Evaluation of the Study Program in Civil and Environmental Engineering at the Norwegian University of Science and Technology (NTNU)

A Report by the International Evaluation Group:

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1. Background

The Norwegian University of Science and Technology (NTNU) has formulated a quality assurance system which involves conducting a comprehensive review of the learning objectives, program structure and academic profile of each educational program every 5-6 years. While each MSc in Engineering is undergoing such an evaluation in 2008 the evaluation of the study program in Civil and Environmental Engineering (CEE) is also an integral part of a joint project between the Departments of Civil Engineering at NTNU and a group of major Norwegian industrial organizations with a strong interest in the future of Civil Engineering in Norway called The Industry Link (NLR). This joint project is named "A Civil Engineering Course for the Future."

As part of this process an international evaluation group was appointed to compare the quality and content of the CEE study program and courses at NTNU with those offered at universities of similar standing elsewhere. The key issues to be tackled by the evaluation group were summarized as follows:

1. How does the structure and academic level of the civil and environmental engineering education at NTNU compare with similar programs internationally?
2. Comparison of key figures and indicators relative to international trends;
3. Assessment of learning quality and learning methods, including laboratories;
4. Is the study program suitable for international cooperation and mobility? Most relevant areas for developing cooperation with international universities?

The international evaluation group consisted of the following members (Appendix A)

- Professor M.P.Collins University of Toronto, Canada
- Professor W. Rauch University Innsbruck, Austria
- Professor J.K Vrijling Delft University of Technology, The Netherlands
- Professor em. A. Elmroth Lund University of Technology, Sweden

The evaluation group visited NTNU from June 2nd till June 4th 2008 and met with representatives of the faculty, the students, and the Civil Engineering industry. See schedule of meetings in Appendix B. This report summarizes the findings of the group. The preliminary findings of the group were discussed with the CEE Study Program Board in the meeting on June 4th 2008.

2. Information Acquired

A number of background documents concerning the CEE Program at NTNU were provided prior to the site visit and were explained in more detail at the meetings (Appendix B). In addition some new documents were provided during the meetings.

The main documents were:

- "Engineering Education in the 21st Century" English summary of 1993 NTH report which is basis of current curriculum.
- "Engineering Education with a New Perspective". Suggested changes to non-tech. courses. July 2003.
- "Evaluation of the Engineering Education at NTNU" a Self-Evaluation Report by the Executive Committee for Engineering Education NTNU, Jan. 2008.
- "Supplementary Documentation" to above report, March 2008.
- Key figures and indicators Study Program in Civil and Environmental Engineering.
- "Self-Evaluation of Study Programme Civil and Environmental Engineering", Jan. 2008.
- International evaluation and benchmarking of study program in Civil and Environmental Engineering at Norwegian University of Science and Technology (NTNU).
- Target picture for the Study Program in Civil and Environmental Engineering at NTNU in 2040.
- Norwegian University of Science and Technology (NTNU), ppt-presentation by Ingvald Strömmen, Dean of the Faculty of Engineering Science and Technology.
- Jan Moksnes from Industry Link, ppt-presentation on "A Civil Engineering Course for the Future".

3. Vision and Future Goals

The vision statement for the Norwegian University of Science and Technology includes the statement that NTNU will be among the top ten technological universities in Europe by 2020.

Given the important role that technological innovation must play in maintaining Norway's exceptionally high standard of living, given Norway's ability to invest in such innovation, and finally given the very solid technological strengths that NTNU possesses, it seems that with appropriate government and industry help the above ambitious goal could be achieved.

For the CEE study program the long term vision is to have a Civil and Environmental program which is at a high international level through a unique cooperation between the University, Norwegian research based institutions (such as SINTEF, NGI and DnV) and the Norwegian civil engineering industry (both public and private).

Given that about 85% of the total graduates at the Master's level in Civil Engineering in Norway graduate from NTNU it is obvious that if there is to be a centre of excellence in Civil Engineering education in Norway it must be in Trondheim. Further there has been a strong tradition of co-operation between the University, research institutions and industry in meeting the demands of Norwegian society with a notable example of this being the development of the Condeep offshore oil and gas platforms. In view of these circumstances the long term vision of the CEE study program is very appropriate.

The specific **Goals** for the Civil and Environmental Engineering Study Program at NTNU are stated as:

1. *To recruit and educate excellent students in the broad area of Civil and Environmental Engineering, meeting the demands of the society and providing graduates at an international competence level.*
2. *To provide a good and basic knowledge in mathematics, physical sciences and core civil engineering subjects*
3. *To offer a diversity of research-based fields of studies, enabling graduates to plan, design, build and maintain sustainable and environmentally friendly civil engineering works*
4. *To foster a critical, creative and constructive attitude, aiming at a holistic approach towards the impact of engineering solutions in a societal, economic and global context*
5. *To prepare graduates for a changing Civil Engineering profession by providing a sound basis for life-long learning*
6. *To provide a solid foundation for doctoral studies in the various fields*

4. Structure and Academic Level of Civil Eng. Education at NTNU

NTNU is one of the larger engineering institutions in Europe with 1400 new engineering students admitted and 1200 engineering MSc students graduating in 2006. The international evaluation group had some difficulty in understanding the rather complex organizational structure of engineering education at NTNU. Engineering degree programs in many international universities are offered by a "Faculty of Engineering" within which there is a "Civil Engineering Department" offering the Civil Engineering programs. At Trondheim engineering education is offered by four different faculties and the MSc in Civil Engineering is offered by three different civil engineering departments. The four faculties are the Faculty of Information Technology, Mathematics and Electrical Engineering (IME), the Faculty of Engineering Science and Technology (IVT), the Faculty of Natural Sciences and Technology (NT) and the Faculty of Social Sciences and Technology Management (SVT). The three civil engineering departments are the Department of Civil and Transport Engineering (BAT), the Department of Hydraulic and Environmental Engineering (VM) and the Department of Structural Engineering (K). The division of the 16 engineering programs of study at NTNU among the four different faculties and the number of new students which each program admitted in 2007 are given in Table 1. It is worthy of note that the Civil Engineering student numbers have significantly increased in recent years and with 210 admitted students in 2007 CEE is now the largest engineering program at NTNU.

