Harmonising safety and profit: ethical issues in the geotechnical activity of major consulting companies

Harmoniser sécurité et profit: problèmes éthiques dans l'activité géotechnique de grosses entreprises de génie conseil

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ABSTRACT: Industrial enterprises aim at committing the lowest amount of resources and time to deliver a satisfactory product to the client. In the civil engineering industry failure to deliver a satisfactory product, in the form of structures and infrastructures which meet the required performance, may result in huge costs and loss of life. Conversely large uncertainties on the performance may also result in an unnecessarily safe and wasteful design. In the present time, considering the environmental impact of construction activities and the rapid depletion of finished resources, wasteful design is becoming ethically inacceptable. This paper discusses some issues that are specific of geotechnical engineering, where uncertainties are larger and the use of subjective engineering judgement and personal experience is more important than in other disciplines. Particular attention is given to problematic aspects of major projects, like the fragmentation of tasks in many sub-packages and the ensuing difficulty in managing the flow of information at the many interfaces. Practical suggestions are given to improve the compliance to ethical requirements in the geotechnical activity of large consulting companies.

RÉSUMÉ : Les entreprises industrielles désirent minimiser l'usage de ressources et de tempes qui est nécessaire à obtenir un produit satisfaisant pour le client. Dans l' «industrie» du génie civil n'obtenir pas un produit satisfaisant, sous forme de structures ou infrastructures qui parviennent au comportement spécifiée, peut résulter en coûts énormes et même faire de victimes. Réciproquement, grandes incertitudes sur le résultat peuvent aussi produire un projet excessivement sûre et gaspilleuse. Aujourd'hui, à raison de l'impact de les activités de construction sur l'environnement et de l'épuisement rapide de ressources finies, les projets gaspilleurs deviennent éthiquement inacceptables. Ce papier discute des problèmes qui sont spécifiques de la géotechnique, où les incertitudes sont plus grandes, et l'usage du jugement subjectif et de l'expérience personnelle est plus important, que dans autres disciplines. Un' attention particulière est ici donnée aux aspects problématiques de gros projets, comme la fragmentation des actions dans beaucoup des sous-activités et la difficulté de gérer le flux d'informations a les nombreuses interfaces. Des suggestions pratiques pour améliorer la conformité aux critères éthiques de l'activité géotechnique dans les grosses sociétés de génie conseil sont, enfin, proposée.

KEYWORDS: ethics, decision making, risk, uncertainty, trust, communication, education, engineering judgement.

1 INTRODUCTION

This paper examines some ethical issues which are relevant to the practice of geotechnical engineering, with special attention to the activity of large, multidisciplinary consulting companies. The relevance of the subject arises from the peculiar nature of geotechnical engineering, which – in comparison with most other civil engineering disciplines – operates under higher levels of uncertainty and, necessarily, incorporates a remarkable amount of subjective judgement in the decision making process.

Moreover, the recent evolution of civil engineering, in its technical and commercial aspects, and the fast-paced changes our planet is experiencing, demand a constant re-evaluation and discussion of the principles of ethics applied to the civil engineering profession.

The content of this paper expresses the views of the author; it does not necessarily represent the position of the author's employer.

2 CODES OF CONDUCT, CORPORATE REPUTATION AND BEYOND

2.1 Codes of professional conduct

The "code of professional conduct" or "code of professional ethics" is generally the first - and often only - point of contact that civil engineering students and practitioners consciously have with their professional ethics. A code of conduct contains a set of rules of behaviour for civil engineers, established at national level by the relevant professional body. Such documents are essential cornerstones in the civil engineering ethical debate. However, due to the variety and complexity of the civil engineering profession, as well as its dynamic nature, the codes of conduct cannot be expected to always provide readily applicable rules for each and every real-life situation.

The review and discussion of specific national codes of conduct go beyond the scope of this paper. Since these documents are nowadays very accessible, the interested readers can easily expand their knowledge and understanding; for example the ICE Code of Professional Conduct (Institution of Civil Engineers 2008) and the ASCE Code of Ethics (American Society of Civil Engineers 2006) are freely available on-line.

The codes of conduct mentioned above regulate the practice of civil engineering in its entirety, as a macro-discipline. To the author's knowledge no specific code of conduct for specialist disciplines, like geotechnical engineering, exists. The only exceptions apply to even more specific activities within a specialist discipline; for example the AGS Code of Conduct for Site Investigation (Association of Geotechnical Specialists 2007).

