THE CIVIL AND GEOTECHNICAL ENGINEER IN SOCIETY - ETHICAL AND PHILOSOPHICAL THOUGHTS; CHALLENGES AND RECOMMENDATIONS

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INTRODUCTION

DFI considers not only the technical aspects of civil and geotechnical engineering but also ethical and philosophical aspects. Professor Brandl's John Mitchell Memorial Address at the 7th DFI Conference in Vienna, 1998 conveyed a message to prepare 21st-Century engineers with the means to take up new challenges and to inspire young people with words to begin their careers by. Professor Brandl's updated and substantialy extended version of his 1998 John Mitchell Lecture is what follows.

John Mitchell, who died in a tragic site accident in 1990 while undertaking research on pile construction, was particularly aware of the need to inspire young people. Therefore, this contribution is dedicated to the public image of the civil engineer and geotechnical engineer, respectively, seen from an ethical and philosophical point of view. Discrepancies between professional opinions, the gap between theory and practice, and the lifelong learning society are discussed on the basis of the author's more than forty years of comprehensive professional experience. Furthermore, the environmental challenge to civil/geotechnical engineering due to climate change is emphasized. Finally, the younger engineering generation's prospects in the future are addressed and recommendations are given.

1 PUBLIC OPINION

As engineers becomes increasingly central to the shaping of society, it is ever more important that they become introspective. Rather than merely revel in our technical successes, we should intensify our efforts to explore, define, and improve the philosophical foundations of our profession (Florman 1987).

We live in the age of high tech. Though engineering stands at centre stage becoming the key to survival, civil engineering is a much misunderstood and widely underestimated profession. It is a melancholy paradox: in its moment of ascendance and severely needed by society, civil engineering is frequently faced with the trivialization of its purpose and the debasement of its practice.

In the social system of ancient Egypt, civil engineers (especially hydro and structural engineers) ranked directly below the viziers (and the God-King), and were thus in a position equal to governors of the provinces. Architects, painters and artists were subordinate to them. But these times are long gone.

Most individuals, living in a modern industrial state, are not aware how much it is the achievement of civil engineering that so many people can live comfortable lives in such relatively small areas. For the basic needs of society, civil engineers build water supply and sewage facilities, they construct apartment and office buildings, factories, as well as storage facilities and silos. For the distribution of goods they build roads and railways, waterways, market halls, department stores and supermarkets. For the education of children they construct all kinds of schools, and, to an ever increasing extent, trade schools, colleges and universities for the professional education and training, because more and more people strive for higher education to enrich their lives. Civil engineers erect (drinking) water supply systems, irrigation systems and the facilities to obtain natural resources, they build power plants for energy generation, hospitals where people hope to be cured, sport facilities for bodily fitness - as well as sewage removal systems, waste water purification plants and refuse deposits in order for society not to be suffocated by the waste created by industrial production and by every-day-living, and in order to prevent irreparable damage to the environment. Furthermore, civil- and geotechnical engineers minimize natural hazards (e.g. by landslide stabilization, flood protection, avalanche and mudflow protection, design of earthquake resistant structures, etc.).

Very few people recognize that it was primarily civil/geotechnical engineering that made it possible that the average life expectancy of men in the industrialized countries increased so dramatically during the past 100 to 125 years: In former centuries drinking water was often contaminated and full of bacteria. This foul water and the improper removal of waste caused terrible epidemics (e.g. cholera, typhoid fever, dysentery), which killed millions of people in Europe alone. From this point of view, it is the merit of civil/geotechnical engineering to have saved more lives than medicine by providing the means for clean drinking water supply and for the proper disposal of liquid and solid waste. The first public Vienna drinking water system, for instance, was constructed in the years 1870-1873, and it has been supplying the population with 470 million liters of high quality water per day ever since. The total length of the pipes from the headwaters region in the mountains to the reservoirs in Vienna is 3,100 km.

Most people understand construction as constructing houses or buildings. This misconception had made civil engineering a very small term in public opinion. But actually, construction is one of the biggest industries worldwide, in India for instance even number two behind agriculture. And it is far beyond the film industry, which takes at least one full page in every newspaper describing its legends every day.
It was through dams, not gold that California became the equivalent of the world's seventh richest country: Dams have turned the arid Central Valley into an agricultural supermarket to the world. Dams quench the thirst of coastal cities from San Diego to San Francisco with billions of gallons of fresh water annually. Dams let Sacramento escape regular devastating floods. And above all, dams power the states aerospace, microchip, film or "dotcom" industries with an average 40 BMWh of electricity: more than coal, oil, geothermal waste, wind and solar energy sources combined (Asmal 2000).

The main reason for this discrepancy with regard to our profession is that most achievements are taken for granted. They simply work, and civil or geotechnical engineers are not spectacular enough for the media. Attention is paid more or less only in the case of failures or building collapse, according to the media's principle "only bad news is good news".
On the other hand it is our fault that the public is not informed about outstanding achievements of our profession, e.g. construction of 10-lane underground expressways in urban areas and soft soil, structures in sliding slopes and earthquake zones, etc.: Engineers do not talk very much about the work that they have done, and they are rather reserved towards media people.

It is hardly known that the first fully-working, program-controlled, electromechanical digital computer in the world (already with 2000 relais) was invented in 1941 by a civil engineer (the German K. Zuse, 1910-1995), who in 1955 also invented the first electronic device to rationalize and accelerate the many comprehensive calculations he had to perform in structural and geotechnical engineering.
The Scottish bacteriologist Sir Alexander Fleming (1881-1955), for instance, is well known worldwide (Nobel Prize for development of penicillin), but only few persons have heard about the Canadian civil engineer Sir Sanford Fleming (1827-1915) who coordinated the development of railways, telegraph, and standard time zones.
The American civil engineer (and medical doctor) Andrew Taylor Still (1828-1917) founded the osteopathy, an alternative medical treatment using only the hands.
The German civil engineer Johann Tschauner (1908-1974) became a pioneer of rocket and space technology and astrodynamics.

Also very few people know how much civil engineering contributes to modern medicine: Hydraulics is not only used in waterpower technology and for designing drinking water supply systems and sewage systems but increasingly also for the calculation/assessment of the streaming behavior in blood vessels (especially in the vicinity of bypasses). Statics contributes significantly to the medical understanding of stress-strain behavior of the human (or animal) skeleton and muscle system - thus becoming an important factor for difficult operations, rehabilitation, for prostheses, etc. Screws made of bone material are used in the oral and maxillo-facial surgery. Statics and strength of material sciences are even helpful in dermatology: For example, taking into account the major and minor principal stress directions of a local skin area during skin operations helps to minimize scar formation later.

The main task of the building industry (including geotechnical and environmental engineering) is not only the construction of new structures, but also the maintenance, and finally the repair of those old damages, which have been caused within the last decades by our industrial "squandering society" - partly through ignorance and partly through lack of knowledge.

For nearly a century the "men of technology" had been considered the personification of progress. The historian Thomas Buckle (1821-1862), for instance, wrote with enthusiasm: *"The railway did more to bring people together, than all philosophers, poets and prophets before"*. This glorification of technology has now, in many cases, turned into just the opposite. The present doubts and uncertainties are expressed by Peter

Ustinov (1921-2004): *"The last voice to be heard before the globe exploded was that of an expert saying that this would be technologically impossible."*

Anti-technology fanatics and unrealistic environmentalists have now even created the rude term "techno-fascism" which comprises the whole field of technics. But they forget that modern life depends entirely on technology, and this will increase more and more as time goes on. Technology critics would, no doubt, ask for remote surgery if this advanced technique could save their lives. And most of those who condemn modern production nevertheless are consumers of those products.

From the "warm bed" of an affluent, industrialized society it is relatively simple now to globally criticize the enormous achievements of technology, which would not even have been possible in dreams 100 years ago. This criticism is not voiced by the generally practical and realistic silent majority, but by some thoughtless or even untrustworthy media people, opportunistic politicians, narrow-minded idealists who do not understand the paramount connections, and finally by dreamers, pseudo intellectuals, and image neurotics. "Experts" who, more or less, oppose any new project without proposing alternatives are like dentists who bore holes into the teeth but don't fill them.

Without any doubt, criticism on the former excessive progress-thinking is as appropriate as is an appeal for restrictive behavior and sustainable, environmentally friendly thinking; such criticism would serve the human race as well as it does environmental protection. The "Green Parties" worldwide cannot be praised enough for the booster they have given to the general environmental consciousness. But to globally condemn the former "heroes" of spectacular construction sites (as the builders of hydropower plants, railroads and highways once were euphorically celebrated) and now to disdainfully call them "wicked contributors to the asphalt jungle" or "concrete covers" certainly is swaying into a very dubious extreme. Such an inconsistent attitude can be observed in many industrialized countries. If anybody should be criticized, it should be the politicians who were preaching never-ending progress and prosperity and the mass media, which used to do the same.

The civil and geotechnical engineer is, and always has been, primarily an executive organ (but not an executive "slave"). Not he should be criticized but those clients, official or private, who wanted to have a certain project realized. Until a few years ago, almost every mayor of a city or a village fought like a lion to have as many broad streets built as possible, because that was considered modern and a sign of progress. Now, the same individuals complain of the disadvantages of increasing traffic. Can this development be blamed on the civil engineer? Definitely not!

A fair judgment about the planning philosophy of the past decades as well as the present time can only be given by taking into account the historical events in Europe and the dramatic increase in population in many developing countries. In Europe, the indescribable poverty during the years after World War II inevitably led to the effort to raise the general standard of living as quickly as possible.

As in most cases, it can be seen that also in this controversy and in the connected public discussion about technology, truth and reality lie somewhere in the middle. Civil engineering is a profession, which can be viewed only within a realistic realm. We do not want to ignore or belittle the boundaries or dangers of technology, but we do believe that the great engineer Max Eyth (1836-1906) was really speaking the truth when he characterized his profession with the words: *"In no other profession than ours is it so certain that mistakes and lies will be punished. An engineer offending the truths of the theory of material strength will be crushed by his own violation before he has even finished committing it. We are irreversibly bound to the great, everlasting laws of nature, and we have to be true, whether we want to or not".* This is also the reason why extremely diverging expert opinions in the building industry are rather the exception than the rule.

We run risks. Most of the time we ignore them; Sometimes we stop and decide how to deal with them. That's life. Risks arise in sports, in business, in personal relationships; they are present in the laboratory, in technology, in medicine, on construction sites, in traffic, in political calculations, everywhere. Acting individually, we often prefer to gain some benefit by accepting some danger. Acting collectively, we make similar trade-offs (Nicholas, 2000).
When society must assess risks, and those risks can be clarified, at least in part, by science, technology or mathematics, the responsibility of the research community seems to be "clear and complete". But that is not always so easy. Too few people ever pay full attention to the best evidence, much less act on it. Even when the evidence of high risk is clear (in the case of smoking, for instance) many will deny the risk, or dispute it, or play the poor odds. Moreover, people will risk a lot to prevent a loss; some people will even rush into a burning building to save a pet. But they will usually risk very little if the only perceived outcome is a possible gain: many people won't even risk pursuing an exciting job, if the current job, though unfulfilling, remains comfortable. That psychological mechanism, a desire to maintain the status quo, helps explain the high hurdles that any rational risk assessment must confront. This irrational behavior also involves the (sometimes very emotional) sensitivity of society towards risks in the field of technology and engineering. People frequently expect a so-called zero-risk or at least that today's risks must be manageable. The first demand is absolutely unrealistic; the second one can only be partly achieved. Risk level, risk assessment and risk management depend on numerous interacting factors and on the specific fields, as medicine, transportation engineering, mechanical engineering, civil engineering, etc.

Civil engineering, especially geotechnical engineering, involves higher professional risks than most of the other technical fields. Calculated risk and residual risk have to be well balanced, whereby a central question remains: "How safe is safe enough?" Failures can occur in spite of detailed ground investigation, sophisticated calculation, site supervision and monitoring - they are inevitable because of the complex nature of ground and groundwater. Nevertheless, the public opinion is very critical towards this branch of engineering, and "building scandal" or "construction scandal" is a term easily used by the mass media for headlines. Moreover, engineers, as viewed by the public, should exclude every risk (even if unidentifiable). On the other hand, the public has more or less got used to traffic accidents killing thousands of people per month worldwide. There is a great difference in the evaluation of car accidents on the one hand and other accidents on the other. The car has obviously become today's "idol" or "golden calf" which consequently involves the public acceptance of high risks to life and health, while accidents e.g. caused by a failure in the road structure, by uneven pavement on expressways, or by a bridge collapse (e.g. due to scouring) are condemned as almost criminal acts.