The somewhat unusual structure of the delivery of the engineering programs at NTNU may handicap the university when international rankings are being formulated and could somewhat impede international cooperation and mobility.

Table 1. Engineering Programs and Distribution of Admitted Students

Name of programmes of study, 5 year	Faculty	Students/ year (07)
Master of Science in Applied Physics and Mathematics	NT	115
Master of Science in Chemical Engineering and Biotechnology	NT	95
Master of Science in Materials Science and Engineering	NT	30
Master of Science in Nanotechnology	IME	30
Master of Science in Communication Technology	IME	50
Master of Science in Computer Science	IME	110
Master of Science in Electronics	IME	90
Master of Science in Energy and Environmental Engineering	IME	120
Master of Science in Engineering Cybernetics	IME	110
Master of Science in Civil and Environmental Engineering	IVT	210
Master of Science in Earth Sciences and Petroleum Engineering*	IVT	105
Master of Science in Engineering and ICT	IVT	50
Master of Science in Marine Technology	IVT	100
Master of Science in Product Design Engineering	IVT	25
Master of Science in Product Design and Manufacturing	IVT	140
Master of Science in Industrial Economics and Techn. Management	SVT/IØT	120
Total number of students admitted per year (2007)		1500

* Divided in two programmes from 2008/2009

The 5 year MSc engineering curriculum structure at NTNU is based on a "fade in – fade out" principle in which the work load of mathematics, basic science and generic engineering courses that dominate the first 2 to 3 years gradually fade out to open space in the later years for the core engineering courses in the individual engineering programs. Table 2 below shows how this structure has been applied for the Civil and Environmental Engineering (CEE) program. There are 10 semesters each having 30 ECTS credits corresponding to contact hours of about 26 hours a week and an implied total work load of about 48 hours per week. For the first 8 semesters there are 4 courses per semester. The first two years are common for all civil engineering students and consist of courses like chemistry, physics, mathematics, information technology, basic mechanics and an introduction to some of the core subjects for civil engineering. Note that all courses in these first two years are mandatory.

Table 2. Program Structure– Civil and Environmental Engineering

Semester	7.5 ECTS	7.5 ECTS	7.5 ECTS	7.5 ECTS
10 Spring	MSc Thesis (20 weeks)			
9 Autumn	*Non- techn. course*	Specialization course (Theory courses and project)		
8 Spring	*Interdisciplinary Teamwork*	Elective Eng	Elective Eng	Elective Eng
7 Autumn	*Perspective course*	Elective Eng	Elective Eng	Elective Eng
6 Spring	Elective Eng	Elective Eng	Elective Eng	Elective Eng
5 Autumn	**Mathematics 4M**	Elective Eng	Elective Eng	**Technology Management 1**
4 Spring	**Statistics**	**Fluid Mechanics**	**Building and Construction Materials**	**Design of Build. and Structures**
3 Autumn	**Mathematics 3**	**Mechanics 2**	**Physics**	**Geotechnical Eng. and Eng. Geology**
2 Spring	**Mathematics 2**	**Mechanics 1**	**Philosophy and Theory of Science**	**Hydraulic and Environmental Engineering**
1 Autumn	**Mathematics 1**	**Information Technology**	**General Chemistry**	**Physical Planning & Environment**

At the beginning of the third year the students must choose one of five different sub-fields of civil engineering. For each of these five sub-fields there are a small number of mandatory courses and a relatively large number of electives. The five sub-fields and the number of students choosing each in 2007 are shown below:

- Building and Construction (50 students)
- Structural Engineering (77 students)
- Roads, Transportation, Land use and Geomatics (9 students)
- Water and the Environment (10 students)
- Property Development and Management (8 students)

The distribution of student numbers over the five different sub-fields is strikingly uneven with 82% of the 154 third year students choosing either Structural Engineering or Building and Construction. This uneven distribution, which has existed for quite a few years, is explained as being due to a number of causes. The first is the excellent health of the construction industry in Norway and the many prominent projects which have been

built recently, a number of which have inspired the students. The difference in the number of professors with profiles attractive to students is argued to be another reason behind the large difference in the student numbers. Thirdly perhaps the students lack sufficient insight into the opportunities in the different fields of Civil Engineering as not all fields can be introduced adequately during the first two years of study.

In the last two years of the program the 5 sub-fields are further subdivided into 15 different lines of specialization offering a total of 64 different engineering subjects. The lines of specialization relate closely to the research specialties of the about 70 professors in the three civil engineering departments. The main areas of study of these professors and how they relate to the different sub-fields in the CEE program are summarized in Table 3 below. Note that the sub-field of Property Development and Management includes courses from several study programs other than CEE and hence is not included in Table 3.

Each course in the CEE program carries 7.5 ECTS credits and hence is supposed to involve a work load of about 12 hours per week. However surveys by the Network Learning Lab at NTNU indicate that there is a very large variation between different courses in the number of hours worked by the students each week, with the most demanding third of the courses requiring about twice as much work as the least demanding third of the courses. Further it seems that very few students spend a total of 48 hours per week on their 4 courses.

The quality and the level of general education of the NTNU Civil Engineering students that the international evaluation group met, was outstanding. This is probably a result of the now very rigorous standards used in the selection process for new students, the high standard of the education in the CEE program and the valuable experience these students have obtained in the organization of student activities (festivals, international engineering excursions, and participation in student councils) which supplement the official NTNU educational program. The international group was also impressed by the quality of the MSc theses made available for their perusal.