2.2 Trustworthy corporation

One of the functions of ethical behaviour is to protect the reputation of civil engineering professionals and corporations. This aspect is powerfully captured in the "Little Yellow Book" by Jim Howland (1982), whose *test to determine if a contemplated action is ethical is to ask: "Would I want to see it in the headlines tomorrow morning?"*. Although such an approach to ethics emphasises appearance over substance, the importance of corporate reputation and trustworthiness in the relationship with clients, contractors, third parties and society as a whole should not be underestimated. It is, in fact a key ingredient in developing successful projects which are capable of bringing benefits to the full range of stakeholders, as further discussed in Section 3.2.

2.3 Full meaning of civil engineering ethics

The full and deepest meaning of civil engineering ethics goes well beyond the straightforward application of the rules of behaviour contained in a code of conduct and the attempt to build and preserve corporate reputation.

Ethics involves the systematic study of moral norms and standards of behaviour, together with their underlying values and justifications (Armstrong *et al.* 1999). Applied ethics deals with the formulation of morally good decisions which can be made in a particular area of interest, for instance various professions (e.g. medical ethics, legal ethics, etc.) or particular issues of private and public interest (e.g. environmental ethics, bioethics, etc.). Part of the complexity of civil engineering ethics – which is one of the many branches of professional ethics – derives from the involvement of several ethical subjects and many different competing views of what is morally right or wrong. Those affected by the ethical decision-making of a geotechnical engineer for good or bad may include, for example:

- i the geotechnical engineer (and, where appropriate, their family and associates);
- ii the engineer's colleagues (from the same discipline or from other disciplines);
- iii the engineer's employer (in the present case a large engineering company);
- iv the engineer's professional community (at national or international level);
- v the client;
- vi the society at large (ranging from a local community affected by a particular project, to larger groups of stakeholders at national and international level);
- vii the environment (the biosphere and its interaction with lithosphere, hydrosphere and atmosphere).

An extensive discussion of the philosophical theories of ethics is beyond the scope of this paper. The author agrees with Armstrong, Dixon and Robinson when they suggest that practical, real-life decision making requires a combination of the three main ethical theories: (a) deontological - to do with duty, (b) consequentialist - concerned with outcomes, (c) virtue ethics - concerned with moral excellence.

3 CIVIL ENGINEERING IN CONTEXT

3.1 The intrinsic conflict between performance and profit

Industrial enterprises aim at committing the lowest amount of resources and time to deliver a satisfactory product to their clients. In the civil engineering industry failure to deliver a satisfactory product, in the form of a structure or infrastructure which meets the required performance, may result in huge costs and even loss of life.

In practice there is the need to strike the correct balance between a quick, cheap, approximate design of uncertain performance - on the one extreme - and slow, expensive, accurate design with much reduced uncertainty on the performance - on the other extreme. In a consulting company the "right" balance has to be satisfactory from both a commercial and an ethical point of view. Uncertainty in performance may result in either safer-than-required design (not dangerous but wasteful) or less-safe-than-required design, which is observed more rarely but may have extremely severe consequences.

In civil engineering, and particularly in geotechnics, a great deal of uncertainty in the final performance is associated with the human factor. Assigning tasks (including checking, reviewing and approving the design) to individuals with the appropriate level of competence and experience is of paramount importance. From a purely economic point of view a project manager or a project director wishes to see each task completed as quickly as possible by the available team member with the lowest hourly cost rate and therefore, most likely, level of experience. However, pushing tasks too far down the chain of competence/cost, has unacceptable implications on the quality of the design process and on the resulting uncertainty in the performance of the finished product.

There are no easy recipes to resolve this tension between cost control and profit, on one side, and quality in the form of performance of limited uncertainty (which avoids waste or lack of safety) on the other side. A useful strategy, however, consists of resisting short term pressures and "narrow framing" to embrace a long term view. Considering an oversimplified example, there is little use in containing the cost of project delivery if the final product is non-satisfactory and the client will therefore not be inclined to assign future commissions to the company. This elementary consideration can easily be suffocated by the pressure of working against tight programmes and budgets. More generally, whenever it is possible to avoid narrow framing and short term planning, commercial needs and quality assurance tend to become more compatible in an ethically satisfactory way.

3.2 The problem of fragmentation

A similar, often deleterious, tension between commercial and technical needs is connected to the problem of fragmentation, which affects the design process at many levels. From a purely technical point of view there is an obvious benefit in achieving continuity through the many phases of design and construction and in ensuring the same subject – same company and, ideally, same personnel – develops a project from inception to completion. This approach limits the need for knowledge transfer between different teams and individuals, thus minimising repetition and possible misunderstandings or loss of information. However, in some situations and in some forms of contract the continuity is discouraged or even prohibited. Such a choice is based on the principle of efficiency through competition and specialisation, which, in theory, should result in optimised cost and outcome. In practice there are other considerations which should complement, and in some cases overrule, these aspects. In a nutshell, commercial competition and specialisation push toward ever further fragmentation, while technical efficiency would require unity of vision and continuity of knowledge.