Consequently, it should be emphasized that a so-called 100%-safety cannot be obtained in many cases of geotechnical engineering (e.g. landslides, earthquakes). And this must be accepted by

- the public,
- politicians and other decision makers,
- and by lawyers.

Several clients and politicians have been quoted as saying that they would like some day to meet an engineering geologist or geotechnical engineer who is one-armed - so that he will not be able to say "on the other hand". This rather feeble witticism reflects on all too prevalent impatience with uncertainty. We crave for clear answers, but ground is an uncertain material. Hence, it is one of the greatest challenges in geotechnics to come up with a design or an answer when no clear-cut, ideal solution exists.

Geotechnical engineering achievements or scientific work cannot be evaluated by prizes as in case of architectural competitions. Though originally very laudable and productive, the rating business has been in many cases taken to ludicrous extremes (e.g. "best" dentist or pizza parlor of the town). It may be explained by the US syndrome for ratings and rankings, which results from the super-competitive urges of its population. But what shall all this rating/ranking accomplish in geotechnical engineering? An objective evaluation is practically impossible and makes no sense. So please, let us stay away from producing rankings (Dunnicliff 2000).

Despite all efforts to improve the image of the civil engineer, it will always be below that of the colleagues of medicine, physics, or chemistry - because high-tech surgery, for instance, directly saves lives, and flights to the moon are just more spectacular than even the most impressive structures. Especially disadvantaged in this respect are we, the geotechnical engineers. It is said that surgeons cover up their mistakes by burying them; in our work the successes are buried and hidden below the ground surface, upon which the architects put their "visible" structures and are praised for them. Our names are only mentioned if something goes wrong. This should not frustrate us too much, *because geotechnical engineers work with the contents and not with the image.*

Coming back to the comparison geotechnical/civil engineering and medicine: Recent medical statistics disclosed that in Great Britain about 40,000 people annually lose their life because of medical mistakes. The same number is known from Italian hospitals, whereby organizing problems and defect equipment, and less medical mistakes play a role. In Germany, about 25,000 patients die because of wrong treatment or unsuccessful surgery. In addition, about 300,000 patients survive but suffer permanently from severe treatment mistakes. Imagine, if geotechnical engineers designed and constructed in such a way that, let's say, 10 people annually would lose their life in each of these or other industrialized countries. The public would rip them apart. Nevertheless, the doctors still remain the Gods in white, while the engineers are frequently looked down upon as technocrats. But anti-technology fanatics forget that modern life depends entirely on technology, and this will increase more and more as time goes on.

New technological approaches to sustainable global development are required - not just better policies. Technology is the most promising way out of a lot of seemingly irreconcilable goals associated with bringing the world's impoverished regions into a certain economic boom. But until now global development efforts have been hampered by the failure to mobilize science and technology adequately. In this connection geotechnical and civil engineering could contribute essentially (e.g. infrastructure, irrigation, clean and renewable energy supply, urban ecology, resources and waste management, disaster mitigation).
The challenge for all of us is to demonstrate that, as civil engineers, we can improve the quality of life in an equitable and lasting way.

2 DISCREPANCIES BETWEEN PROFESSIONAL OPINIONS

A close co-operation of experts of various disciplines is wanted and definitely necessary (e.g. geology, geotechnics, structural engineering, hydraulics, physics, chemistry, etc.). But it becomes ethically questionable when some specialists let themselves drift into fields of expertise other than their own, and when they think they would be qualified to act as commentators or even experts, despite their lack of specific knowledge. In addition, more and more self-appointed "experts" appear on the scene, most of them contributing to the undermining of the decision makers' judgment, sometimes even leading to their total confusion. Experts who are under the pressure of one of the parties in a hearing, or who are otherwise subjected to directives, have to be considered biased. There is also a certain obsession for image building or the striving for the receipt of contracts and jobs, which sometimes influence expert opinions in a questionable way. Whoever has observed the performance of such experts in meetings or hearings will be able to understand the reactions of distrustful or confused politicians - especially in environmental and transportation engineering and in urban design. Sometimes it is not clear *"if such experts help to solve a problem or if they are themselves the problem".*

Many experts believe in the philosophy of *"he who pays the piper calls the tune".* This attitude - which can be found in almost any field - might bring short-term success, but in the long run it represents a dangerous boomerang: Both parties lose credibility. Experts who knowingly write tendentious reports in the interest of their client are not legally liable (as long as no criminal offence exists). Therefore, the term "appointed expert" has more and more acquired a bitter aftertaste. These experts can be compared to lawyers who primarily have their client's interest in mind. The lawyer defends his client by over-stressing the positive aspects and omitting the negative ones. In contrary, an engineer must take an equal account of both sides, otherwise he will be considered as a

"one-sided, tendentious expert" and lose professional reputation. To sum up, the engineer has definitely to look for the truth, which is not necessarily the duty of the lawyer.
In politics the "KISS"-principle (*Keep It Simple and Short*) dominates, and in science the "KILT"-principle (*Keep It Lucid and True*). Generally a combination of both principles would be the optimum with regard to conference contributions, expertises, discussions, public hearings, etc.

In the scientific-technical field tendentious practices are, without any doubt, to be considered dangerous developments. It should, therefore, be in the interest of all of us to bring the term "appointed expert" back to its original and respected meaning, which definitely has to include independence. Otherwise the public will believe even more that expert opinions can be ordered according to need (and sufficient payment), which may result in mistrust.

It can certainly happen within the realm of the sciences that experts of unquestionable integrity are of different opinion on special points. Diversity of opinion of experts is hardly new - on the contrary, such discrepancies have always been a spark for further development and often have bred innovation. They should therefore not necessarily be regarded as negative. But there obviously is cause for concern if the public believes that for each expert opinion there might exist (or be ordered) a contradictory opinion by another expert. Typical examples throughout the industrialized world are environmental impact assessments or the site evaluation and selection for a new waste disposal facility.

Experience tells us that the largest source of claims and disputes in the civil engineering field is in the ground. Nevertheless, an alarmingly large percentage of ground engineering is done by non-geotechnical engineers or by geologists with insufficient civil engineering background.

What is very often not realized is that - as in most other aspects of life - there exists a difference in the quality of professional opinions and qualifications. Equal (professional) levels - in a democratic or legal sense - can hardly be found in the case of totally contradictory statements. Actually, experience has shown that highly qualified experts usually arrive at rather similar opinions - or they are at least able to agree on a joint declaration. Huge discrepancies are nearly always based on big differences in the qualification of the experts. Friedrich Engels stated already in 1878 *"There is just no democratic forum for scientific work".*

Complex, negative expert situations are partly caused by improper jurisdiction when it states for instance: *"The persuasive value of the means of evidence does not depend on the order of precedence, whatever that might be. Professional opinions, therefore, generally do not own a persuasive value which is graded depending on the rank or authority of the expert, which includes even university reports."*

The legal formulation *"The deciding factor at the presentation of the evidence is solely the completeness and conclusiveness of the professional opinion and its inner content of truth"* - though hitting the point exactly - causes problems in the actual application: Who is supposed to finally examine, evaluate and judge these aspects when, from a legal point of view, there is no formal difference between an ordered private expert opinion (possibly based on pseudo-science) and a faculty report of a renowned university?

Especially dangerous are those "experts" who don't know what they don't know. Incompetent persons are sometimes like noisy sparrows: they appear in swarms and drive away the songbirds.

The decision makers, especially the politicians, thus have to have the courage to stand by the opinions of high-level professional experts - and should ignore possible "counter-opinions" from biased, image-neurotic, or self-appointed experts. Here, the interest of the community has to be put before the egoistic interests of individuals.

"Experts" or groups hindering or even preventing the construction of buildings, which are required for the infrastructure of modern society (e.g. highways, railways, power plants, waste disposal facilities) should be called to account for their egoistic or fundamental, or even anarchistic activities. Most of the time such people only discuss what is not possible, not justifiable, not allowable, not appropriate, not functional, etc. Positive, constructive suggestions and the (co-operative) search for feasible, realistic solutions are pushed into the background. This can result in a feeling of uncertainty on the part of the politicians, can diminish their ability to make decisions and sometimes even lead to their total resignation.

The expert, for his part, will have to get used to accept and allow doubts that are expressed with regard to his qualification, his professional knowledge and the correctness of his opinion, and not consider them as lèse majesté. Distrust about the expert's objectivity should be accepted by him with philosophical calmness.
Moreover, the expert increasingly needs inexhaustible patience, for instance with those neighbors of construction projects who lose all objectivity purely because of their contradictory standpoint and personal interest. A typical example is the "not-in-my-backyard" syndrome which can be found so often in the siting of new waste management facilities (landfills, incineration plants). All too often, the issues opposing such siting are non-technical, e.g. they are political, social, conceptual, emotional, etc. When considering a new or virgin site (also called "greenfield" site), the situation is heightened to the point where technical logic is often completely left out of the decision making process.
To sum up, that type of expert is needed *"who gains his self-confidence and his authority from the quality of his expert opinion and not merely from his function and position".*

3 THEORY AND PRACTICE

In the last decades the level of geotechnics has increased tremendously, especially in ground engineering but also regarding numerical methods. However, the latter includes - to a certain extent - some danger to younger colleagues if they are not led properly: They frequently think that everything can be calculated, even to an accuracy of several decimal places. More and more, a so-called "point-and-click generation" of "white collar engineers" without sufficient site experience is emerging.

The world is becoming digital, whether we like it or not. We may soon arrive at the stage where nothing can be designed or evaluated unless it can be done numerically. Nevertheless, engineering judgment will remain essential in the whole field of civil engineering, especially in geotechnics. But engineering judgment can be gained only by combining theory and practice. An excellent geotechnical (and structural) engineer requires not only a firm theoretical knowledge but also comprehensive experience, as well as engineering feeling and intuition in equal parts.

Practical examples and empiricism have proved to be more effective than theoretical instructions and courses when trying to reach this wide knowledge and experience. This has been a valid fact for most professions since ancient times *"Long is the way through courses, short and effective through examples"* (L.A. Seneca, 55 BC-40 AD).

The role of experience in geotechnics had already been emphasized by Professor Karl Terzaghi towards the end of his life when he wrote: *"There was only one temporary deviation of the professional line I pursued. It involved a brief period in the twenties during which I believed that the problems of earthwork and tunnel engineering like those of bridge design could be solved by theory alone, on the basis of the results of adequate laboratory tests."*

With regard to publications and lectures, another statement of K. Terzaghi, included in the foreword of the first issue of Geotechnique (1948), is still valid: *"A well documented case history should be given as much weight as ten ingenious theories."* This recommendation could help to bridge the gap between theory and practice.
Terzaghi's close colleague, Ralph B. Peck predicted in 1991 the consequences of a gradual widening of the gap between theory and practice as follows: *"Researchers will take refuge in increasingly esoteric investigations; practitioners will pay little attention to the research results. Reading learned journals will become less interesting and profitable to practitioners, scientific oriented workers will find themselves more or less writing to each other."*

To be experienced does not necessarily mean to be knowledgeable. And pure practitioners ("we have always done so and don't need any theory or science") are just as one-sided as pure theoreticians. A cross fertilization between theory and practice is needed, as has been successfully demonstrated by bringing modern geotechnics to practical tunneling and vice versa during the past decade.

My own professional activity of more than 40 years has confirmed again and again: *"The deeper you penetrate into your profession, and the more difficult a project is, the more experience counts, but combined with theoretical knowledge."* A design, which is exclusively theoretical may lead to results, which are widely contradictory to practice. Two spectacular examples of then innovative technologies which were widely criticized in the first stages of their application may illustrate this: The deep dynamic consolidation (heavy tamping) of soft clays seemed to be completely contradictory to the conventional consolidation theory and soil improvement technology of that time. Crib walls and slender geosynthetic retaining walls were also questioned until the observational method proved their suitability. The safety of these structures up to 20 - 30 m height and installed in steep slopes could not be proved in a theoretical, conventional way. Hitherto calculation methods had provided safety factors clearly below 1 (sometimes F = 0.7), whereas the structures - constructed with engineering feeling, empiricism and experience - showed sufficiently safe behavior, as monitoring disclosed.