In addition to the about 850 Norwegian engineering MSc students currently in the Civil Engineering program, there are also about 60 international (non-EU) students in four specialized International MSc programs (e.g. Hydropower Development) and a total of about 110 Ph.D. students. It is a major concern that surprisingly few of the very capable Norwegian students completing their MSc degrees this year are interested in staying on to commence doctoral studies, the first step towards an academic career. Perhaps part of the reason for this is the non-competitive salary structure for Norwegian engineering professors when compared with engineers in Norwegian industry. Given that we would expect future professors to come from perhaps the top 10% of the graduating class, it seems surprising that the average salary of a 50 year old engineering professor in Norway is considerably less than that of the lowest quartile of 50 year old engineers working in the private sector. See Figure 1.

Table 3. Distribution of Professorial Staff in Civil and Environmental Engineering

	Professor	Associate Professor	Assistant Professor	Adjunct Professor
Building and Construction				
Geotechnics	**3**	-	-	**0.3**
Building & Material Technology	**3**	-	**1**	-
Project Management & Construction	**2**	**3**	**1**	**0.6**
Marine Civil Engineering	**3**	**1**	-	**0.4**
Structural Engineering				
Concrete Structures and Technology	**6**	-	-	**1**
Steel, Light Metals and Timber	**2**	**2**	-	-
Numerical Modelling	**5**	**2**	-	**0.2**
Impact, Energy Absorbance, Dynamics & Fatigue	**4**	**1**	-	**0.4**
Biomechanics & Nanomechanics	**3**	-	-	-
Roads, Transportation, Land Use and Geomatics				
Road Planning	**2**	-	-	-
Pavement Design & Road Tech.	**1**	**1**	-	-
Traffic Safety and Regulation	**1**	-	**1**	-
Transport Planning	**1**	**1**	-	**0.2**
Geomatics	**3**	-	**1**	-
Water and the Environment				
Hydraulics and Hydrology	**2**	**1**	-	-
Hydro Power	**1**	**1**	**1**	**0.4**
Water and Wastewater Treatment	**3**	**1**	-	**0.2**
Waste Eng. & Industrial Ecology	**2**	-	-	**0.4**
Totals	**47**	**14**	**5**	**4.1**
Percent	**71%**	**21%**	**8%**	-

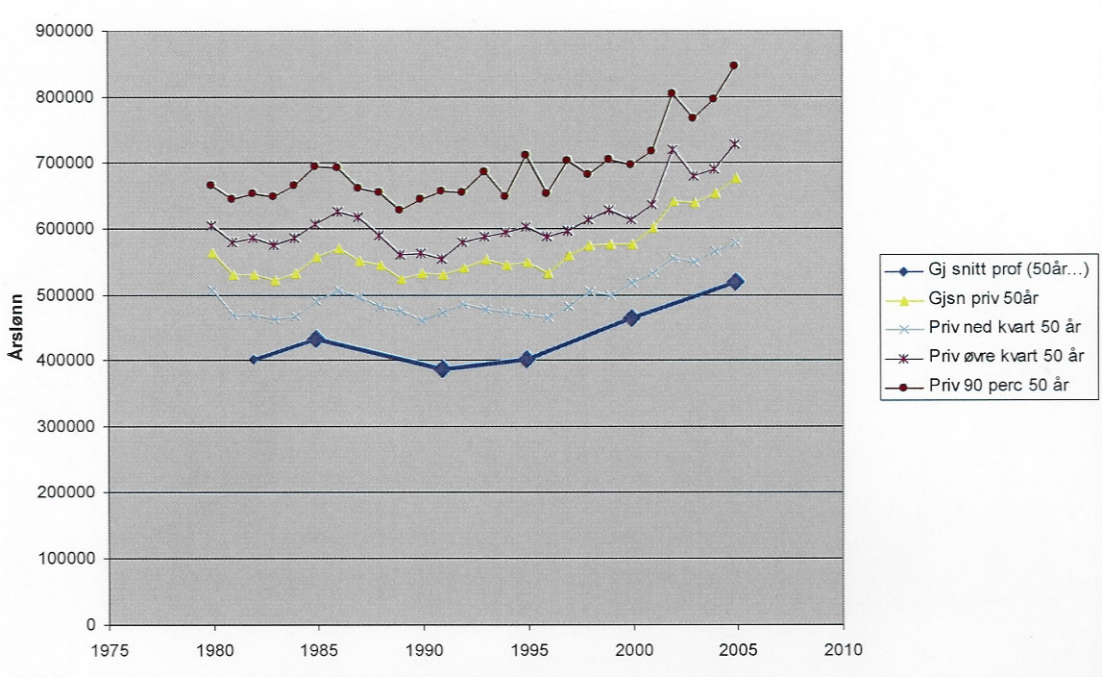

Figure 1: Comparison of inflation adjusted salaries for 50 year old engineering professors in comparison to 50 year old engineer in private practice.

In summary the international evaluation group believes that the Civil and Environmental Engineering program at NTNU faces the following challenges:

- There is a strikingly uneven distribution of students in the various fields of study. Together with the high level of specialization in the CEE program this results in a severe and unhealthy lack of engineers in certain important fields of Civil Engineering – with the most critical shortages being in Roads & Transportation and Water & Environment.
- Recruiting new Civil Engineering professorial staff of the highest level seems to be more difficult at NTNU than it was in the past. This is attributed to a non-competitive salary structure as compared to industry and high teaching loads. Further, as NTNU is the only major technical university in Norway, certain aspects of "inbreeding" are difficult to avoid.
- It now seems more difficult to attract the brightest and the best Norwegian MSc graduates to embark on a PhD program resulting in an ever larger percentage of PhD students in the CEE program being non-Norwegian. The reduction in Norwegian PhD graduates in Civil Engineering is seen as a major threat to both research and top level engineering in Norway.
- Because government funds allocated for engineering education are seriously inadequate, the equipment, space and technical support required to provide laboratory based engineering education in fundamental areas is very difficult to keep up to date.

5. Comparison of Key Figures and Indicators

Because of different definitions and classifications used in different universities (e.g. who exactly is the "staff" in calculating "student to staff" ratios) it proved very difficult to provide the data requested for the tables "Key figures and indicators". The requested data that could be assembled is presented in Appendix C.

