Dispute Resolution in Geotechnical Engineering Practice – Some Lessons Learned

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Challenges from North to South
Des défis du Nord au Sud

M.A.J. (Fred) Matich, P.Eng. MAJM Corporation Ltd.
John L. Seychuk, P.Eng. Golder Associates Ltd.
Gordon C. McRostie, P.Eng. Golder Associates Ltd.

ABSTRACT

The scope of applied geotechnology has increased greatly since it was introduced into modern engineering practice by prominent pioneers in the profession. Geotechnical expertise is increasingly applied in conjunction with other specialty fields and to a broad range of end uses including design, construction and performance. More formal contractural arrangements have evolved together with greater expectations by clients. Notwithstanding significant advances in the state of practice, disputes unfortunately still arise which require resolution by arbitration or litigation. Avoidance of claims and exposure to risk is an important issue. The Authors provide lessons from their experience particularly to benefit younger members of the geotechnical profession.

RÉSUMÉ

La portée de la géotechnique appliquée a grandement augmenté depuis son introduction dans la pratique de l'ingénierie moderne par les pionniers de la profession. L'expertise géotechnique est de plus en plus souvent appliquée de concert avec d'autres spécialités, ainsi que pour un large éventail d'utilisations finales incluant la conception, la construction et la performance. Des dispositions contractuelles plus formelles ont évolué conjointement avec des attentes grandissantes de la part des clients. Malgré les avancées significatives dans la pratique géotechnique, des litiges surviennent malheureusement encore, nécessitant une résolution par arbitrage ou contentieux. Éviter les réclamations et l'exposition au risque est un élément important. Les auteurs offrent une série de leçons tirées de leur expérience, au profit notamment des plus jeunes membres de la profession géotechnique.

1.0 INTRODUCTION

The scope of geotechnology as applied to practical problems has increased greatly since it was introduced into modern engineering practice in the early 1930's with Terzaghi taking a leading role among the pioneers in this specialty field as represented, for example, by the participants at the First International Conference on Soil Mechanics and Foundation Engineering (ICSMFE) in 1936. There was a pronounced increase in scope in the years immediately after World War II as applied soil mechanics (as it was known then) benefitted progressively from factors such as advances in field exploration and laboratory testing equipment, significant improvements in analytical capability, research, and the increased availability of students graduating in this speciality, from prominent Universities. At the same time, it became increasingly applied in conjunction with other specialty fields and to a broad range of end uses, including design, construction and performance of structures. More formal contractural arrangements evolved together with greater expectations from Clients.

There was a significant capability in applied soil mechanics in Canada prior to World War II. This included a number of prominent engineers who had made a specialty study of this field, and also designers and constructors with experience-based success in handling foundations and earthworks matters. Younger geotechnical engineers learned that they could benefit greatly by consulting such pioneers, particularly on the practical factors involved. The lesson of benefit from mature, experienced-based peer review is very much valid today.

With time, geotechnical engineering became increasingly diversified and technologically advanced. Concurrently, consulting geotechnical engineering services provided on a commercial basis, grew rapidly, and in the process acquired vulnerability to errors and associated liabilities. As business enterprises, firms offering geotechnical engineering services had to pay appropriate attention to contractural and legal matters and in due course were obliged to carry professional liability insurance, and adopt other defensive measures. Despite best efforts by technical specialists, disputes occurred due to problems such as "changed soil conditions" with resort to dispute resolution measures, including litigation. The risks and available defensive measures are undoubtedly well known to management and experienced senior technical personnel in consulting geotechnical engineering firms. Younger geotechnical engineers should also give them due cognizance. The avoidance of problems, to the extent possible, is stressed in this paper, and some "lessons learned" are provided against the possibility that they may be of benefit to the younger members of the geotechnical profession in Canada.

The Authors each began their careers in consulting geotechnical engineering firms a few years after World War II although their career paths differed in important respects. They are still actively involved professionally in consulting. The "lessons learned" are thus necessarily made from the perspective of the Authors varied experience, and it is hoped that they may be of value as well to the many younger geotechnical engineers not engaged in consulting.