Such discrepancies occur not only in geotechnical or structural engineering but also in other disciplines of science as an example from aerodynamics illustrates: *"Theoretical investigations have proved that the bumblebee, because of its bodily form, its heavy weight, and its relatively small wing area cannot fly. Thank God, it does not know this, and so it keeps buzzing happily through the air!"*

Those who think that engineering problems can be solved by theory alone should be reminded of Leonardo da Vinci: *"It has been said that the knowledge acquired from experience is purely mechanical, while scientific knowledge always begins and ends in the mind. But it seems to me that those sciences which have not been born by experience, the mother of all certitude, are vain and full of misconceptions."*
J.W. Goethe also addressed this subject when his Mephisto in Faust II states: "*They think, what cannot be calculated cannot be true"* and
"Das ist eine von den alten Sünden, sie meinen Rechnen, das sei Erfinden"
meaning *"This is one of the old sins, they think calculating be inventing."*

In the thirties, when the young science of soil mechanics was severely questioned and even opposed by many academics, K. Terzaghi stated: *"The present opponents of soil mechanics will die out; so this problem will solve itself biologically. But the worst harm to soil mechanics will come once it is discovered by pure theoreticians because the efforts of such men could undermine its very purpose, especially if they don't distinguish between idealization and reality."*
A. Einstein obviously had a similar opinion of pure theoreticians when he stated: *"Since pure mathematicians have fallen upon the relativity theory, I myself don't understand it any more."*

With regard to the ever increasing capacity of modern computers and numerical methods, it should be emphasized that soil is a physical model, a particulate material and not a virtual model.
In his Nash lecture J.B. Burland stated 1987: *"It is both arrogant and dangerous to believe that ground engineering can be carried out solely on the basis of numbers given from site investigation coupled with codes of practice. It is necessary to study case histories, learn about local experience, examine the soil and visit the site."*

A field where theory and practice inevitably collide is the remediation of contaminated sites if pure theoreticians, idealistic environmentalists or formalists require an "absolute" cleaning. But this is in a strict physical/chemical sense practically not possible. Cost-effective measures achieve an effectiveness of about 70 to 80(90)%. Cleaning of more than 90(95)% commonly leads to an excessive increase of costs. From a pragmatic point of view, it therefore should be preferred to remediate more sites on a lower level than to spend the available money on just one site - whereby the question "how clean is clean" still remains.

In conclusion, geotechnical engineers must go on bridging the gap between theory and practice. A simple example from the field of deep foundations shall underline this: Theorists have been thwarted by the complexity of the boundary conditions during pile installation and the limitations of existing soil models; experimentalists have been handicapped by the number of independent variables needing measurement. As a result, pile design still relies on empirical correlations between a limited set of parameters, while other (equally important) factors are neglected.

A lack of practical experience can be observed among many academic staff. A detrimental effect of research evaluation in universities has been to create "paper-writing machines" (Langdon 2002) who have no practical experience. On the other hand, a lack of mathematics and science in the university education is also to blame. For instance, how many geotechnical engineers question the certainty of their (semi-) empirical design correlations (and how many would even be able to do so?). Consequently, teaching of theory and practice must be well balanced. Otherwise the systems leads to graduates who will be increasingly unlikely to have heard about an alternative to the textbook solution.

Engineering is the application of science to technological problems. But it is not simply the gross application of sublime theory; it is also a versatile scientific field per se. Nevertheless, a non-negligible group of architects and even civil engineers frequently looks the other way. Of course, the usefulness of new theories has not been always immediately apparent, but the incorporation of science into engineering was eventually extremely successful. *"There is nothing more practicable than a good theory!"* (I. Kant, 1724-1804)

With this opinion, the greatest German philosopher was far ahead of his contemporaries. For instance, in 1822 Thomas Tredgold, a celebrated British engineer observed that *"the stability of a building is inversely proportional to the science of the builder"* (Florman 1987). When in 1858, W.J.M. Rankine issued his famous and widely used *Manual of Applied Mechanics*, he sought to put an end to the deplorable "separation of theoretical and practical knowledge." Yet as late as 1872 the author of a *Cvil Engineer Pocketbook* stated that he would not refer to Rankine or other exponents of theory because they are "but little more than striking instances of how completely the most simple facts may be buried out of sight under heaps of mathematical rubbish" (Florman 1987).

The basis for an interaction of theory and practice should be laid already during university undergraduate education. Students should be trained to think critically and independently. More thoughtful skepticism should be emphasized instead of concentrating too much on certainties or on details of limited value. Instruction, education and training should be properly balanced in the curricula, and diversity and creative design should be encouraged. Teaching should incorporate the presentation of case histories and precedents.

University education must be more than mere instruction (training) and increasingly becomes only an introduction into a lifelong learning process. Continuous education and flexibility (in the positive sense - not opportunism) are becoming more and more important in their relation to the classical studies.

There is a certain tendency - a spirit of the "modern" age to make things as complicated as possible. This refers, for instance, to theories, which are not applicable in practice, to over-sophisticated quality assurance, etc., but also to some "esoteric" conference papers or oral presentations. Such "development" is certainly neither desirable in practice nor for conferences or for technical journals. It is much more difficult to present really complicated hypotheses, etc. in a clear way than to "complicate" relatively simple methods or theories in an artificial way (being mistakenly of the opinion to thus gain scientific reputation). Hence, one should focus more intensively on the old tradition *"Nothing beats simplicity"* - but avoiding over-simplification.

The philosophy of calibrating simplified calculations against more analytical methods and field data has proved very effective in geotechnical design. Over-sophisticated calculations frequently pretend an accuracy, which in reality does not exist. A typical example are retaining measures in unstable slopes where soil and rock parameters exhibit a wide scatter and pore water pressures represent another uncertainty.
The gradual substitution of global safety factors by several partial safety factors does not conclusively mean that the "real safety" can be assessed now more precisely than before - neither in geotechnical nor in structural engineering.

Already Terzaghi was clearly in favor of "high-quality simplicity" when he wrote about his Vienna period, with regard to laboratory and field tests: *"The simpler and the cheaper a device is, the better it serves the purpose of verifying a basic theory's rightness, since it can be adapted without loss of time or money according to the growing understanding of the process to be investigated. Expensive and sensitive instruments are not justified unless the inherent properties of the phenomena are clearly understood and the raw figures are to be replaced by exact ones. If you start with costly apparatus, you will be the slave of your instruments, and an experiment which does not serve for the verification of the correctness of a superior idea will help only to identify a fact, but will never enable one to discover the conformity with a natural law."*

Accordingly, sophisticated and more or less fully computerized test equipment should be considered a valuable supplement to conventional devices and performances of field and laboratory tests, but it should not replace the tried, "simple" methods. The latter are needed for comparison and for calibration; furthermore, they hardly ever result in hidden mistakes or wrong outprints as automated devices sometimes do.

Young engineers and especially professionals of a low qualification frequently stick slavishly to codes, standards and guidelines. If a theory finds its way into a textbook, it is considered by many readers a law. Moreover, too many regulations, standards or codes, which are too confining hinder innovation in geotechnical engineering. They act like a brake, slowing down new development. Furthermore, there is the danger that our professional activities are going to be degraded to a mere ful-

filling of regulations. Over-specifications may also have a detrimental impact and pretend that there is no residual risk left. Furthermore, engineers are increasingly afraid to design outside of standards or codes because they fear legal problems in case of a failure. This also has been dramatically reducing the willingness to take responsibility. Fear for liability or litigation is stifling innovation in civil engineering, especially in geotechnics, and pushing engineers towards over-reliance on standards. But over-reliance on standards or codes hampers also engineering judgement and kills "engineering intuition". The tendency to do things as we've always done is another hindrance to innovation and development in construction.
Therefore, personal creativity, interlinked thinking and responsibility should be much more promoted. Otherwise, engineering judgment would deteriorate dramatically - which would be disastrous, especially for the young, upcoming generation of engineers. Consequently, educating young people to be creative problem solvers as 21st century engineers should begin already at the universities and engineering schools.

A courageous engineer is willing to take a calculated geotechnical risk, which involves detailed ground investigation, geotechnical prognoses, "active" design (i.e. adaptable), proper risk assessment, and monitoring with back analyses. The more prerequisites of such a serious geotechnical risk are missing, the more it approaches a *"Geopoker"* (or "Geo-Gambling"). Geopoker is favored by brutal competition, time pressure, economy and lack of knowledge (thus underestimating risk and danger). Geopoker has led to the paradox that the number of geotechnical failures has continuously increased during the past years (statistically confirmed) - despite the advanced geotechnical education at the universities.
This negative tendency is, additionally, favored by today's fiercely common money saving policy, by increasingly shorter construction periods and by the pressure to construct on/in poorer and poorer ground. But while good ground was much more available in former centuries, time pressure existed already in the ancient world: The Roman Latin architect P. Vitruv complained already 31 B.C. in his 10 books "De architectura" about low construction quality because of too short and strict time schedules.
The opposite of "Geopoker" is costly overdesigning, which is definitively not an engineering art. The transition zone between these two extremes depends on numerous factors, whereby particular demands, costs, acceptable risk and failure consequences dominate. With regard to roads, for instance, this can be illustrated by a quotation of K. Terzaghi: *"A road exhibiting no failures or at least deficiencies along its alignment (slope cuts, embankments, structure/pavement) is overdesigned and hence too costly".*

Outstanding theoretical basis and best practice hardly count if clients order work on the basis of cost rather than quality. Hence, the geotechnical/civil engineers should increasingly convince clients of the importance of high quality. Proper site investigation, for instance, should not be seen as a necessary evil but as essential. In this connection it should be mentioned that - according to European statistics - about 80 to 85% of all building failures and damages are related to problems in the ground. Most failures are due to design or construction flaws.
This number could be reduced primarily by proper site investigation, more flexible/conceptual design plus observational method rather than rigid, fully-engineered design, and by stringent site supervision (performed by experienced geotechnical engineers but not by formalists). Designers should be involved in construction inspection/supervision (is the design intent being satisfied by the construction?) But it should be kept in mind that money cannot buy risk-free ground, even if ground investigation costs increased from usually between 0.1% to 1% of project costs to 5% and more. Residual risks are unavoidable, because ground is the greatest uncertainty in civil engineering.

Highly qualified work of civil engineering- and geotechnical designers and consultants, of laboratories or testing and research institutes should not be subjected to routinely performed bidding procedures. After all, in case of an illness, the client would certainly not collect bids to find a surgeon who would perform the operation at the lowest price, but he would look for the one with the highest qualification.

The use of project management teams in the construction industry is now wide-spread. This system, originating in the petroleum industry, was adopted first in the building industry and later on for the public transportation infrastructure. It has proved successful in the latter field, but seems to a certain extent questionable in geotechnical engineering. But on the other hand, very positive contributions from project teamwork can be gained if geotechnical and structural engineers or geotechnical and infrastructure engineers cooperate. Moreover, civil/geotechnical engineers increasingly find themselves brainstorming within multidisciplinary teams.

Another tendency is to install commissions for solving difficult problems. This might be useful in politics and in international co-operations but not so in regional civil/geotechnical engineering projects. An exception is environmental engineering where several disciplines should co-operate. What we actually need, more than commissions, are real personalities with the ability and willingness to make decisions and to take responsibility. Already Charles de Gaulle criticized the increasing tendencies towards commissions when he ironically said: *"Why are the Ten Commandments so concise? Because they were not created by a commission."*

There is a certain danger, that the development in civil/geotechnical engineering might not proceed as intensively as during the past decades. The main obstacles to progress are:

- Restrictions imposed by some codes which may be over-prescriptive or over-conservative.
- Unwillingness to adopt new design philosophies or site procedures (e.g. piled rafts, roller integrated continuous compaction control).
- Increasing tendency for non-geotechnical engineers and inexperienced geotechnical engineers to use complex programs for design (Poulos 2003).

4 DESIGN

Design is becoming increasingly fragmental as specialist consultants and contractors are used, and as new forms of construction management are introduced. Design is a continuous process, requiring regular review to ensure that the client's needs are being met (Clayton 2001).

Moreover clients, pressure groups and the general public across all continents require their transport infrastructure, utilities and services constructed with minimum disruption to their daily lives and their respective local environments.

With regard to geotechnics, it should be emphasized that building in unstable, heterogeneous, or soft soil and rock includes a significantly higher calculated risk than is experienced by other branches of civil engineering. Consequently, proper design and construction require not only a firm theoretical knowledge but also comprehensive experience, engineering intuition, engineering judgment and the willingness to take responsibility. This involves in many cases design concepts, which need to be adapted during construction, or even in the long-term, according to the observational method. Monitoring is therefore essential, and an "active design" exhibits significant advantages over a conventional and rigid "fully-engineered design". Futhermore, creativity prefers conceptual design rather than detailed design resulting in solutions that reduce geotechnical risk by avoiding the hazards.

Failures and accidents will always happen. There are too many variables in ground, construction and structure to believe they won't, and it is a dangerous arrogance to assume otherwise. However small the actual risk, it is imperative to anticipate the worst-case scenario. *"Forewarned is forearmed"* should be an essential principle of active design, semi-empirical design, and observational method.