Over the past 6 years there has been a renewed interest in Civil Engineering as a career by young students in many countries. At universities like Trondheim and Toronto this has resulted in both higher numbers of civil engineering students and higher standards for admission to the program. Thus at Toronto the total student numbers in the 4 year Bachelor of Applied Science (B.A.Sc.) Civil Engineering program grew from about 300 to about 480, while the minimum high school grade for admission rose from 75% to 80% over these 6 years.

For universities where essentially all of the full-time academic staff is classified as Professors, Associate Professors and Assistant Professors, one key indicator of educational quality is the number of full-time students per full-time professor. For the elite, small, private and doctoral research intense universities like Caltech and MIT these numbers are as low as 7 and 10, while for large but still excellent state universities like Michigan or UC San Diego they are 14 and 18. For Trondheim dividing the total number of full-time students by the number of full-time professors gives (850 + 60 + 110)/ 66 = 15.5 students per professor. For comparison the Civil Engineering Department at the University of Toronto has 480 B.A.Sc. students, 120 M.A.Sc./ M.Eng. students, 66 Ph.D. students and 36 full-time professors resulting in 18.5 students per professor.

Comparing grading statistics between different universities is also difficult but can give some useful indicators. The Trondheim and Toronto Civil Engineering grade distributions for 2007 are compared in Appendix C. The University of Toronto "Grade Definitions" are as follows: A (80-100%) Excellent; B (70-79%) Good; C (60-69%) Adequate; D (50-59%) Marginal; and F (0-49%) Inadequate. In the B.A.Sc. program it is required to obtain at least a 60% average for the 5 courses in each semester to advance "clear" to the next semester. Considering that by 2007 both Trondheim and Toronto were dealing with Civil Engineering students that all had very good high school academic records, it seems surprising that the number of students obtaining less than 60% in the courses was 9.4% (BAT), 15.4% (VM) and 24.6% (K) for the 3 Civil Engineering departments at Trondheim while in Toronto it was 7.9%. The Norwegian policy of requiring that the average grade for a course be C irrespective of the quality of the students will hurt Norway's very top engineering students if they wish to gain admission to doctoral programs at elite universities in North America.

Again there are difficulties in comparing the "Staff-related data" between the different universities shown in Appendix C. Does the data refer to "all employees" as the heading for average age suggests or only to "professorial" staff, as the 97% of employees with doctoral degrees in the Structures Department implies. If professorial staff at Trondheim

were all first hired at the age of 30 and all stayed for 40 years before retiring and if for the last 40 years the university hired the same number of professors each year the average age of professors would be 50 years and each of the 10 year cohorts (30-40, 40-50, 50-60, and 60-70) would contain 25% of the professors. It is remarkable and poses a considerable challenge for future staffing that about 40% of the professorial staff in Civil Engineering at Trondheim are in the 60-70 age cohort. Perhaps partly because of this skewed age distribution 71% of the full-time professorial staff in CEE at NTNU are Professors, 21% are Associate Professors while only 8% are Assistant Professors. See Table 3. For comparison 44% of the full-time professorial staff in Civil Engineering at Toronto are Professors, 36% are Associate Professors while 19% are Assistant Professors.

6. Recommendations

In the sections below recommendations will be given about the future educational programs for NTNU Civil Engineering MSc students and PhD students and about the academic staff, research and teaching facilities and resources required for the Civil Engineering departments to mount these programs at a high international level.

6.1. MSc Program in Civil Engineering

NTNU has a stated obligation to maintain the high quality of Civil Engineering education in Norway. The question is, however, does this means protecting all the specialized subjects that are currently taught or guaranteeing a broad and fundamental civil engineering education that will form an excellent basis from which to develop any new specialization that may be required by future economic opportunities. Such a thorough and broad foundation would in the opinion of the group also form an excellent base for life long learning (NTNU objective 5).

The group proposes that the first three years of the CEE program be devoted to giving all students a solid foundation in the core areas of civil engineering. This wider basic civil engineering education in the first three years would involve replacing the current 6 engineering electives in third year with a carefully chosen set of mandatory courses covering the major civil engineering subjects. This will give the students a wider understanding of civil engineering issues, an improved base for the choice of specialization during the last two years, and a significantly enhanced ability to practice civil engineering over a wider range of sub-fields.

It would also seem to be wise to significantly reduce the number of “lines of specialization” in the last two years of the program from the current fifteen lines to perhaps about eight. These lines should reflect the demand of industry for CEE-profiles (e.g. structural, geotechnical, hydraulic, building, construction, water management, etc.). The present fifteen lines seem more a reflection of the various research lines in the Departments than of industry education requirements. The reduced number of lines

should still be related to research interests in a matrix structure of industry requirements and research lines.

The group is convinced of the need for more integrated/multidisciplinary design assignments. Examples could be the design of a complete building with form, structure, foundation and installations or of a breakwater in conjunction with quarry production, cross section, foundation and construction. These projects should be joint efforts of the relevant disciplines e.g. structural, building physics, installation, construction engineering and architecture. Engineering work always requires cooperation between different specialists and it is necessary to take many aspects into consideration during the whole realization process – from the first drawings to the operation and maintenance of the completed construction. The introduction of such integrated/multidisciplinary design assignments would be met with enthusiasm from The Industry Link and also support NTNU objective 4.

The environmental aspects should in the opinion of the group be part of the integrated design effort, rather than as an “afterthought” in an ‘environmental impact study’.

The construction industry in the form of Industry Link informed the group that they will support the recommended improvements discussed in this section and are willing to contribute ideas to the set up of a revised program.

It is also recommended to offer the flexibility in the program to stimulate students to take courses abroad in e.g. the Erasmus programme as is already currently the case.

In designing the curriculum it is suggested that it would be appropriate to increase somewhat the challenge that the CEE MSc program poses to students by a deepening of the content of some subjects and by an increase of the amount taught per ECTS per year.

Many of the non-technical subjects in the fifth year are insufficiently demanding according to the students. This can be solved by condensing the material and putting top level teachers from these non-technical disciplines in charge. Such an improvement would contribute to NTNU objective 4.