Whereas this paper is intended for the benefit of younger engineers in the profession, in the Authors' experience the avoidance of pitfalls which lead to formal dispute resolution of geotechnically-related factors, is of major importance to all relevant parties, including owners, designers, constructors, operators, etc. The topic of dispute resolution, with emphasis on avoidance of disputes, deserves continuing attention by the geotechnical profession.

2.0 THE GEOTECHNICAL ENGINEERING REPORT

The process of incorporating findings of geotechnical site investigations, laboratory testing, and analyses into formal reports has evolved over the years and the contents have increased to include appendices on special testing programs, important individual topics such as earthquake engineering, hydrogeology, etc., as technology has advanced. The format used originally in Canada in the 1940's reported primarily on the geological characterization of the site under investigation, together with the results of drilling, sampling, and laboratory testing programs. The work carried out at each exploratory borehole was consolidated onto a Borehole Log and the overall findings on subsurface conditions were portrayed graphically on drawings as inferred stratigraphic cross-sections. Most laboratory test results were also presented in graphic form. The factual findings of the investigation were presented in written form. The text included an interpretation of the findings directed at the specific purpose of the investigation. The same basic format, with variations from organization to organization continues to be used and no "standard" format for geotechnical engineering reports has been developed. In recent years exculpatory notations such as "Statement of Limitations and Conditions" (and the like) have been added to the reports.

From the standpoint of vulnerability, it is (as a reminder) of some importance to understand the various inputs associated with the production of such reports, given that they represent an obviously important "deliverable". A number of different inputs are involved, each requiring application of special skills and judgement. The subject of the report is important enough to deserve consideration in detail by itself in the context of this paper. However, space constraints do not permit it in this venue. Suffice to say that (i) geotechnical engineers have control over each of the inputs, (ii) checking and review at the levels where factual data is generated and analytical work is carried out, is fundamental, (iii) the engineering report should be sufficiently complete and concise to provide (in text) a range of solutions to the problem which the client can readily understand with, in appended form, the supporting technical and professional liability documentation, and (iv) that the value of continuation of involvement of the Geotechnical Consultant in activities on a given project, after report submission, should be recognized.

3.0 DISPUTE SITUATIONS ENCOUNTERED

There is reference in the published technical literature to dispute situations and resolution methods, such as Naismith 1986); Lardner (1997); Stieber (1997); Koutsoftas (1998); Fielding et Al. (1968); XL Insurance (2004, 2013), and others. In the Authors' experience, disputes involving geotechnical matters have occurred in a variety of different situations with, at times, serious implications to not only the geotechnical provider, but also project owners, designers, constructors and operators. The disputes have taken different forms and were predominantly in the claims class and which were resolved through a process of negotiation, or other alternate dispute resolution methods. However, some unfortunately involved litigation proceedings.

In discussing dispute situations encountered, the Authors point out that in their collective experience of thousands of projects, only a small percentage has required resolution by a formal dispute process. This is probably representative of the geotechnical profession in Canada. The Authors however find the increasing incidence of such cases to be disquieting and deserving of special attention by geotechnical engineers on an ongoing basis. The case histories briefly discussed below have been drawn from among the simpler cases from the Authors' collective experience and are presented with some thoughts on avoidance of lawyer dominated disputes to the extent possible. They represent some of the pitfalls which might be avoided through the "lessons learned" process, as follows:

1. Importance of Practical Factors

On May 3, 1964 a section of rock fill highway embankment near Parry Sound, Ontario failed suddenly and without warning, a car having passed over the road 15 minutes before. It occurred more than 3 months after completion of construction (Rutka and Matich, 1967). Regrettably a car went over the scarp formed by the failure and the occupants of the car were injured. During subsequent litigation, the question was raised as to whether such a failure could have reasonably been anticipated and prevented by appropriate design and construction procedures.