Application of the observational method was pioneered by Terzaghi, and the principles were formally set down by R. Peck in his 1969 Rankine lecture. The essence of the observational method is that performance is monitored in such respects as to allow usually predetermined supplementary measures (according to a contingency plan) to be adapted where observation departs from accepted criteria for stability or deformation: The observational method facilities design changes during construction and establishes a framework for risk management. However, it is unfortunate that the method may be inappropriately associated with uncomfortably low safety margins (Powderham 2002).
In reality it is one of the most important tools for proper design, material savings, reduced construction times, and risk assessment in geotechnical engineering. The potential to make modifications during construction and to strengthen the structure at any time, even after construction, is a fundamental requirement of the observational method. It allows a continuous re-evaluation of the parameters used for design. *"Simplicity is at the heart of the observational method - a simplicity made comprehensive by good judgment"* (Peck, Powderham 1999). The observational method involves the concepts of the most probable and most unfavorable conditions, hence a creative process and not over-complication, but "high-quality simplicity" (based on detailed ground investigation, prognoses and monitoring). High-quality simplicity does not forget the reasoning behind "simple" practices, because over-simplification, sometimes through so-called high-tech mechanistic calculations, can cloud one's engineering judgment.

In mountainous regions the soil and rock parameters frequently exhibit scatter, even within a small area, to such an extent that geotechnical calculations seem to provide merely border values and serve for reference only. Due to steep slopes there is also the uncertainty of seepage flow. Therefore, the safety of such slopes cannot be proved conventionally by theoretical methods but only by "semi-empirical" design (Brandl 1979). The optimal solution can be achieved only step by step in connection with in situ measurements. It would be economically unjustifiable to construct most expensive structures by assuming the most unfavourable parameters. Calculations and theoretical consideration are only the basis for the first design and for interpreting the measurements. This "semi-empirical" design method has proved successful under most difficult conditions for about 35 years.

A careful examination of ground condition and ground-structure interaction, as well as close monitoring before, during and after construction are vital to both the semi-empirical design method and the observational method. Moreover, a proper site investigation should be the basis of each serious design. There is an old saying that you pay for your site investigation, whether or not you do one.

Aspects of sustainability should be widely integrated into a creative and integrated design and planning process of the built environment. They should be also integrated into the operation and management of the built environment throughout its lifecycle as some topics illustrate:

- Effect of the built environment on quality of life, in particular on social behaviour,leisure and mobility.
- Reduced and more efficient energy and material consumption in the built environment.
- Optimum balances between comfort and energy consumption of houses.
- Management strategies for the built environment to ensure maximum use of existing structures and infrastructure for different technical end economic conditions; in particular with regard to synergy effects.

If the development of novel techniques and more efficient sites is to continue, the regulatory framework needs to be open to these new ideas and solutions. Emphasis should be placed on integrated approaches/designs. Revolutionary design and construction improvements have been achieved hardly from the classical parts of geotechnics than by challenging the dogmas combined with ingenious engineering.

A practicable design should also consider the qualification of local workforce. What is a highly polished project good for, if the workforce (and site supervision) is poor?

Not only over-reliance on standards or too strict regulations are an obstacle to good design but also rationalization, time pressure, and convenience. It is so much easier to replicate design and specification information from previous contracts, making adjustments as necessary to suit the new site or application. It is easier and quicker than initiating new and original design work which, while being groundbreaking in terms of engineering development, will take longer to produce, cost more man hours and run the risk of raising questions with the client or regulator. It is so much easier to stick to the same tried and tested solutions which can be simply reproduced and will not elicit any expensive questions (Atchison 2002).

Design-bid-build/lowest price contracting for high-value capital works seems to be out of fashion. It is considered expensive and takes too long. The alternatives range from design-build/fixed price contracts to all-out private enterprise concessions with various forms of public-private partnerships (PPP) in between. But do these alternatives improve quality and safety? "Best-value" contracting instead of lowest-price contracting seems to be the better alternative in the long-term, especially for structures with a long design life. The "lowest bid is best"-philosophy is not the way to continue. This refers also to fees for design works. On the other hand, designers and consultants should not engage in cutthroat competition; this reduces inevitably quality, hence also their professional reputation.

5 THE LIFELONG LEARNING SOCIETY

Human society has become more and more a lifelong-learning society, especially in the fields of technology, medicine, and natural sciences. We are changing from the "industrial age" to the "age of special knowledge". The development of civil engineering and geotechnical engineering during the past decades represents a typical example. Furthermore, the Internet has exponentially increased access to journals, opening them also to many scientists and engineers in developing countries.

There has been a continuous increase in knowledge since written documentation exists. But since the middle of the 19th century there has been an absolute explosion of new scientific findings and discoveries. This is connected with the fast changes in the human environment caused by technical achievements. For instance, the greatest German poet, J.W. Goethe (1749-1832) was - technologically speaking - further away from the end of the 19th century than from the technics of the antique Roman Empire. During the first third of the 19th century, Goethe traveled to Italy by the same means as did the Hohenstaufen Emperors 600 years before, and their technology was hardly higher than that of the Romans, again 1200 years before.

Until about 20 years ago continuous learning was primarily a means to professional advancement. Today it is already required to maintain the quality of work in one's current position, and hence the job itself. Therefore, continuing professional education and training have become an absolute must, especially in the technical and medical fields but also, more and more, in the natural sciences and the humanities. Increased education also increases employability in the international economy. There is a paradox though: the more knowledge is accumulated and the faster it is renewed, the less is actually known in many cases. There exists even a danger of a new kind of "analphabetism", as information is getting outdated faster than the time period that is needed to acquire it. It is, therefore, not surprising that some people - mostly from the older generation, but also younger ones - show fatigue symptoms which are coupled with the question, *"what good is all this hectic, continuous learning going to do in the end?"* It would be absolutely fatal for humanity if this kind of mood would spread even further.
What should be aimed at is a *"key-qualification"* consisting of a well-rounded general education together with specialized knowledge. This would also defuse the debate, who is to be preferred, the professionally "well-rounded" person or the one who is highly specialized in a particular field. As these individuals cannot replace each other, therefore more and more personalities are required which combine both qualities, at least in parts. The concept of the civilized engineer - the humanistically educated engineer - coupled with the recognition that not all engineers want to, can, or in any event, will move in that direction, gives rise to the conclusion that we must look, at least initially, to a select group - an elite (Florman 1987).

Engineers today must absorb more information about business, communication, ethics, professionalism, entrepreneurship, and other "soft" skills. However, while demands on engineering curricula have increased, many schools and universities have (significantly) reduced the credit hours required to earn an engineering degree (R.B. Flowers 2004). Thus, university education and training is partly/widely replaced by on-the-job training. On-the-job training is certainly a proven way of teaching graduates and gaining practice. But a certain problem is that it is provided frequently by senior colleagues who had not the time to keep up with the changing technologies or techniques; hence bad practice will be perpetuated. Just industry-trained engineers often tend to "jobs are done like that because they have always been done like that." But over time it is a case of "Chinese whispers", leading to a dilution of expertise (Wheeler 2004).
Well educated, trained and confident staff are essential for a quality service and growth in a highly technical, intensely competitive industry.

According to the report "Human Capital Investment" (1998) by an international expert group, about two third of international prosperity is already now based on human intellectual capital. The physical capital (engines, buildings, infrastructure) and the material resources represent only one sixth each. Therefore, the rise or decline of nations depends more and more on the education and qualification of their working force. Human resources management requires *"more heads than hands"*, as a Swedish sociologist recently stated. This definitely also applies to the field of civil and geotechnical engineering.

"The empires of the future" Winston Churchill already said, *"are the empires of the mind."* Four decades later the economist and Nobel laureate Theodore W. Schultz echoed Churchill's sentiment in his 1981 book, *Investing in People: The Economics of Population Quality.* The wealth of nations, Schultz argued is not limited by land or minerals. It comes instead predominantly from *"the acquired abilities of people - their education, experience, skills, and health."*
The validity of this thesis can be illustrated on the example of two typical countries: In 1900 Argentine belonged to the richest countries in the world, Singapore, on the other hand was a poor trading port. 1950 Argentine's wealth was still three times higher than Singapore's. But since Singapore has been investing in human capital, the picture has changed dramatically during last 30 years. In 1997 the Asians exceeded Argentine already three times with a per capita production of almost $30,000 (purchase value). With this amount Singapore led the world - being even slightly ahead of America and far ahead of Germany.

The speed at which technology advances is fascinating. What seemed a utopian dream just a short while ago, is now taken as standard. But on the other hand, there does exist a danger that "new" knowledge is considered more valuable than "sound" knowledge. Sometimes one gets the impression that "speedy movement" has developed its own dynamic and has

become a value of its own. Scientifically sound, well-founded contents seem to have become gradually less important, and rapid change is over-emphasized.
Scientific papers and papers on case histories published years ago are frequently a treasure of information. Unfortunately, many civil/geotechnical engineers and geologists read only new papers instead of good papers. Therefore, in many cases, "the wheel is invented again and again", which means wasting of time, costs and intellectual capacity.

The modern growth-oriented society demands more output and better quality in consumer goods, economy and science - and this with less input of time and material. This results, among other things, in an enormous, almost out-of-control flood of information, which is very often repetitive. Even the experts in the specific fields increasingly lose the overview. Furthermore, many papers contain absolutely nothing new once the quoted data of the original authors are subtracted.
Internationally there is too much research time wasted and too many poor quality publications are being repeated. There is far too much "bumph" being published at far too detailed a level, which people are just not finding the time to read. What happened to the concept that publication was intended primarily for breakthrough developments? (Rankilor 1999).

Lifelong learning, therefore, means increasingly also to be able to select what is actually worth knowing out of the staccato of information, which is showering down on "postmodern" man every day. This is relevant not only for general- but also for specific professional knowledge. Only he who is able to keep his memory free from useless information and to erase from his memory things which are no longer "state of the art" will keep his head clear for real innovation.
Virtual knowledge is not sufficient in practical engineering. Furthermore, pursuit of knowledge for its own sake as in philosophical disciplines, for instance, can hardly be indulged in by civil/geotechnical engineers.

A major share of breakthroughs reported in leading scientific journals are increasingly produced as a result of collaborations among researchers at multiple institutions, often at institutes spread across the globe. Even more frequently, new inspirations arise form cross-disciplinary, cross-institutional conversations. Consequently, academic research directors should support mechanisms that draw together researchers from diverse institutions. Though the effect of such interconnections is less in civil/geotechnical engineering than in other sciences, it is throughout promising and brings together different cultures.

To sum up, continued education (and training) has to become the central challenge of education policy, whereas lifelong learning has to be the responsibility of the individual. Experience confirms that already now about 70% of our knowledge and skills are acquired after primary and university education. But education must not be looked at primarily from the point-of-view of economic usage. The importance of education reaches far beyond the professional-economic aspect; it has to incorporate the dimensions of a well-rounded humanistic education, of creativity, of basic values, responsibility and a willingness to achieve, and it has to be a major contributor to the individual's ability to cope with innovation and unusual novelties.
Modern education experts observe a rising tendency towards a "reduction" of general education to a mere professional education. Universal education is more and more being replaced by special knowledge in specific fields. *"What is above all important nowadays is the ability to change quickly from job to job and from task to task"* (E. Egger, historian). This almost indicates a parallel to the rise and fall of the Roman Empire and its culture, and is in stark contrast to the "civilized engineer".

Recent analyses of management consulting companies have disclosed that about 50% of personnel managers set value on the best practical experience of "High Potentials" ("HiPos", i.e. candidates for leading positions). Next in the ranking are the knowledge of foreign languages (46%), stays abroad (21%) and specialisation (16%). Professional education and training stands at the end. Furthermore, self-motivation and the teamwork ability are desired, but less the willingness to take risks. This result is in stark contrast the needs of civil/geotechnical engineering where firm knowledge is required and risks are unavoidable.

High Potentials possess an above-average amount of the so-called "soft skills": Analytical and logical thinking, assertiveness, emotional intelligence, flexibility, communication skills, creativity, mobility, motivation, talent for organisation, team-orientation. These soft skills are certainly valuable in management, but tend to be less important in activities involving design, calculation and construction, risk assessment, project evaluation, etc., i.e. professional engineering. Management, applied engineering, and the sciences require different levels of these skills, with useful combinations providing the best results.

There is a relation between advanced technology and civilization; nevertheless an advanced civilization may be uncultured. Hence, striving for technology, civilization and culture as an interacting trinity or a single entity should be the goal of education and professional practice.
The civil engineer should be a civilized engineer - and cultured too.

6 CLIMATE CHANGE - A CHALLENGE TO GEOTECHNICAL/CIVIL ENGINEERING

Climate change has already begun to reshape the earth's environment from tundra to rainforest, and it will have an increasing impact on cities, hence on the urban ecosystem. Climate change has two faces: an overall warming trend, and more frequent and severe droughts and floods.