The group recommends that the final year students should make an oral presentation of their MSc theses to a mixed industry/academic audience. The ability to present the analysis and solution of an engineering problem to interested non-specialists, be they higher management or political representatives, is essential for implementation of innovative civil engineering solutions. This presentation should be followed by questions, criticisms and comments by the audience. Relaxing somewhat the 20 week limit on the MSc work should be considered so that it is possible to schedule groups of such thesis presentations in areas of related interest. Presenting the theses in this way would also allow the examination of the theses to be somewhat more broadly based than at present. The current increasing trend of writing the MSc theses in English is to be encouraged as this makes the work internationally accessible and is a good exercise for students that will

have to compete in the international arena.

In implementing the proposed changes, the CEE Program Council will presumably play a critical role. Difficult decisions will need to be made involving compromises between the objectives of the three different Civil Engineering Departments.

As part of the ongoing quality assurance process, a simpler and more direct student evaluation of the quality of the teaching is recommended. It is the experience of some international universities that the simpler the questions, and the shorter the evaluation form, the more valuable the results obtained. At Toronto, the answer to the key question: "What is your overall rating of this instructor as a teacher?" plays a major role in promotion, merit pay increases and nominations for teaching awards. The results of such evaluations should be directly communicated both to the professor and to his or her administrative superior.

6.2. PhD Program in Civil Engineering

The group also advises to change the profile of the PhD in such a way that it results in a more attractive type of employee for consultants and contractors. If the career outlook for PhDs is improved, the willingness of Norwegian candidates to study for a PhD will increase. Industry could help by presenting some clear thinking about the value of PhD's in their organizations. Our discussions with the industry representatives indicated that there is a growing need and interest for employing PhDs in the near future.

The group spent some time discussing the need for the introduction of PhD coursework requirements. Such PhD-level courses would permit candidates to develop expertise in a wider range of advanced topics covering a broader spectrum than just the topic of their doctoral dissertation. This would make PhD graduates of more immediate direct use to potential employers.

It appears that the current doctoral candidates at NTNU spend considerable time in completing their PhD programs. For a highly capable young engineer finishing a 5 year MSc degree, the prospect of another 5 or 6 years may appear both daunting and not offering a reward commensurate with the investment of time required. A number of international universities are currently attempting to significantly shorten the average time required to complete a PhD. Such an effort at NTNU would make the PhD program more attractive.

A more active advertisement of PhD positions is advised and could be supported by industry. The PhD work could be made more attractive if it were mixed with interesting consulting assignments related to the PhD subject with adequate remuneration by the industry. Such assignments would contribute to practical project management skills.

Paradoxically, it is, perhaps, in the best interests of the future development of NTNU if some of the very best Norwegian MSc graduates pursue doctoral studies at elite

universities outside of Norway. This would provide a pool of internationally experienced Norwegian PhD graduates who could potentially become future professorial staff at NTNU.

6.3. Academic Staff and Resources

Academic salaries at NTNU are not competitive with the levels of pay in industry. Also the difference in NTNU salaries for different categories seems rather small with the average salary for a 50 year old professor being perhaps only 50% greater than that of a new MSc graduate. It can be seen in Fig. 1 that a young Norwegian engineer in private practice can aim towards receiving a very adequate salary by the time he or she is 50 years old provided that they perform in the top quartile. A young Norwegian engineering Assistant Professor should have a similar incentive to perform at the very highest level and if he or she does, to receive comparable rewards. In this regard, it is interesting that the "Progress through the Ranks" (PTR) merit pay increase system introduced some years ago at the University of Toronto is stated to be "one of the most effective tools the university has in striving to improve its standing amongst the best research and teaching universities in the world." The concept of this system is that over the average professorial career, the inflation-adjusted salary should increase by a factor of about 2.3. While this is the average increase, some careers will progress rapidly and, hence, will merit high PTR awards, while some careers will not progress and, hence, will merit no PTR award. It should be appreciated in the "steady state", the system of PTR awards does not have any net cost to the university.

The policy change that makes a professor's position more attractive in the eyes of capable candidates should include a more advanced view on the hierarchy of teachers and assistants supporting the professors. Such an organizational change will most probably mean a reduction of the number of full-professors (with a competitive salary) in favor of an extension of the supporting hierarchy.

It is also very important that the selection criteria for professors are interpreted according to the international standards that are now developing at international Technical Universities. When determining if candidates have made outstanding and innovative intellectual contributions, a portfolio of outstanding innovative designs should be regarded as being as valuable as a number of published scientific papers.

Endowed chairs awarded by successful alumni or industrial organizations would help alleviate the financial difficulties of NTNU. Care should however been taken to ensure the intellectual independence of the chair from the benefactors is maintained. The suggested actions listed by The Industry Link would be an excellent base upon which to build an outstanding civil engineering program. This list is reproduced in Figure 2 below.