The author argues that, currently, the way major civil engineering projects are delivered is grossly unbalanced toward an excessive fragmentation which arises from the prevalence of commercially inspired principles over technical criteria. Often clients, and society at large, pay additional costs at the end of a project due to mistakes or inefficiencies associated with this misguided approach.

It is here suggested that, without neglecting the value that project management and commercial specialists add to the delivery process, it is extremely important that high level decision-making incorporates sufficient input from technical experts. The subject deserves a richer and broader discussion than what is possible in this conference paper. The author agrees with Muir Wood (2004) on the detrimental role of discontinuity – sometimes deliberately enforced – between the functions of design and construction, and of the fragmentation of responsibility. Without reasonable continuity and unity a project is unlikely to meet satisfactory ethical standards with respect to impact on the society and the environment. Even the success in strictly engineering terms is endangered. In Muir Wood's words a successful engineering project comprises *a Client whose requirements have been understood and fulfilled; a Contractor who has been adequately reimbursed for a job well done; an Engineer who has fully understood the Client's need and has applied competence and creativity to a well-engineered project.* The final sign of success is *the rarity of unresolved dispute and litigation*. It is worth highlighting how this last point is largely dependent on the trustworthiness of the Engineer and all other parties. It is also strongly linked to the Engineers' reputation (see Section 2.2) and their conduct (Section 2.1).

A useful concept to inform the current and future discussion on successful forms of contract and procurement strategies is the Intelligent Market discussed by Muir Wood and Duffy (1991). This approach focuses on a holistic approach which avoids fragmentation and neglect of synergy, in summary taking generated value, not cost, as the main criterion for decision making.

4 SPECIFICITY OF GEOTECHNICS

4.1 Uncertainty and judgement

In geotechnical engineering uncertainties are typically larger than in other branches of civil engineering (structural engineering in particular). The analysis of geotechnical systems and the decision making associated with planning, designing and maintaining them often contains an unavoidable and significant component of engineering judgement. This can (and, when possible at all, should) be based on and informed by the existing literature, which condenses valuable and selected experience from others. However, in many circumstances individuals or teams of engineers have to introduce a considerable amount of subjective opinions in to the design process in order to achieve practical and usable solutions.

This consideration reveals how ethics, intended as good decision-making under uncertainty, bears particular relevance to the geotechnical discipline. The consequences of large uncertainty and reliance on judgement are numerous. On the one hand, geotechnical engineers willing to deliberately distort design outcomes for their own interests or for the interest of their direct employer can easily do so, when dealing with a client who is not familiar with ground behaviour and geotechnical works, by cherry-picking the most convenient results within the often large uncertainty band associated with different interpretations of site data and the selection of different models. On the other hand, the honest and scrupulous engineer in a consulting company may meet with resistance externally – with clients – and internally – with project managers and colleagues from other disciplines – when correctly trying to incorporate in to the design in a transparent way large levels of uncertainty which others may wish to ignore.

In this context helpful ethical behaviours from the geotechnical engineer include building trust by avoiding over-conservatism and by communicating risk accurately, also highlighting which assumptions and hypotheses are judgement based. At the same time experienced geotechnical engineers need to hold their ground when unreasonably pressed to under-represent and under-communicate uncertainty. The author believes that in a discipline so closely associated with quantification of judgement a basic knowledge of the principles of cognitive psychology which are relevant to this task (Kahneman *et al*. 1982) should be more widespread.

Considering that large uncertainty on the performance of even very common geotechnical structures is not unusual, it is here suggested that national and international professional bodies and institutions should start recording statistical data on the key performance indicators for large numbers of structures.

4.2 New challenges

The constant evolution of geotechnics, and of the perception that mankind has of its own role and position on the planet, bring to light new ethical issues which should be incorporated in to the daily activity of geotechnical engineers. For example, the necessity of limiting greenhouse gasses emissions and of containing, as much as possible, the consumption of energy and other finite resources have never been so clear. These concepts need to become part of the basic consideration a geotechnical designer goes through when selecting and developing technical solutions (see for example Inui *et al.* 2011). Most importantly, the tendency to regard a large uncertainty in the performance of structures as tolerable and the inclination to deal with it by overdesigning, which implies producing a safer but potentially very wasteful structure, is becoming increasingly unacceptable. In fact such an approach cannot continue in the face of the new perception that the current generation must preserve the health of the environment and avoid resources depletion as much as reasonably practicable. Avoiding wasteful design is becoming an ethical imperative which cannot be achieved without credible understanding, accurate management and effective communication of uncertainties.