In Alaska, the average temperature has risen by 5.4 degrees Fahrenheit over the past 30 years, and entire villages are being forced to move inland because of rising sea levels. Greenland's glaciers are melting. The world's ecosystems are in the throes of rapid transformation. And large, costal cities are among the most vulnerable of all. For instance, the area of New York (Rosenzweig 2002): Some scientists have estimated that by the 2080s, as a worst-case scenario, a major coastal storm could occur every three to four years, compared with every 100 years in the past, while a 500-year flooding event could hit every 50 years. Consequently, New York will likely need to build higher seawalls and raise airport runways to protect against rising sea levels and increasingly severe and frequent floods. Also the water supply system has to be accommodated to meet the impacts of expected hydrologic extremes.

In Austria, the floods of the year 2002 locally exceeded all maxima registered in the past: Statistically, values of 2000- to 10,000-year flooding events were assessed.

This growing hydrologic variability represents an outstanding environmental challenge to civil and geotechnical engineering. As to flood protection dams (dikes), for instance, the following aspects should be considered for rather densely populated areas:

- Quality assessment of existing flood protection systems.
- Risk analyses and improvement of insufficient systems.
- Construction of dams and dikes which can be flooded locally in order to reduce flood wave extremes.
- Definition of risk areas for extreme flooding events, i.e. for 500- and 1000-year floods.
- Installation of early warning systems.

To sum up, the climate change has drastic consequences for safety, water management and country planning. This will require radical adjustments of river and coastal structures and it will influence agricultural regions as well as urban areas. Netherland's government, for instance, has already established a new Directorate-General for Water Affairs (2002). Its main task is to protect against inudation and to accomplish sustainable use of water and its infrastructure.

The protection of coastal zones from the impact of global warming, sea defences and beach regeneration are therefore increasing challenges to civil/geotechnical engineering. In densely populated areas huge projects may become necessary. A prominent example is Venice: It has been sinking for centuries, but since 1900 subsidence has accelerated up to additional 23 cm, mainly because of abstraction of ground water by heavy industry surrounding the lagoon. Global warming now is fuelling fears that the sea could rise by as much as 1 m over the next 100 years. Therefore the Italian government is considering a mammoth submersible barrage to protect Venice from floods.

Avalanches and mudflows are increasing events in the mountainous regions of Europe and elsewhere. In the Himalayas global warming leads to the development of glacial lakes, whereby the stability of their natural dams is rather uncertain. These lakes exhibit a high risk potential: For instance, when the natural barrier of the Luggye Lake failed (1994, North of Buthan), about 20 millions m^3 water rushed down the valley. These issues and the development of protective measures are another environmental challenge to geotechnical engineering. Consequently, snow mechanics and mudflow-, debris flow - events have become important research fields.

Due to the increasing world population one cannot stop urban growth. In urban areas the population has increased five-fold in the last 40 years - an expansion that is speeding up exponentially. Consequently, specific "urban ecosystems" are developing with an increasing demand for electricity, energy, sewage and waste disposal systems, etc. It is now the task of civil and geotechnical engineers - in cooperation with other scientific disciplines - to design and construct such systems which are widely sustainable, i.e. *they meet the needs of the present without compromising the ability to satisfy the requirements of future generations.* This means that an *"ecological design"* has to consider environmentally friendly materials, construction, operation, overhaul, decommissioning, removal, and disposal of residual materials. The interlocking issues of clean water, waste disposal, energy and land use should be investigated not only site-specifically but also from a broader far-sighted point of view. Especially large projects have to meet political, economic, ecological and social demands at the same time.

But also on a small scale, many environmentally friendly ideas can be put into action by civil/geotechnical engineers thus contributing to a significant accruing effect:
For example, one should start to design buildings that are more energy-efficient and foster thermal refurbishment of existing buildings. This would save natural resources and reduce greenhouse gas emissions at the same time. A promising example is the "passive house" that consists in the main of biogene materials and requires only a minimum of energy for heating and cooling. "Passive houses" have among other things ecologically balanced heat-insulating facade systems (site-specific composites). Roofs covered with soil and planted improve not only the energy efficiency but exhibit several other ecological advantages. An optimum solution is achieved if such energy-efficient houses are equipped with energy foundations or other geothermal energy utilisation.

The use of clean and renewable geothermal energy for heating and cooling of buildings is certainly a field where geotechnical engineers could contribute essentially. This refers not only to the utilisation of hot springs or deep-seated thermal water but also to geothermal boreholes in common ground (mostly needing a heat pump). A promising innovation are "energy foundations" where heat absorbers are installed in foundation elements, and "energy tunnels" where the tunnel support is used to extract energy from or store energy into the ground for heating/cooling buildings (Brandl 1998, 2001).

Naive environmental activists sometimes even think that power plants are not necessary, because electric current comes from sockets anyway. These fundamentalists (especially in industrialized countries) oppose even against new, innovative highest voltage lines which would be required to transport electric current in a most energy-efficient way. High capacity overhead power lines could significantly reduce electric current loss in a far-reaching electricity supply system. This would be a promising field of cooperation between high-voltage engineering and civil engineering. In many cases this could provide (= save) more energy than alternative eco-power systems for electric current generation.

Hydro power, solar power, wind power and geothermal power are the "clean" and renewable alternatives to the greenhouse gas emitting power sources like oil, coal and gas. Hydro power is certainly still dominating; nearly 1 million dams already exist worldwide. Optimum solutions are achieved if hydro systems serve not only for generation of energy but also for flood protection and irrigation. Continual advances in technology and materials are required to keep hydro up-to-date in both existing and new facilities, maintaining hydro's position as environmentally friendly choice for providing needed electricity for utility systems worldwide.

When dams are ageing, unsafe or no longer serving their original purpose decommissioning or even dam removal are increasingly discussed if other viable alternatives exist. Significant drop in solar power costs, commercial fishermen interests (e.g. restoring abundant salmon runs), touristic aspects (e.g. rafting instead of houseboats), agricultural aspects (need of fertile mud), etc. may help to locally offset dams - for instance in California which now leads the world in a new growth industry: dam removal. But this local situation cannot be generalized, because each case has site-specific issues, problems and characteristics.
Another geoenvironmental challenge is the restoring and reshaping of canal-like creeks and rivers in order to revitalise natural flora and fauna, and to reduce flood wave extremes.

In such cases the civil engineer is increasingly challenged not only as a professional expert but also as economist, negotiator, diplomat and even press officer: Most questions are not resolved until several public meetings, hearings and information sessions are held. Discussions with environmentalists and the relevant press coverage are usually extensive.

From an ecological point of view it should be mentioned that under certain conditions earth dams may even become new nature reserves:
The flood protection dam along the river Danube near Vienna was constructed between 1884 and 1902. Meanwhile a versatile flora of about 440 different plants is growing there, including rare orchids and 48 plants of the "red list" (i.e. Europe-wide threatened by extinction), which do not exist in the surroundings. The extreme flood in August 2002 exhibited, that this dam has to be enhanced. There the interests of geotechnical engineering (= remediation) and biology (= preservation) are widely contradictory, which requires a close and sensitive cooperation of both disciplines. This example illustrates very clearly that a vegetation like in "natural nature" may thoroughly appear also on man-made structures. Similar observations have been made in abandoned quarries where often very rare species of flora and fauna develop.

The old principle "prevention is better than cure" is also valid for flood protection. Of course, "absolute safety" cannot be achieved in most cases. But flood mitigation by preventive engineering and ecological measures is by far cheaper than rehabilitation work after disaster has struck - not to mention the potential loss of lives. Take, for example, the catastrophic flood events in Europe in the year 2002: If only about 5 to 10% of the damage costs were appropriately invested into preventive defense measures against future flood events, the situation could be improved significantly. Dedicating a certain percentage of expected damage costs caused by possible floods to hazard mitigation measures would benefit the national economies and is hence a challenge to politicians - and engineers.

Global warming and population growth in the very regions that are lacking drinking water even now are additional challenges confronting geotechnical and civil engineering.

The need for water is increasing worldwide; at the same time hazardous materials threaten the water reservoirs. According to a study carried out by the World Health Organisation WHO in 88 countries, 77% of the population are not provided with sufficient water, and the groundwater levels in many regions are falling drastically.
"Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity" (Kofi Annan, United Nations Secretary General). But does this human right to water justify overexploitation of natural water resources? Shouldn't we think of the basic needs of future generations too?

To sum up, nature does not lie behind us, so that we should call for "back to nature". It lies before us, and environmental geotechnics as a combination of engineering and natural science can contribute substantially to protect and preserve the environment in such a way, that ecology and economy are well balanced.

7 ENGINEERING ETHICS

In many countries, the construction industry has been exposed to severe criticism as a result of poor business behavior, malpractice, or even corruption. Illegal actions cannot be excused under any circumstances. For instance, price-fixing and bribery are against the law in most countries. In different cultures the lines between the acceptable and unacceptable are drawn differently, but these differences are "marginal rather than fundamental". If "gift giving" involves secrecy it is unacceptable. In 1999, 34 OECD countries signed the Anti-Bribery Convention making it a criminal offence to bribe foreign officials. So, why should the building industry take the law any less seriously than other industries?

The time is right for the engineering profession and the construction industry to take a public stance against corruption. Corruption has - among other things - the effect of lessening the amount of capital invested in locations where infrastructure is often desperately needed.

Questionable and even unethical are arrangements where consultants or designers are rewarded with success fees if they achieve savings in construction costs by recommending lesser or poorer materials. This will cause a decrease in quality and an inexcusable increase in risks. Unfortunately, the different results gained from different theories and assumptions facilitate such negative practices. After all, buildings, especially underground structures or embankments, etc. appear "stable" to the eye, no matter if they exhibit a "real" safety factor for instance of $F = 1.05$ or of $F = 1.50$.
Making money and high moral standards are in principle not contradictory. But price competition at the expense of technical quality should be avoided.

Natural uncertainties are unavoidable in geotechnical engineering, but safety standards should not be reduced additionally by low quality or brutal competition. In this connection the British social reformer John Ruskin (1819-1900) should be quoted. It might be of interest for clients, authorities and contractors alike:
"There exists hardly anything in this world that could not be produced in a lower quality and be sold at a lower price - and people who orientate themselves on the price only are the natural

prey for such practices. It is not clever to pay too much, but it is even less clever to pay too little. When you pay too much, you lose some money - that's all. When, on the other hand, you pay too little, you sometimes lose everything, because the purchased object cannot fulfill its intended purpose. The law of economics does not allow to obtain big value for little money. If you take the lowest offer, you have to add something for the risk you take. And if you do that, you also have enough money to pay for something better than the lowest offer."

Not the price and fancy juridical agreements should be in the center of negotiations, but the product, the "engineered building". Not the lawyer's but the engineer's word should carry the most weight.

The daily work of civil/geotechnical engineering has be done under increasing time pressure. Nevertheless, the attitude *"Better to offer a poorly conceived design or calculation than to be too late"* contradicts professional ethics (and may cause severe failures if supervisory control is missing). This refers also to tendering and following claims.
A lowest price tender that is significantly lower than its nearest competitor bid should be excluded.

"Value engineering" is a great concept potentially saving huge sums in construction costs, and in many cases, providing improved, safer design. (Osterberg 1999). *"Value engineering"* in the interest of the engineers' employer or client could be achieved if engineers (or other geotechnical professionals) followed the old rule of thumb: *"How would I do it if I were paying for it?"*

In many cases, ethics is only based on rhetoric and good intentions. Engineering societies have traditionally treated questions of professional obligation under the rubric of "engineering ethics". But how is it possible to move beyond platitudes? Should young engineers be prepared to abandon their careers rather than abdicate their moral responsibility? Should engineers have an ethical obligation not do be involved with weaponry not to work in the defence industry, etc.

The endeavour to come up with a uniform code of ethics that might be endorsed by all the major professional societies is decades old - and the search for virtues that nobody can define. In the end, each individual is accountable to an inner moral code, to his inner conscience. The Austrian philosopher Arthur Schopenhauer (1788-1860) once stated in his pessimistic-ironical manner: *"Ethics can as little help to become virtuous, as comprehensive aesthetics can teach how to create real works of art."*

Morality cannot be achieved by making noble-sounding proclamations. The morality we seek should be founded in the real world and be capable of practical application. It should be able to meet standards of both good will and good sense (Florman 1987).