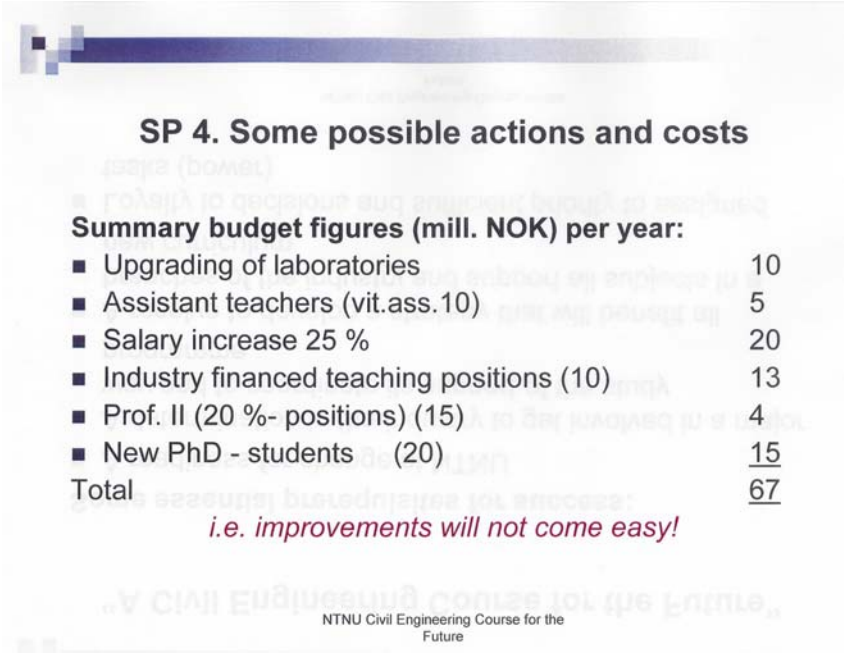

Figure 2: Suggested Program for Improvements by The Industry Link

The industry might also develop entirely new research programs. The Ecoshape initiative of the joint Dutch dredging companies may set an example. In reaction to the reduced research activity of Rijkswaterstaat these companies set up a program that addresses their need for an integral environmental approach to dredging projects that is internationally accepted. The Industry link may provide an excellent basis for similar initiatives.

Appendix A – Members of Evaluation Group

Members of the International Evaluation Group (IEG) for the Civil and Environmental Engineering (CEE) Study Program at NTNU

Name, phone, e-mail	Postal address	Comment
Professor M.P.Collins Phone: +1 416 978 5906 Fax: +1 416 978 2077 Email: mpc@civ.utoronto.ca	Department of Civil Engineering University of Toronto 35 St. George Street Toronto, ON Canada M5S 1A4	Contacted by Tor Ole Olsen Structural Engineering
Professor Wolfgang Rauch Phone: +43 512 507 6921 Fax: +43 512 507 2911 Email: wolfgang.rauch@uibk.ac.at	University Innsbruck Inst. of Infrastructure Engineering Technikerstrasse 13 AT-6020 Innsbruck Austria	Proposal by Hallvard Ødegaard Urban water management
Professor J.K Vrijling Phone: +31 15 27 85278 Fax: +31 15 27 85124 E-mail: j.k.vrijling@tudelft.nl	Delft University of Technology Faculty of Civil Engineering and Geosciences P:O: Box 5048, 2600 GA Delft Stevinweg 1, 2628 CN Delft The Netherlands	Contacted by Eivind Bratteland Probabilistic design and hydraulic structures
Professor em. Arne Elmroth Phone: +46 156 20170 Cell: +46 70 6784560 Email: arne.elmroth@byggtek.lth.se	Lund Institute of Technology Private address: Askögatan 13 SE-619 31 Trosa Sweden	Proposal by Jan Vincent Thue Building physics Professor emeritus

NTNU 5.06.08

Appendix B – Schedule for Visit of IEG to NTNU, June 2008

Meeting room L1-320, Lerkendalbygget.

1. **Sunday June 1.**

   Arrive Trondheim. Hotel rooms booked at Britannia Hotel, by NTNU.

2. **Monday June 2.**

08.30 – 08.45	Welcome by the Dean of the Faculty of Engineering Science and Technology.
08.45 – 09.15	Briefing on the project - *A Civil Engineering Study Program for the Future.*
09.15 – 11.30	Internal Panel meeting/discussion.
11.30 – 12.30	Lunch with invited guests
12.30 – 14.30	Meeting/interview with the Board of study program.
14.30 – 16.30	Internal Panel discussion/meeting
19.00	Dinner

3. **Tuesday June 3.**

08.30 – 10.30	Meeting/interview with selected teachers.
10.30 – 12.00	Meeting with representatives from the Industry.
12.00 – 13.00	Lunch with invited guests
13.00 – 14.00	Internal Panel discussion
14.00 – 16.00	Meeting/interview with students
16.00 – 17.30	Internal Panel discussion.

4. **Wednesday June 4.**

08.30 – 11.00	Internal meeting/discussions or added meeting/discussion with NTNU personnel if wanted/needed.
11.00 – 13.00	Laboratory visit to Valgrinda, including lunch.
13.00 – 15.00	Internal meeting/discussion and opening for added discussions.
15.00 – 16.00	Closing session with Board of study program.

5. **Thursday June 5.**

   Departure from Trondheim.

Appendix C – Key Figures and Indicators

Student data (Average over the last 3 years)						
Subject	**IVT**	**CEE**	**Delft**	**Innsbruck**	**Lund**	**Toronto**
Total number of applicants/admitted students	10.7	10.5		Does not apply as there is no entry qualification system allowed		
Ratio of primary applicants to admitted students [1)]	Approx. 1.9	2.5				2.7
Percentage of admitted students that showed up	Approx. 67	Approx. 68				Approx. 40%
Percentage female students		30		16.7		23%
Minimum entry qualification [2)]	Varying from 48.5 to 52.6 [3)]	57.4		See above		80% Min.high school grade.
Student to staff ratio	9.8 [4)]	11.6 [5)] 10.0 [6)]		12.4		Student to professor ratio=18.5
Drop-out analysis after 3 years in percentage, admission 2004. Continue same programme Continue another MSc programme Dropped out MSc programme	72.8 7.1 20.0	83.3 1.2 15.5		No exact data – app. 80% of students finish		Approx. 85% complete B.A.Sc.

