receive 0.03 pts. My experience is that the direct supervisor receives approximately 35 % of the points. 2 * 26 * 0.03 * 0.35 = 0.55 pts
6. As committee member I approximately receive approximately 15 % of the points. 2 * 26 * 0.03 * 0.15 = 0.23 pts
7. Statistics show that 1 out of 4 projects is granted. Projects are often written for € 500000. 2 * 500000 / 4 = 250000. Restrictions exist on how this money is spent.
8. For a successful Ph.D. project 12 points are obtained. A project takes approximately 4.5 years. Presumably as a supervisor I will receive 15 % of the points. 12 / 4.5 * 0.15 = 0.4 pts.

Summary

My research interests are
- Computational modelling of structural behaviour
- Design procedures
- Computational optimisation
- Reliability analysis

Specifically, this includes
- Applying advanced analysis to practical design problems
- Developing design procedures for specific structures and structural components
- Developing algorithms for computation of safety factors and load combinations
- Implementing computational optimisation for structural shape and dimensions
- Supporting the application of general-purpose finite element programs
- Initiating and participating in the development of special purpose programs for structural design
- Reporting promising software developments to structural engineers
- Introducing successful developments in teaching

Literature

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11. ETABS, Frame program for performance-based design and pushover analysis, http://www.csiberkeley.com/ETABS_PT_One.htm .
12. WCOMD, Program for dynamic nonlinear analysis of reinforced concrete structures, http://www.forum8.co.jp/english/uc-win/wcomd-e.htm .
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Appendix 1. Key Research Area's of Delft University of Technology [8]

Current key research areas

1. Earth-observation, -utilization, -ecology and –engineering
2. Information and communication technology
3. Life science and technology
4. Mechatronics and Microsystems
5. Mobility of persons and transport of goods
6. Nanotechnology
7. Water works, water management and water quality

Intended key research areas (beoogde speerpunten)

8. Computational science and engineering
9. Management and design of multifunctional infrastructures
10. Material science
11. Sustainable energy, extraction, conversion and use
12. Sustainable industrial processes
13. Sustainable urban areas

Appendix 2. Engineering Software Markets

Engineering software markets are subdivided by education of the population, codes of practice, engineering culture and above all by language. Advanced software is most likely to emerge in a large market with challenging construction projects. Three dominant markets can be distinguished for innovative engineering software, which are the English market, the Japanese market and the German market (Table 2).

Country	Population	Gross National Product	GNP per Person
USA	267 900 000	$ 6 975 312 000 000	$ 26 037
Canada	30 280 000	$ 620 740 000 000	$ 20 500
Australia	18 530 000	$ 400 600 000 000	$ 21 699
New Zealand	3 570 000	$ 60 060 000 000	$ 16 866
Great Britain	58 800 000	$ 1 102 658 000 000	$ 18 913
Ireland	3 520 000	$ 72 800 000 000	$ 20 055
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		$ 9 232 170 000 000	
Japan	125 760 000	$ 4 128 701 000 000	$ 32 830
Korea (South)	45 990 000	$ 329 196 000 000	$ 7 158
		---------------------- +	
		$ 4 457 897 000 000	
Germany	82 070 000	$ 2 431 898 000 000	$ 29 632
Austria	8 070 000	$ 196 020 000 000	$ 24 290
Switzerland	7 090 000	$ 268 697 000 000	$ 37 898
		---------------------- +	
		$ 2 896 615 000 000	

Table 2. The three largest engineering software markets [9]

By far the largest market is English speaking with a population of almost 400 million people. In contrast with the USA society at large, the USA construction community is known to be rather conservative. This may be encouraged by the dominant presence of the labour unions and lawyers. However, groups of innovative people can certainly be found, for example in the Californian Department of Transportation (CALTRAN). Some advanced structural analysis and design programs have been introduced in this market. These are either education-oriented, for example Dr. Frame [10], or practice-oriented, for example ETABS [11].

The second largest market is Japanese speaking with a population of approximately 170 million people. Due to an ageing population, the Japanese economy has hardly grown for the last ten years. To prevent unemployment the Japanese government spends large sums of money on construction projects. Exceptional projects have been realised and valuable experience has been obtained. The Japanese society is quite bureaucratic. For many structural types special codes and code committees exist, for example for tunnels, LNG tanks and hydro power stations. However, many of these codes allow advanced software models to be used next to code regulations. Many finite element analyses are made of unusual structures. All popular international programs like Windows and AutoCAD have Japanese versions. Sometimes a Japanese program has an English version, for example WCOMD [12]. However, Japanese software is quite expensive compared to software from the USA.

The third largest market is German speaking with a population of almost 100 million people. The German economy is growing slowly due to the reunification of West and East Germany in 1990. The German construction industry is innovative. For example, already six years ago nonlinear analysis of frame structures was common practice in Germany, while in many other countries this is still considered to be advanced technology. Recently, several interesting special purpose programs have become available, for example for design of sheet-pile walls [13].