Comprehensive statistical investigations of structural failures disclosed that insufficient knowledge has been the dominating type of human unreliability (followed by underestimation of influence, carelessness and error). Most of the mistakes could have been detected in time by additional supervisory control. Consequently, the great need in engineering ethics is an increased emphasis on *competence*. Additional words are: *dedication, energy, self-discipline, caution, alertness, awareness* - and most of all *conscientiousness*. "The greatest threats to moral engineering are carelessness, sloppiness, laziness, and lack of concentration. An engineer may start out honest and high-minded but become immoral by falling prey to one or more of theses sins. On the other hand, an engineer who starts out by being conscientious must end up by being honest, since competent engineering, excellent engineering, is in its very nature the pursuit of truth. A conscientious engineer, by definition, cannot falsify test reports or intentionally overlook questionable data, cannot in any way evade the facts" (Florman 1987).

Ethics also means also humility and modesty, hence virtues that construction often has been lacking in the past decades. This is not inevitably the fault of architects and still less of civil or geotechnical engineers, but rather that of clients. Frequently, such "outstanding" projects or designs are determined by a tendency towards most striking features, sensations, or gigantism (megalomania), with display patterns and over-ambition being the driving forces. Thus, numerous unnecessary "superlatives" have been created.
Higher, longer, larger, deeper are the keywords of over-ambitious architecture and construction that approaches the limits of technical feasibility, the limits of what can be done.

Sometimes ethical issues arise during an engineer's career regarding situations in which an engineer has a responsibility to blow the whistle. Consequently, ethics plays an important role in educating young engineers. It should help them when being faced with ethical dilemmas in the work environment.

Education in ethics is essential, because laws alone are insufficient to combat corruption. Laws are ineffective, for example, against acts that are not strictly illegal, that are committed, for example, in a socially and culturally tolerated zone that forms a gateway to dependencies. Therefore, the goal must be to define values such as incorruptibility and transparency as demands of the individual's conscience within the scope of professional ethics. Accordingly, several authorities and companies have started to use ethics awareness programs as a means of communicating ethical awareness to their employees.

Guidelines for ethical professional practice could, for instance, include the following issues:

- Engineers shall place their responsibility for the welfare, health and safety of the community before their responsibility to sectional or private interests.
- Engineers shall continue to develop relevant knowledge, skill and expertise throughout their careers to gain an utmost level of competence.
  (Many universities have already a similar sentence in their final graduating ceremonies. Consequently, such an attitude to one's professional life should be a self-evident obligation from the very beginning - with out further saying.)
- Engineers shall act only within areas of their competence. Hence, geotechnical engineers should not act as geologists and vice versa - unless they have the appropriate double education. Interdisciplinary cooperation should be promoted.

- Engineers shall, when asked to review or critique the work of fellow professionals, advise them accordingly.

As far as the economical and ethical part of the profession is concerned, a saying by Thomas Mann (1875-1955) is highly recommended: *"Enjoy your business activities during the day, but take on only such which let you sleep at night."* Personal integrity and a clear conscience have always been an assurance for a good night's sleep. The historical statement of the Roman Emperor Vespasian (70 AD) *"Pecunia non olet" ("money does not smell")* is sometimes quoted to justify lack of ethics. But this is a total misinterpretation because the original statement was exclusively referring to the fees collected for the use of public toilets and can therefore not be applied generally.

Ethics cannot be enforced on the unwilling, but geotechnical and civil engineers ought to set an example of high ethical standards to improve the image of the building industry in the future.
Ethics should not be substituted by "monethics".

Finally a comment that refers not only to our profession but also to industry and engineering as a whole, to the economy, commerce, the world of business, etc., and sometimes even to the sciences: A society which regards brutal competition as the essential principle of all human activities will in the end destroy itself, because it will have stopped to consider itself as a group that strives for and shares the same values and goals; it will become a *"pool of sharks where everyone fights everyone else."*

8 RECOMMENDATIONS AND EXPECTATIONS FOR YOUNG ENGINEERS

The following thoughts should be an appeal to the young graduates, never to forget the high professional and moral responsibility, which is laid upon their shoulders when they enter their working career. Professional ethics should not be an empty phrase. Engineers should not be guided by short-lived trends but should stay consistent (but innovative) - without acting like narrow-minded, stubborn fanatics. They should be ready to compromise without, for instance, stooping to the level where expert opinions are given as favors.

A career in civil/geotechnical engineering is exciting, challenging, innovative and partly well-paid (at least above a certain level of knowledge, experience, etc.). What makes the job stressful, is often what makes it interesting too. But sometimes it becomes a juggling act between feast and famine.
Geotechnical engineering is both, science and art, theory and practice.

The profession of an engineer demands one's best possible performance, if one aims to exceed beyond the average. The founder of soil mechanics, Prof. Karl v. Terzaghi, once described his outstanding activities with the words: *"Only 10% is inspiration, the remaining 90% is perspiration".* Albert Einstein is supposed to have said something similar. Werner von Siemens, one of the pioneers of the practical utilization of electricity, once advised a mother who came and asked if her son should become an engineer, because he was very skillful and liked to experiment: *"You have to get your son used to rise at 5 am and to work from the first cry of the rooster until deep into the night. Should he be able to do that for a long time without his effort diminishing, then, maybe, he can achieve this or that."*

Most geniuses of all professions had (have) huge work ethics. Edison worked eighteen-hour days most of his life and two shifts (sixteen-hour days) at the age of seventy-five. Work was the elixir of his life, as it is for most creative geniuses, including Picasso and Einstein. Picasso had an inexhaustible vitality. He painted eighteen hours a day virtually everyday until his eighties. Einstein felt that there was never enough time for work, and the inspired conductor Herbert von Karajan (1908-1989) worked tirelessly until his death despite severe health problems.

Engineers with an outstanding ingenious creativity are mostly *"criss-cross thinkers"*, which is not necessarily the same as "think-tank" members. Criss-cross thinkers are even more successful than "normal" geniuses because

- they are not afraid of committing errors or failures,
- they consider all possibilities,
- they rely on their intuition,
- they have manifold interests,
- they think positively, and
- they take time to relax.

Creative engineers usually are also innovative, competitive and risk takers. Geotechnics, for instance, usually includes a significantly higher calculated risk than is experienced by other branches of civil engineering. Practically every project entails unknowns or uncertainties. Hence, a so-called "absolute safety" does not exist in geotechnical engineering (just as it does not exist in so many fields of daily life). Moreover, "*no risk at all"* in the end means *"no business."*
The geotechnical industry is certainly innovative, but creativity is often stifled by excessive regulations, codes etc, and by a lack of practical experience.

The requirements which today's engineers have to face exceed by far the traditional picture of the profession. Besides the knowledge of their special field (which goes without saying), it is expected that they understand economic relationships, have social competence, and are fully aware of the consequences of engineering actions for nature and society.

While getting fully engaged in his profession, the engineer should not forget that, next to the elite of intelligence (and power), there exists also an elite of service, which is particularly necessary to society. To this group belongs a person who *"understands to waive his interest without fuss or even demonstration and whose professional ethics have their roots in the performance and in the service for a cause which results in little or no personal advantage"* (G.K. Kaltenbrunner).
Contrary to this humanistic pro-society attitude, there is the egoistic point of view *"In a competitive situation, only my own interests count"*. In this case competition will become so fierce that all concern for the well-being of others will disappear. Such an attitude would in the long run surely backfire, and in one way or another hit such selfish professionals like a boomerang.
Human beings cannot survive without the co-operation and help of their fellow men and without their mutual exchange of

different skills, talents and abilities. Consequently, the individual must put the general well-being above his own, at least to a certain extent, because his own destiny is inseparably linked to that of the group. Harmony in the group is of course always endangered by the lurking individual egoism. But fraud, brutality, or maliciousness bring only short-term benefits. A wise businessman knows that he cannot keep cheating on his partners or clients without, in the long run, jeopardizing his own success. Fairness, therefore, can be considered the interaction of mutual advantages - a kind of balance of the singular egoism. Universal benevolence, however, is a dangerous utopia, and a society which relies exclusively on the unselfish virtues of the individual has to fail or will end in dictatorship. History can tell many bloody chapters of the dictatorship of fanatic morality preachers which ended in terror.

In my university graduation speeches I always recommend to the young engineers what really should apply to all generations of our profession:

- Should you be criticized during your professional career, do not immediately deny any wrongdoing, but carefully reflect on your own actions first. You will oftenbe subjected to unreasonable criticism, because even the most responsible and careful fulfillment of your duties will not save you from certain critics: *"In order to avoid critics, one must not say anything, write anything, do anything and be anything"* (O. Werner, 1922-1984).
  Furthermore: *To be right does not automatically mean to be considered right.*
  And: *Some people appose or reject a good idea for the sole reason that it was not theirs.*
- Welcome independent review. Do not view it as an attack on your design or competency but as a benefit to you as much as to your client. And, on the other hand, criticising others has never spared anyone own work and achievement.
- Try to be a good colleague!
  Differences in professional opinion should not be carried out in public in a way that would damage the image of the profession. As far as loyalty within a profession is concerned, the medical profession provides an excellent example. During a recent international conference of lawyers in New York it was stated that it is very difficult to get medical doctors to testify against each other. But, this is not the case among engineers. This negative behavior of our profession should be changed. Medical doctors are competitive as well, but there exists, nevertheless, a professional bond, which takes precedence over competition when necessary.
  A good partnership will create a win-win situation for all involved.
- Teamwork (increasingly multi-disciplinary) and co-operation are certainly essential for a successful professional life. But it should be kept in mind that it is quite impossible to do everything right for anybody.
  "*Nothing makes us more cowardly, less principled, and less scrupulous than the wish to be loved by all"* (Marie v. Ebner-Eschenbach, 1830-1916).
  Optimal teamwork means a balance of the rights and duties of all team members. Lack of balance - in the long run - can only be carried out on the backs of others. One person's personal freedom ends *where the others' begins.*
  "If we were all determined to play the first violin we should never have an ensemble." (R. Schumann, 1810-1856).
  The key lies in how the members of a team, from client to designer, consultant and contractor, pool their knowledge and resources to overcome critical site situations. A flexible approach and the ability to respond quickly to unforeseen events is a must for any geotechnical engineer.
- Living in a society requires, without any doubt, adaptability on the part of the individual. But an exaggerated striving for adaptation, acceptance and recognition might lead to mere superficialities or to activities, which are only a parody of real efficiency and constantly overwhelm the human being.
  Excessive craving for admiration leads to an emotional captivity in the prison of vanities. Do not just strive for publicity and prominence in order to move in the "right circles". Very often you will find yourself in a narrow-minded group, which just follows the latest trends.
- Young people frequently tend to ignore social conventions. But these conventions are to a great extend the rules of culture - at least with respect to mutual politeness - and they facilitate daily life. Whoever remembers this while abiding by them is not going to suffer under them. Furthermore, *"kindness works like a boomerang."*
- Always think of the *"Big Five"* in your life:
  Anthropologists and psychologist have disclosed that the major personality traits, by which people judge other people, have remained unchanged since ancient times. All over the world, independently of era and culture, the following traits ("Big Five") have been considered most significant: Conscientiousness (including honesty and reliability), Amicability, Extroversion (moderate), Emotional Stability, and Openness for new experiences. This evaluation applies as well in private life as it does in business and seems to have held up for thousands of years.
- An extreme dynamic and increasingly excessive speed has started to govern our lives. Modern society is suffering more and more from an *"acceleration syndrome."* While weeks, days, hours still have the same length - at least objectively - more and more events are being packed into these time periods, increasingly leaving nearly zero possibility to go into depth. A "24/7 society", which can be reached 24 hours per day and 7 days per week (by mobiles, etc.) is a rather unhealthy development, frequently governed by personal pomposity and striving for big impression by all means. Exceptions may be useful or necessary only temporarily.
  A strong and competitive market certainly favours the ingenuity of the contractors' world. Many new ideas on geotechnical engineering have been borne without being (fully) exploited yet. But the alarm bells

ought to ring if in the "event staccato" there is no time left for some intermediate contemplation in quiet or if - for example - there is rarely enough time to *carefully* work on a project or *carefully* prepare written/oral contributions to conferences, journals, etc.

- A "nine to five-engagement", however, is certainly not sufficient to reach a professional level higher than the average. The optimal line between rigid routine and excessive hectic is subjective and lies somewhere in the middle, depending on the interests, ability, ambition, physical condition and engagement of the individual. *He who always reaches his goals has obviously not set them high enough.* Important goals should not be given up just because the road thereto is rocky. *"Overcoming obstacles is the ultimate in life's pleasures"* (A. Schopenhauer, Austrian philosopher, 1788-1860).
  On the other hand, you should not become adrenaline-addicted or a "performance neurotic". The latter are those pitiful people who would like it best to reply to a letter before it has arrived.
  Furthermore, resist professional dilution by trying to do everything! This advice is a simple but effective recipe against overloading, overcrowding - and even overteaching.