[1)] Primary applicants have Civil and Environmental Engineering as their first priority

[2)] Maximum score including all possible extra scores is 70

[3)] The small study programme of Industrial Design had a very high level of 62.7

[4)] Relative to man-year of academic staff with own funding

[5)] Data when including prof., adjunct prof., associate prof., assistant prof., and research assistants

[6)] In addition to above, including post doc and research fellow with a given time for teaching activities

Student data continued	Grading statistics for 2007 in percentage							
Grade	**IVT**	**BAT**	**K**	**VM**	**Delft**	**Innsbruck**	**Lund**	**Toronto**
A	14.4	10.9	16.3	13.3		Data not available		19.9
B	31.3	35.7	25.9	29.7				38.9
C	36.3	44.1	33.3	41.5				33.3
D	8.0	5.6	10.0	9.9				7.4
E	4.8	1.9	7.6	3.2				-
F	5.2	1.9	7.0	2.3				0.5

	Trondheim	Toronto
A	90 – 100 points	80- 100%
B	80 – 89 points	70-79%
C	60 – 79 points	60-69%
D	50 – 59 points	50-59%
E	40 – 49 points	not used
F	0 – 39 points	0-49%

Staff-related data								
Subject	**IVT**	**BAT**	**K**	**VM**	**Delft**	**Innsbruck**	**Lund**	**Toronto**
Average age all employees	44.2	45.6	44.4	45.8		41.5		47.9
Percentage employees 50 – 60 yrs [1)]		28.8	22.2	23.3		25.9		25.7
Percentage employees 60 – 70 yrs [1)]		39.3	41.2	37.9		7.4		20.0
Percentage employees with doctors degree [1)]		79	97	88		60.5		97
Ratio Master graduates/ PhD student graduates average over last 3 years	6.8	CEE 7.7				5.6		5.0
Master Thesis per academic staff man-year, average over last 3 years [1)]		2.9	2.7	2.3		1.1		2.0

Note: For Toronto “employees” refers to Professorial staff only.

Appendix D – Example of Course Offerings

The pages from the study plan presented below show the many choices the students have during the years 3, 4 and 5 for the field “Building and construction.” They have many electives “valgbare emner”. In the three last years there are only very few mandatory (obligatoriske) courses. The result may be that all students can choose an individual specialization. It must be difficult for the industry to understand the competence of the students. This provides an additional argument for our proposal to limit the number of specializations. This table is only for information purposes.

Studieprogram Bygg- og miljøteknikk (MTBYGG)
3. årskurs
Studieretning Bygg og anlegg (Building and Construction)

1) I tillegg til de obligatoriske emner skal det velges emner slik at kravet
om 30 studiepoeng pr. semester er oppfylt.

Und.-
sem. Emnenr Emnetittel Anm Sp
Obligatoriske emner (Mandatory)
Høst TIØ4256 TEKNOLOGILEDELSE 1 7,5
Høst TMA4122 MATEMATIKK 4M 7,5
Valgbare emner 1(Chooseable courses)
Høst TBA4135 ORG/ØK I BA PROSJEKT 7,5
Høst TBA4160 BYGNINGSFYSIKK GK 7,5
Høst TBA4201 VEG OG MILJØ 7,5
Høst TBA4265 MARINT FYSISK MILJØ 7,5
Høst TKT4170 STÅLKONSTR 1 GK 7,5
Vår TBA4105 GEOTEKNIKK BER MET 7,5
Vår TBA4130 PRODUKSJONSTEKN I BA 7,5
Vår TBA4140 MURKONSTRUKSJONER 7,5
Vår TBA4270 KYSTTEKNIKK 7,5
Vår TKT4175 BETONGKONSTR 1 GK 7,5
Vår TKT4211 TREKONSTRUKSJONER 7,5
Vår TPK4115 PROSJEKTSTYRING 1 7,5
Valgbare emner som det
ikke tas hensyn til ved timeog
eksamensplanl.:
1
Høst TEP4225 ENERGI OG MILJØ 7,5
Høst TVM4105 HYDROLOGI 7,5
Høst TVM4110 VANNKJEMI 7,5
Vår TBA4315 KOST/NYTTE SAMFANL 7,5
Vår TBA4240 GEOGR INFO BEHANDL 7,5
Vår TKT4180 KMEK BEREGN METODER 7,5
Vår TMR4145 PRODUKTMOD/DESIGN 7,5
Vår TVM4125 VA-TEKNIKK GK 7,5
Vår TVM4165 VANNKRAFTVERK/VASSDR 7,5

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FAKULTET FOR INGENIØRVITENSKAP OG TEKNOLOGI
Studieprogram Bygg- og miljøteknikk (MTBYGG)
4. årskurs
Studieretning Bygg og anlegg

1) Ett emne fra en annen studiekultur skal velges. Se egen tabell, side 301, for oversikt over anbefalte perspektivemner. TIØemnene
blir ikke time- og eksamensplanlagt i forhold til sivilingeniørstudiet. I samråd med fakultetet kan også et annet emne velges, i henhold til definisjonen, såfremt det ikke kolliderer på time- og eksamensplanen.
2) Emnebeskrivelsen for Eksperter i team, tverrfaglig prosjekt, står omtalt på egen side etter tabellene i boken.
3) I tillegg til de obligatoriske emner skal det velges emner slik at kravet om 30 studiepoeng pr. semester er oppfylt. Blant disse
emner skal et ingeniøremne fra annet studieprogram inngå i 8. semester. I tillegg til ingeniøremnet fra annet studieprogram,