A detailed review of site conditions and construction procedures indicated that both were generally consistent with past practice for which there was much successful precedent in Northern Ontario. Site conditions consisted of muskeg over soft to firm sensitive silty clay forming a swamp area between two steep outcrops of bedrock. Construction was completely under freezing winter conditions and by the method of partial excavation and displacement which resulted in an embankment "floating" in the clay. On detailed examination, it was established that the bedrock outcrops were close enough to enable arching to be developed in the frozen winter-placed fill, and that the failure occurred during pronounced thawing conditions in the spring. Analysis of all of the evidence led to the conclusion that the failure was due to an unusual (and probably rare) combination of circumstances relating to weather, subsurface conditions, and geometry of the fill, and that the timing of the incident was determined by destruction of arching in the rock fill by the effects of spring thaw. On the basis of this finding the (then) Department of Highways Ontario prepared guidelines covering embankment design for unusual field conditions such as prevailed in this case.

Lessons learned included (i) become conversant with construction procedures for earthworks which are based to an important extent on successful practical experience, and (ii) be on the alert for local situations which may be outside of such experience and analyse them individually.

2. Project Heavily Reliant on Practical Experience

This case history deals with a dredging project in a Harbour in Ontario.

In the 1980's, Public Works Canada (PWC) was frequently encountering claims from dredging contractors for additional compensation for a variety of recognized reasons including (i) "changed soil conditions", namely, discrepancies between the anticipated and actual subsurface conditions, and (ii) variations in the interpretation of geotechnical information between contractors and design engineers.

At the time, site investigations for PWC dredging contracts were usually contracted out to geotechnical Firms and there was not a consistency in scope and quality of information provided by the Firms. This had important implications to end-users, in this case both the dredging contractors and PWC's design engineers.

PWC approached the general problem in commendable fashion:

(a) It appreciated the value of a Contracts Dispute Advisory Board
(b) It established Guidelines for Geotechnical Investigations, for use by geotechnical consultants and design engineers,
(c) In the case of this particular claim, PWC and the dredging contractor agreed to resolution by an independent geotechnical engineer acceptable to both parties, and to give the reviewer access to precedent on dredging contracts in archives at PWC and the contractor's offices. The soil type at issue was "till", a highly variable material in composition, strength, boulder content, etc; almost rock-like at times; difficult to describe in terms of "diggability".

The first Author assisted in developing the Guidelines and was assigned the task as reviewer on this claim. Research showed that there was much practical data on previous dredging projects in till overburden in both PWC and the contractor's archives. The reviewer was able to develop an approximate relationship between "N" values and undrained shear strength for the class of till involved, and on the basis of this and other factors, recommended that the contractor should be compensated favourably in respect to its claim. PWC accepted this finding. It was supported by technical evidence which would also be useful on future dredging contracts in similar soil conditions.

Lessons learned included (i) dredging is a construction methodology the success of which is dependent to a significant extent on practical experience, (ii) the Owner appreciated this and established guidelines on geotechnical matters which would be of benefit to all of the parties, (iii) the importance to the Contractor of interrogating its own experience from a geotechnical standpoint was clear, and (iv) the merits of the alternate dispute method were demonstrated.

3. Selected Mini-Examples

Some "mini-examples" are provided below which are among the more straight-forward cases encountered by the Authors. Although they were each associated with contentious situations, in most cases they were resolved by methods other than resort to litigation.

3.1 Inappropriate Use of Terminology

Avoid embellishment and gratuitous comments in reports such as "it is our opinion that there are no environmental concerns at this site." Such a statement was made in a report where only a few test pits were put down at wide spacing across a site. This observational statement (which led to a lawsuit) should have been qualified by stating that based on the limited scope of the investigation, there appears to be no significant contamination (at the time of the investigation) at the specific test pit locations. However, there is no assurance that there are (for example) no possible contaminants between the test pit locations.

The important matter of terminology and its potential implications is discussed later, in more detail, in Section 5.0.