- The *"faster, higher, stronger"* of today is definitely not new but was already known to the antique Romans as *"citius, altius, fortius"*. The fact, that the word "hectic" goes back to the antique Greek "hektikos" (= permanent activity) indicates that the point of view of the Greek philosopher Diogenes (+323 BC) in the barrel was obviously not the rule of everyday life then. This even raises the question if today's manager rushing with his car from one meeting to another produces more or less stress hormones compared to the antique warrior who staggered with his bronze spear from one battle to another.

- Support research and development as much as possible during your professional life!
  Today's science and research shape the reality of the future.
  Research and development will improve not only your personal prospects but also those of society. Research is the procedure where money produces knowledge while innovation is the procedure where knowledge produces money.
  Industrial research requires mostly a balancing act between business and science. University research, however, should be absolutely independent and objective.

- A responsible scientist/researcher should always question and somewhat doubt the truthfulness of his own work. He ought not to generalize too much and too fast. In the end each theory is based on certain assumptions, models and idealizations; and even apparently correct measurements can include unnoticed or even unnoticeable imperfections.
  Overreliance and uncritical acceptance of theories, experimental data, etc. were criticized already by A. Einstein: *"Experimental data are believed by everyone, except the person who did the experiment; while theory is believed by nobody, except the person who developed it."*

- Stick to your opinion if you are convinced of it, but don't be stubborn. Sometimes more courage is necessary to change one's opinion than to stick to it.
  A sound self-criticism never will hurt anyone: The more I know, the more I recognize how much I don't know. The volume of our non-knowledge - ignorance - seems to increase with the extent of our secure knowledge.

- Develop design concepts and procedures which *work with, not against, nature* (Poulos 2003).

- Do not work outside of your area of competence or experience. This also includes not using "off the shelf" designs that may have been successful for you in the past but are possibly woefully inappropriate for the project at hand.

- Risk assessment is essential in geotechnical engineering. It requires comprehensive knowledge and experience and remains - in spite of codes, standards, regulations, etc. - partly subjective. I confess to being an optimist. My glass is generally half full, and not already half empty. But whether one's temperament is optimistic or pessimistic, everyone in our scientific and engineering community has a specific responsibility: measure, calculate and decide with care, and assess with honesty the level of risk in the glass.

- *Problems exist to be solved*. A practising geotechnical engineer is less frightened by visible dangers than by imaginary/unforeseen ones (based on a quotation from W. Shakespeare, adapted to geotechnics). Overcoming known as well as unidentified risks is one of the most exiting challenges in geotechnical engineering.

- Field observations are essential in geotechnical engineering. Not only for research and development, backfeed of ground and structure response, but also in connection with the observational method. Already in 1936, K. Terzaghi stated in his presidential address at the first International Conference on Soil Mechanics and Foundation Engineering (Cambridge, USA): *"Our theories will be superseded by later ones, but the results of conscientious observations in the field will remain as a permanent onset of inestimable value."*

- The lifelong-learning society, international competition and the relatively high risks in geotechnical engineering require a continuous increase in personal knowledge during the entire professional life.
  "Anyone who stops learning is old, whether at twenty or eighty" (H. Ford, 1863-1947).
  "Learning is like rowing against the current: as soon as one stops, one drops back."
  With regard to geotechnical engineering: *"There are no (insurmountable) weak soils or rocks, there are only weak engineers".* This (human) weakness can only be minimized by teaching, educating, training, learning and gaining experience.
  Knowledge and experience are the only true wealth, because one cannot loose them, but only give them away to others, while still keeping them.

- Exploring the boundaries of scientific knowledge and the limits of science is an outstanding challenge - it may even become an obsession. Distinguishing between the unknown and the unknowable could lead to a great enrichment of science. It should always be kept in mind, however, that science and engineering have to take responsibility for the consequences of their achievements and activities (e.g. in civil engineering: waste management, regulations of rivers, infrastructure and environmental planing, etc.). Planing ahead should therefore involve husbanding resources, saving something for those who will come after, leaving the world a better place - hence long-term thinking. An increased knowledge about the environmental impacts of projects will ensure their sustainability.
  From today's point of view, Alexander Humboldt (1769-1859) was the first ecologist who already then promoted a balance between self-renewable resources and human activities in the fields of economy, industry, agriculture and technology.
- If you prefer working in the field of theory and indoor science rather than on construction sites, you should still not restrict yourself to being a purely "white collar engineer". Try to regularly visit the sites in order to compare theory and practice and to bridge the gap between these two fields which both are essential for engineering progress. There is an old saying: *"One always finds the best sailors on the beach".* Moreover, an appraisal of the construction process and site supervision are necessary in order to check that the design assumptions are justified. The deeper you go in geotechnics and the more difficult projects you have been involved in, the more you will recognize that geotechnical engineering is not only a science but also a craft - and an art (but certainly not a "black art" as sometimes considered by those who don't understand soil mechanics as a much wider field than pure theory).
- The fulfilling of standards, codes, regulations, etc. is certainly necessary to a wide extent during the daily professional life. But additionally, you should try to leave the conventional paths as much as possible and intensify creative work - even if it seems sometimes to go against the present state-of-the-art.
  "The man with a new idea is a crank, until the idea succeeds" (Mark Twain, 1835-1919)
  and *"Progress is the realisation of Utopias"* (Oscar Wilde,1854-1900).
  "Don't walk along smooth, straight ways only; take also paths not yet gone by others so that you leave marks and not only dust" (Antoine de Saint -Exupéry,1900-1944).
- Creativity provides with profit, and profit supports creativity. On occasion, the technically creative engineer gets it all - wealth and fame along with the satisfaction of invention. Furthermore, as R.W. Emerson (American philosopher and poet, 1803-1882) said: *"The reward of a thing well done is to have done it."*
- One of the greatest challenges in engineering is to develop or apply new geotechnical concepts or proce dures. But never cross the borderline from a serious calculated risk to "Geo-gambling" or *"Geopoker"* in order to save money or win a bid (i.e. insufficient ground investigation, improperly reduced safety factors, lower quality of material and execution, etc.).
- *"Whoever wants to move the world, has to first move himself"* (Sokrates, 470-399 B.C.),
  "Don't forget, success is the reward for hard work" (Sophokles, 497-407 B.C.),
  "Nothing great was ever achieved without enthusiasm" (R.W. Emerson, American philosopher and poet, 1803-1882) and
  "Not the beginning of something will be rewarded but solely perseverance and endurance" (Katharina of Siena, 1347-1380).
- *"Complacency is the death blow to any kind of progress."* and *"just avoiding failures only is not a success."*
- People who are looking for a deeper meaning in life enjoy a higher degree of well-being than people who are striving only for short-term material gain. These meaning-seekers not only lead less stressful lives but they are also more efficient and more innovative in their work.
- Above all you should keep the following philosophical thoughts (old Asian wisdom) in mind during your professional career:
  - *Everything interacts.*
  - *Everything changes.*
  - *We belong to nature and not nature to us.*

Learning by mistakes and failures is not a disgrace but rather a professional evolution. But for this to work there must be two stages: being aware of the error and finding a solution. A typical example are tunnel collapses and emergencies, which still occur worldwide during construction, despite better health and safety provision. In this context there is a need to improve the identification of risks throughout the tunneling process and in other sections of ground engineering, and the ways in which these risks can be eliminated or controlled. But the dissemination of such information is slow. Therefore, more international co-operation in sharing information is required - perhaps an international database of emergency situations; and failures in geotechnical engineering should be created to help contractors, designers and consultants to avoid repetitions of past mistakes (T&T International, 1998).

Sometimes it is argued that conventional international conferences, symposia or workshops might not be necessary any more, because in our modern time it is easier to transfer information by computer links or internet than by costly conferences. Search and retrieval software provides easy access to the world's foremost research literature. But this argument is completely wrong, and we must go on with international conferences, seminars and workshops: Firstly, because we now have the chance of a closer international co-operation than ever before - and secondly, because the human being is fortunately not a computer but needs personal contacts, discussion, background information and friendship. Meetings, discussions and original publications continue to bring the fresh winds of new knowledge into the sails of research.

It should be obvious to all engineers that, especially nowadays, it is important to have a strong united professional representation. Therefore it came as a shock to learn about the age structure of several national and international engineering societies: Sometimes the age group from 20 to 40 years has less than half the members than the group from 70 to 80 years. There seems to be a certain international lack of interest on the part of young graduates. This lack of interest in learned society activities will lead to slow professional suicide if not stopped in time. Only a strong professional representation can represent the interests of the engineers (and geologists) on the outside and in public. Moreover, it promotes education, training, professional development and international co-operation. Therefore, I especially appeal to the young colleagues to join the national institutions of civil engineering and/or the International Society for Soil Mechanics and Geotechnical Engineering.

There is a further recommendation I like to give to young engineers for their career: Never stop studying! This does not mean just the fundamental, specifically technical education. Make up your own thoughts and opinions about science in general and about ethical, philosophical, and ecological issues. The more you broaden your horizon, the more satisfaction you will achieve in your life. Furthermore, learning strengthens the brain just as physical exercise strengthens the muscles, and, as medical long-term research has disclosed, intellectually well-trained and active individuals live longer and healthier.

The professional's career should not be based on trying too hard to set records or on over-competing with others (e.g. "deepest excavation", "fastest tunnel advance", "highest retaining wall", etc.), as this involves increased risks. "Record bridge", "Monster tunnel boring machine", "Super sky scraper", "Mega dam", "Underwater Giants" are just some examples from PR documents. Taking *calculated* risks, however, especially in connection with the observational method is undoubtedly the basis of innovation, progress, and success. Occasional setbacks should be taken in stride and regarded as positive learning experience. But crossing barriers only to reach a high level of recognized achievement or self-congratulation for a job well done is condemnable. "Records" are on the one hand significant indicators of the vitality and the future development of geotechnical/civil engineering, but on the other hand they indicate the rough behavior of today's vibrant industry.

Furthermore, a universally educated professional should make sure that he cultivates his mother tongue. Engineers especially neglect this sometimes because they see their mode of expression particularly in calculations, drawings and computer plots. But clarity of expression also means clarity of thought. Moreover, a lack of cultivation of language and the often underdeveloped ability to properly express themselves could be the reason for the sometimes low image of the engineer.

The ability to communicate in clear, accurate written language is a powerful tool for a civil/geotechnical engineer. With e-mail fast becoming the favoured form of day-to-day business communication, the sloppy standards of grammar and writing associated with it need to be improved. Consequently, formal e-mail policies ought to be enforced, emphasising the need for courtesy and awareness of cultural issues. Especially in an international context, the informality of emailing can easily lead to unintentional offence. This cultural minefield can be crossed best by improving one's word power and cultural knowledge (N.N. 2004).

Finally, foreign languages are becoming increasingly necessary due to the globalization of our profession. The world is becoming a *"global village"* according to the thesis of the Canadian media philosopher Marshall McLuhan (1911-1980). Due to Internet and digital communication everybody can exchange data or do business with everybody at all times. We all have become inhabitants of a singular place that we could call *"Telepolis ".*

9 FUTURE PROSPECTS AND CHALLENGES

Civil engineers (geotechnical engineers commonly belong to this professional community) have chosen a highly interesting and always changing profession, which opens up for a variety of possibilities and of which they can be proud of. In Germany, for instance, the building industry is still the biggest employer of industry, with hundreds of billions of Euro. About 80% of the national product - not including plots of land - are buildings, half of them apartments. The existing buildings have a value of trillions of Euro - and this substance can only be maintained with the help of civil engineers. Next to the building maintenance, the recycling processes and environmental problems represent the biggest chances for the future of civil engineers. The Austrian construction industry, for instance, shows by far the greatest potential for investment in the environmental sector, almost as high as mechanical engineering plus electrical engineering plus chemical and synthetic material industry put together.
In the European Community of the year 2003, about 27 million jobs depend directly on the building industry, which consequently is an important factor with regard to employment. Geotechnical engineering represents a key part of all building activities and of environmental protection worldwide.

Design, construction, operation, maintenance and restoration of water supply and sewer systems in the rapidly growing mega-cities becomes an increasing challenge to civil engineering and especially to geotechnical engineering.
Novel technologies for upgrading sewage systems with minimal disruption to surface activities are also required to prevent polluting sewer discharges.

Drinking-water supply, sewage removal/treatment and waste disposal are essential elements of prophylactic medicine. Therefore, civil and geotechnical engineers are challenged to develop proper sewage and waste disposal systems in time to prevent serious outbreaks of communicable diseases. For instance, solar-aided municipal sewage sludge drying plants are a promising innovation. Recently, the world's largest plant was opened in Austria providing a dry, crumbly residual waste that can be used as fuel due to its high calorific value.