skal studentene kunne velge enten et basisemne, et ingeniøremne eller et ikke-teknologisk emne i 8. semester.
Det er mulig å ta deler av studiet ved UNIS, se særbestemmelsene foran. Opplegget må godkjennes av fakultetet.
Hovedprofiler:
Geoteknikk Prosjektledelse og anleggsteknikk
Bygnings- og materialteknikk Marin byggteknikk
Und.-
sem. Emnenr Emnetittel Anm Sp
Obligatoriske emner
Høst - Perspektivemne 1 7,5
Vår - EKSP I TEAM TV PROSJ 2 7,5
Valgbare emner 3
Høst TBA4110 GEOTEKN MATR EGENSK 7,5
Høst TBA4150 ANLEGGSTEKNIKK 7,5
Høst TBA4155 PROSJEKTSTYRING 2 7,5
Høst TBA4170 BYGNINGSFORVALTNING 7,5
Høst TEP4235 ENERGIBRUK I BYGNING 7,5
Høst TGB4185 ING GEOLOGI GK 7,5
Høst TKT4215 BETONGTEKNOLOGI 1 7,5
Vår TBA4115 GEOTEKN KONSTRUKSJON 7,5
Vår TBA4127 PROSJEKTERINGSLED 7,5
Vår TBA4165 BYGNINGSTEKNIKK 7,5
Vår TBA4175 BRANNTEKNIKK 7,5
Vår TBA4217 VEGTEKNOLOGI 7,5
Vår TGB4190 ING GEOLOGI-BERG VK 7,5
Vår TKT4225 BETONGTEKNOLOGI 2 7,5
Valgbare emner som det
ikke tas hensyn til ved timeog
eksamensplanl.: 3
Høst TBA4216 VEG/GATEPLANLEGGING 7,5
Høst TBA4265 MARINT FYSISK MILJØ 7,5
Høst TBA4275 DYNAMISK RESPONS 7,5
Høst TBA5150 GEOHAZARDS/RISIKO 7,5
Høst TET4165 LYS OG BELYSNING 7,5
Høst TKT4192 ELEMENTMET/STYRKE 7,5
Høst TKT4201 KONSTR DYNAMIKK 7,5
Høst TKT4230 STÅL OG ALUMINIUM 7,5
Høst TMM4220 ALT ER MULIG! 7,5
Høst TVM4155 NUM HYDRAULIKK 7,5
Vår TBA4145 KYST OG HAVN 7,5
Vår TBA4240 GEOGR INFO BEHANDL 1 7,5
Vår TBA5155 JORDSKRED/STAB 7,5
Vår TGB4200 ING GEOL-LØSMASSE VK 7,5
Vår TGB4210 BERGMEK OG GEOTEKN 7,5
Vår TKT4220 BETONGKONSTR 2 VK 7,5
Vår TMM4215 TREKOMPOSITTER 7,5
Vår TMR4145 PRODUKTMOD/DESIGN 7,5
Vår TTT4180 TEKNISK AKUSTIKK 7,5
Vår TVM4140 VANNRESSURSFORVALTN 7,5
Vår TVM4150

FAKULTET FOR INGENIØRVITENSKAP OG TEKNOLOGI
Studieprogram Bygg- og miljøteknikk (MTBYGG)
5. årskurs
Studieretning Bygg og anlegg

1) Ett fordypningsemne med tilhørende fordypningsprosjekt skal velges etter valgt hovedprofil eller fra en annen studieretning.
2) Fordypningsprosjekt på 15 studiepoeng er et særbehov for de studentene som har samarbeid med andre studier; f.eks. UNIS, Arkitektur eller tilsvarende.
3) Dersom et fordypningsprosjekt på 7,5 studiepoeng velges, skal ett kompletterende emne velges slik at total studiebelastning
i semesteret blir 30 studiepoeng. Kompletterende emner kan velges fra listen over, eller eventuelt emner fra 5. eller 7. semester
etter spesiell avtale med faglærer. Det tas ikke hensyn til de kompletterende emner ved time- og eksamensplanleggingen.
4) Disse emnene forutsetter at studenten har opphold hele semesteret ved UNIS. Avtales spesielt med faglærer.
5) To-ukers intensivkurs ved UNIS, Longyearbyen, Svalbard. Avtales spesielt med faglærer.
6) Ett ikke-teknologisk emne skal velges. Det kan velges fritt fra NTNUs tilbud. Se side 301 for definisjon for hva som kan godkjennes

som ikke-teknologisk emne i sivilingeniørstudiet. Det tas ikke hensyn til emnene ved time- og eksamensplanleggingen.
7) En masteroppgave skal velges. Masteroppgaven velges normalt innen valgt hovedprofil. Unntaksvis kan oppgaven velges fra
annen studieretning.
Det er mulig å ta deler av studiet ved UNIS, se særbestemmelsene foran. Opplegget må godkjennes av fakultetet.
Hovedprofiler:
Geoteknikk
Bygnings- og materialteknikk
Prosjektledelse og anleggsteknikk
Marin byggteknikk

Und.-
sem. Emnenr Emnetittel Anm Sp
Fordypningsemner 1
Høst TBA4515 GEOTEKNIKK FDE 7,5
Høst TBA4525 BYGN/MATER TEKN FDE 7,5
Høst TBA4535 PRLED/ANLTEK FDE 7,5
Høst TBA4555 MARIN BYGGTEK FDE 7,5
Fordypningsprosjekt 1
Høst TBA4510 GEOTEKNIKK FDP 7,5
Høst TBA4511 GEOTEKNIKK FDP 2 15,0
Høst TBA4520 BYGN/MATER TEKN FDP 2 15,0
Høst TBA4521 BYGN/MATER TEKN FDP 7,5
Høst TBA4530 PRLED/ANLTEK FDP 2 15,0
Høst TBA4531 PRLED/ANLTEK FDP 7,5
Høst TBA4550 MARIN BYGGTEK FDP 7,5
Høst TBA4551 MARIN BYGGTEK FDP 2 15,0
Kompletterende emner 3
Høst TBA4110 GEOTEKN MATR EGENSK 7,5
Høst TBA4275 DYNAMISK RESPONS 7,5
Høst TBA4325 SPREDN AV FORURENSN 7,5
Høst TBA5100 TEOR GEOTEKN 7,5
Høst TBA5150 GEOHAZARDS/RISIKO 7,5
Høst TEP4240 SYSTEMSIMULERING 7,5
Høst TKT4124 MEKANIKK 3 7,5
Høst TKT4192 ELEMENTMET/STYRKE 7,5
Høst AT301 INFRA CHANGING CLIM 4 10,0
Høst AT323 TERMO MECH ICE SNOW 4 10,0
Høst AT327 ARCTIC OFFSHORE 5 7,5
Høst - **Ikke teknologiske emner** 6 7,5
Masteroppgaver 7
Vår TBA4900 GEOTEKNIKK 30,0
Vår TBA4905 BYGNING MATERIALTEKN 30,0
Vår TBA4910 PROSLEDELSE ANLTEKN 30,0
Vår TBA4920 MARIN BYGGTEKNIKK