One more challenge currently presented to geotechnical engineers is the adoption of new, more complex and potentially more powerful, design codes. An obvious example is the suite of Eurocodes adopted by the European Union and other countries in recent years. The complexity of these codes requires particular attention to the communication between specialists of different disciplines if mistakes are to be avoided. Currently, in most consulting companies, the design of geotechnical structures (for example retaining walls) is jointly carried out by a geotechnical specialist and a structural specialist. The former verifies the geotechnical stability and provides structural actions from geotechnical considerations (for instance a soil-structure interaction analysis), whilst the latter provides the loading combinations to be studied and checks the structural safety on the basis of the geotechnical analysis results. This interaction, often iterative in its nature, requires particular attention to the communication across discipline boundaries. For example geotechnical engineers designing a structure according to Eurocode 7 – EN 1997 – will have to check and double check that they are fully understanding and using correctly the numerous load combinations that they receive from their structural colleagues. Similarly, when providing results in terms of structural actions, the geotechnical engineers need to carefully communicate to their structural colleagues the relevant explanations and clarifications about how the geotechnical calculations have been developed. A typically delicate situation is, for example, the incorporation of partial factors for the STR/GEO ultimate limit states (ULS) in soil-structure interaction analysis (for instance with the finite element method). In this specific circumstance the ULS partial factors from EN 1997-1 need to be rearranged (see for example Bond & Harris 2008) in a way which may be confusing. A discussion of such aspects and an additional effort to ensure the correct understanding of the specific results communicated across the design team therefore becomes necessary.

5 CONCLUSIONS

In the process of civil engineering design there is an intrinsic tension between cost control, on one side, and quality - intended as confidence on the performance - on the other side. An excessive and uncontrolled effort to reduce costs would result in an unacceptably large uncertainty in the performance of engineering systems. Larger-than-expected uncertainty may produce an excessively safe and wasteful design or an unsafe design. Instances of unsafe design are relatively rare in civil engineering but the severity of the consequences of failure is often dramatic. In a world where we should be increasingly concerned with the human impact on the environment and with the rapid and irreversible depletion of finite resources a wasteful design is becoming increasingly unacceptable from the ethical point of view. A strategy to encourage an ethically balanced design is the avoidance of "narrow framing" and short term thinking, in favour of a long term view.

Fragmentation and discontinuity in civil engineering projects is detrimental to ethical choices and, in many cases, even to the basic success of the project in strict engineering terms (Muir Wood 2004). Procurement strategies and forms of contract should be discussed by the civil engineering community and rebalanced for a better harmony between commercial and technical needs.

The uncertainty affecting decision making in geotechnics is much higher than in other civil engineering disciplines. For this reason many ethical issues in geotechnics can be seen as ethical problems of uncertainty and risk communication. In the parts of codes of conduct concerned with communication the main focus and current interpretation is on restraining inappropriate communication. It is here argued that, still maintaining the integrity, objectivity, accuracy and sobriety requested by the codes of conduct, a new, urgent need to encourage the positive side of communication is emerging. This need for increased and improved communication acts at several levels:

- between geotechnical specialist and colleagues from other disciplines; to avoid misunderstandings (e.g. in the application of complex design codes)
- between design team and project management, to convey a realistic perception of uncertainty in the prediction of performance and programme;
- between Designer (or Engineer, depending on contract terminology), Contractor and Client (or Employer), in the various types of contractual arrangements (possibly including other parties, like checker, regulator, etc.), to maximise the probability of project success;
- between geotechnical as well as – more generally – civil engineers and multiple stakeholders and decision makers in the larger society; to ensure technical issues are understood by the public and rational decisions are made on the basis of credible and serious arguments.

The recognition of the key role that uncertainty plays in geotechnical engineering should result in practical steps being made to improve the capability of technical professionals in assessing and communicating risk. This paper suggests that the creation of databases recording the geotechnical performance of structures and infrastructures would offer valuable information, providing "base rates" to the professionals to support decision making during design.

Since a considerable amount of engineering judgement is integral to the activity of the geotechnical engineer it is here argued that the basic cognitive psychology principles associated with the quantification of expert opinion (Kahneman *et al.* 1982) should be taught to students enrolled in geotechnical engineering courses and offered to experienced engineers in continuous professional development training events.

Finally, the promotion of a culture of trust (Muir Wood 2004) is a fundamental ingredient for the success of civil engineering projects both in terms of commercial reward of the parties which are involved directly and in terms of benefit to society and the environment.

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