The move into the next decades and the expected growth in transportation require an efficient and high-performing infrastructure all over the world. Safety and high-traffic flow is important, and any restrictions due to reconstruction and maintenance should be kept at a minimum.

Transportation infrastructure is widely influenced by the location of industry, local density of population and political decision, and - from an overall point of view - less by geotechnical aspects. This is a great challenge to our profession because good ground (high quality "greenland") for new buildings becomes increasingly rare in the densely populated zones of the world, but size and sensitiveness of buildings have increased. It will become more and more necessary to construct in such weak soils, unstable areas and seismic zones, which formerly could be avoided. Consequently, civil/geotechnical engineers are forced to present solutions, which often reach the border of feasibility. This refers not only to alignments and buildings of infrastructure but is generally valid.

In detail, therefore, geotechnical engineering has a great influence on the alignment, design, construction and maintenance of all "traffic and transportation arteries". Geotechnics facilitates the individual traffic, the supply of modern society with goods and the disposal of the resulting waste and sewage via roads, highways, railways, subways, harbors and waterways, airports, pipelines, water supply and sewerage systems, etc. (including tunnels and pipes, galleries, bridges, retaining structures, landslide stabilization, ground improvement, etc.).

Civil engineering enables the increasing 24 hour-traffic and transportation in urban areas by innovative technology. For instance, special road concrete makes complete road repair and re use by heavy traffic/transportation possible within 12 hours.

Environmental protection from traffic routes gains increasing importance: Not only noise barriers but also barriers against groundwater contamination. Precipitation washes heavy metals and mineral oil hydrocarbons from road surfaces into the ground. In case of heavy traffic and groundwater protecting zones special liner systems are required.

Flood protection along rivers and coastal regions is a further challenge - especially considering the increase of floods and a rising sea level caused by a change in the global climate (see chapter 5). The design, construction and maintenance of safe dikes and dams, and their defense during catastrophic events, requires mainly the skills of civil/geotechnical engineers.

Land reclaiming, especially in densely populated coastal regions is another challenge to civil engineering. The Kansai International Airport in the Bay of Osaka (hitherto the world's largest man-made island), the Hongkong Airport Check-Lap-Kok or Singapore's ambitious land reclaiming activities are outstanding examples of these activities.

Furthermore, geotechnical engineering could contribute essentially to a safety increase of tailings dams. Tailings impoundments are among the largest man-made structures with several of them approaching a billion tonne of stored sludge, sands, etc. Failures may therefore have a huge impact on the environment - and until recently they occurred at an unacceptable rate: at least ten times higher than those for conventional embankment dams (Davies et al. 2000). Though tailing dams are only a cost to the mining process without generating a revenue like hydroelectric dams an increased awareness and emphasis on safety of tailings basins should be developed.

The rise in world population and living standard requires more and more energy. Hence the up-rating and refurbishment of existing power plants and the design and construction of new power plants are required. Small hydro projects are a valuable supplement to large-scale projects, and they save not-renewable natural resources like oil and reduce environmental impacts (air pollution). Small hydros certainly have a great future in the renewables-industry.

Furthermore, the increase in world population requires huge technological efforts to properly manage the available water resources. Environmentally friendly concepts for irrigation and hydropower have become an absolute necessity. India, for instance, had only 300 dams before 1947, currently there are about 4300. Within the next 50 years another 10000 are needed (Varma 2003).

With the rapid economic and industrial growth of many regions, the development of water resources has become a vital element of the infrastructure to satisfy the increasing demand for energy, irrigation and drinking water supply. This development includes both, the construction of new facilities and the refurbishment of existing older plants.

More and more meetings and co-operations of representatives of civil engineering, environmental technology, and ecology allow for great optimism. The fact alone that the Association of Construction Companies and the Society for Environment and Technology hold periodically joint symposia on the problems of waste management and contaminated land remediation shows the positive change in attitude. Mass media resumes, stating: *"The old antagonism between the environmental groups and the "construction lobby" has been resolved"* might be somewhat exaggerated, but it is a fact that the ecological wind does no longer blow so strongly into the face of the technical engineer (especially civil engineer). This can be considered a success of pragmatic thinking: *"If ecology has a future, then only in an industrial form, while industry can only have a future which is ecological."* And finally, *"economy and humanity are interrelated; without the former we are not going to make it - without the latter we cannot bear it".* This realistic insight leads inevitably to the conclusion: *"Environmental awareness and industrial ecology provide new challenges and opportunities for the building industry - hence also for civil and geotechnical engineering."*

"Industrial ecology" seems to be an oxymoron, a connection of two terms, which basically contradict each other. Indeed, the name is provocative in several ways (Lifset 2000), but if the consumer society is treated as an ecosystem, benefits will accrue to both the environment and the society. The underlying idea is that the entities that have been major sources of environmental damage can be converted into agents for environmental improvement. Industries design, construct and produce goods, and so they possess the tools and technological expertise needed to create environmentally informed products and manufacturing processes, to construct and operate waste disposal facilities, to clean contaminated land, etc. That is what motivates the word "industrial".

Waste management (especially landfill engineering), the redevelopment of vacant or derelict land and contaminated site clearing represent additional geotechnical challenges. In this connection landfill mining should be mentioned as a promising waste management tool which simultaneously provides site remediation. This is a procedure whereby solid wastes which had previously been landfilled are excavated and processed to recover potentially useful materials including energy by incineration.

The combination of waste management and sustainable construction is another increasing challenge to civil engineering: For instance, the use of recycled concrete aggregates, exploiting wastes in concrete, the use fly ash and other residual (pre-treated or stabilized) wastes for embankments, roads and liner systems, etc. The conversion of waste and industrial by-products into beneficial products in the construction industry and the utilization of alternative construction materials as a substitute for primary materials provide advantages not only for the environment but also for civil engineering activities.

Waste management covers only a specific topic of environmental issues. The more comprehensive field is resources management, which involves raw materials, recycled materials as well as waste. Consequently, resources management has been included nearly for 15 years in civil engineering education and training act the Technical University of Vienna.

As far as site cleaning, contaminated land remediation, upgrading open old dumps to safe landfills, construction, operation and aftercare/monitoring of new waste disposal facilities, etc. is concerned, a geotechnical/civil engineer is surely more qualified to give a profound judgment than a so-called "environmental engineer". This European experience was also confirmed by Jan Hellings (2000): *"A trained civil/ground engineer is the best equipped to manage remediation projects and liaise with all the specialist advisers from allied professions."*

The relatively new term "environmental engineer" is increasingly used by politicians and in the public because it sounds so competent. But actually it can hardly be considered a special branch of studies with in-depth education, research and knowledge in specific fields. Commonly it is rather an encyclopedic mixture referring to biology, chemistry, civil engineering (including geotechnics), geology, hydrology, mechanical engineering, etc., whereby - as lies in the nature of such things - none of them are covered in real depth. Civil/geotechnical engineers, on the other hand, are specifically trained (or should be educated and trained!) for siting, contaminated land remediation, landfill engineering, waste and resources management, etc. A promising branch is geoenvironmental engineering as a combination of geotechnical and environmental engineering. To sum up, for a particular project, close co-operation of real (high-level) experts with specialized knowledge from different, relevant fields is most of the time more efficient than activities of so-called environmental engineers.

The reconciliation of ecology and economy needs primarily graduates with a solid technical education as well as an education in natural sciences. Accordingly, the highest managerial positions in successful industrial corporations are more and more filled with engineers, with commercial managers serving under them.

Meeting the needs of an ever increasingly thirsty world is another challenge for civil and geotechnical engineering - in cooperation with agricultural engineering, etc.:

Only about 10% of the global water consumption by mankind are used for domestic water supply; 20% are consumed by industry and 70% by agriculture. The area of irrigated land worldwide has increased more than thirtyfold in the past two centuries, turning near-deserts such as southern California and Egypt into food baskets. Artificial oasis cities have bloomed. But while the affluent enjoy desert swimming pools, more than a billion of the world's people lack a safe supply of drinking water, and 2.8 billion do not have even minimal sanitation. The World Health Organization estimates that 250 million cases of water-related diseases, such as cholera, arise annually, resulting in between five and ten million deaths. Intestinal worms infect some 1.5 billion people, killing as many as 100,000 a year. Outbreaks of parasitic diseases have sometimes followed the construction of large dams and irrigation systems, which create standing bodies of water where the parasites' hosts can breed.

Nearly 10 percent of the global food supply depends on the unsustainable practice of depleting groundwater. That raises an unsettling question: If humanity is operating under such an enormous deficit today, where are we going to find the additional water to satisfy future needs? The world's urban population is expected to double to five billion by 2025, which will further increase the pressure to shift water away from agriculture (Postel 2000).

The challenges that lie ahead are to find solutions to satisfy the demands of more and more thirsty people without further destroying the aquatic eco-systems (as for instance the Aral Sea, the Colorado Delta, etc.). We need new technologies, but our actions must ultimately be guided by more than technology or economies - we also need a new ethic: All living things must get enough water before some get more than enough.

Another great long-term challenge which geotechnical engineers are going to face within the next decades is an enormous increase in tunneling and underground work under all soil and rock conditions, especially in urban areas. It is estimated that by the year 2025 at least 100 mega-cities, each with a population of between 5 to 30 million, will exist, and the urbanization of the world will further increase. This requires huge amounts of different underground structures, especially tunnels. Already now the traffic tunnels in Western Europe alone have a total length of more than 10,000 km, which is four times the distance between Paris and Moscow.

Accident statistic clearly exhibits that road tunnels reduce the number of traffic accidents significantly, both in industrialized and developing countries. For instance, the Kohat tunnel of the Indus Highway in Pakistan (opened in 2003) replaces one of the most dangerous mountain roads in the world. Pakistani accounts suggest there may have been thousands of deaths since 1927 on the old mountain pass road over the steep Kohat pass.

Thus, civil engineering contributes essentially to road safety, also saving time by shortening traffic routes.

Underground storage facilities are also increasingly needed. This requires not only new underground openings but could also make use of abandoned mines.

The following list gives an overview of important issues that represent key challenges to civil engineering. This list cannot be complete, nor does it show the individual concerns in any specific order of priority:

- Traffic and transportation infrastructure.
  E.g. high speed railway nets (speeds up to presently 580 km/h)

- Water management
- Resources management
  Civil engineering also for the optimal use of scarce land resources. Extravagant waste of the world's resources has to be urgently reversed, also by political action - enforcing sustainable policies through controls, taxes and investment.
- Waste management (solid and liquid)
- Hazard mitigation and prevention
- Power generation
  E.g.
  - Decommissioning of old energy structures; the design, construction and location of alternative energy devices (e.g. offshore windfarms).
  - Flexible power generation from the tides (the predictable, regular reversal of the tides makes this an important renewable energy resource).
  - Aligning oil and gas pipelines in rugged or permafrost terrain.
- Irrigation systems
  Also rehabilitation of areas detrimentally affected by intensive irrigation (e.g. the Aral Sea Basin having dried out tremendously since 1960).
- Urban and industrial ecology
- Land reclaiming
- Abandoned and contaminated land remediation
- Environmentally sound subsurface construction technologies
- Maritime engineering, involving port, harbour, estuarine, coastal and offshore engineering.

Civil engineering, especially geotechnical engineering, is a challenging profession of much greater versatility than many others. It should be mentioned, however, that international competition has become so strong that to obtain work on the international stage requires a skill in its own right and is not something that can be undertaken in a half-hearted manner. Gone are the days when expertise gained at home was sufficient to ensure an enthusiastic welcome overseas. Today, local relationships must be established and personal reputations forged in the interests of long-term success. The work of civil and geotechnical engineers is spreading, with both contractors and consultants stepping out of their domestic markets seeking work abroad. Winning work internationally is a skill worthy of study and investment, and, for the existing of many companies in today's fiercely competitive market, a definite necessity (Thomas 2003). Constructors and consultants who have excelled on the international scene are able to hook up with local companies to form successful international joint ventures. Furthermore increasing globalization opens the advantage to young people of getting to know other cultures and learning from them. If they are dynamic and find the right balance between an idealistic and a pragmatic attitude, they can expect a prosperous future - and we with them.

Accordingly, I would like to end with some philosophical advice with which I send my students on their way:

- *"The wisdom to recognize the things, which should be changed; the strength to change the things which can be changed, and the tranquility to accept the things which one cannot change."*
  (F. Chr. Oetinger, 1702-1782)
- *"The more you have thought, the more you have done - the longer you have lived."*
  (I. Kant, 1724-1804)

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