3.2 Provision of a Certification/ Assurance Letter

This was required in a Request for Proposal from a City Engineering Department to the effect that their 10 acre site was "environmentally clean" based on 10 boreholes at specified locations and depths across the site. That's one borehole per acre! A clarification telephonic discussion between the City Chief Engineer and the prospective Geo-Consultant indicated that the City Lawyer required this Certification. A meeting was therefore arranged where the Geo-Consultant explained that their proposed investigation program would only examine one in one millionth of the ground – and you are asking for an environmentally "clean bill of health" on this basis? After further discussion, the lawyer responded – "now that you have explained the situation, I understand your concern and your need for qualification.

So the "bottom line" here is, it pays for the Geo-Consultant to communicate with the client in a timely fashion, especially in a "face to face" meeting.

3.3 Deep Excavations Adjacent to Existing Structures

This type of construction is important from the standpoint of risk, not only from a safety standpoint, but also in terms of possible damage to adjacent deformation-sensitive structures. Of fundamental importance in this respect, in addition to adequate geotechnical data, is a good knowledge of such adjacent facilities and the implementation of appropriate construction measures in timely fashion.

3.4 Deep Shaft Excavations Subject to Bottom Heave

This type of problem is not uncommon. It may result from the presence of artesian pressures at depth or weak ground at the base of an excavation. It is important to ensure that exploratory boreholes are extended deep enough and that piezometers are installed to identify these conditions prior to excavation to prevent a "blow-out" or base failure during construction.

3.5 Regional Groundwater Drawdown

This type of problem is also not uncommon.

A deep Municipal Sewer was constructed beneath a street in a built-up City area, where the subsoil was granular in nature with a high groundwater table. Deep educator wells were installed to temporarily depress the groundwater to beneath the invert level. This drawdown had an adverse lateral impact on an adjacent housing development, where settlement and cracking of homes occurred due to consequent consolidation of the foundation soil. This, as might be expected, ended up in litigation proceedings. It is important to take this situation into consideration, by providing some protective form of counteraction, such as a recharge system during construction.

3.6 Settlements of Floor Slabs on Grade

This type of problem and the resultant distress of cracking, uneven surface (with mobility problems for in-house equipment, etc.) is unfortunately fairly common because of lack of attention to design and construction details. It is important therefore to know where problems could occur. Slab on grade type of construction should only be considered if some settlement can be tolerated. But to accommodate settlement, without distress, the concrete slab(s) on grade should be placed structurally separate from any portion of the building walls and columns, with construction joints at spacings determined by established experience. Slabs on grade should also be placed on an engineered base course and designed for the wheel loads which they have to carry (in Warehouse type structures for example). If settlement reaches unacceptable levels, it may be necessary to replace the slab, although in some cases such slabs can be raised and relevelled by low pressure grouting methods (or "mud-jacking").

This type of problem is of particular importance to recognize from the standpoint of its varied pattern of distress and its common occurrence as the subject of either a claim or litigation.

There are other case histories which could be quoted from the standpoint of lessons learned. Space restrictions (and confidentiality matters) do not permit their coverage herein. To some extent, however, lessons associated with them are embodied in later sections in this paper. As a general statement, make a point of learning from the experiences of others, not only from successful case histories in the published technical literature, but also from situations where things have gone wrong and were resolved through some form of resolution process. And keep in mind that geotechnical problems which have become subjects of litigation are, understandably, not common in the geotechnical literature.

4.0 DISPUTE RESOLUTION – UNEXPECTED CONSEQUENCES.

Unfortunately there are instances when despite all efforts to resolve a dispute by negotiation, resolution has to be sought by other means such as Alternate Dispute Resolution (ADR) methods, with resort to litigation being generally the least preferable. The advantages of ADR methods over litigation are alluded to in the next section herein. Several case histories are presented in this section which describe situations where unexpected adverse consequences resulted from litigation procedures.

4.1 Settlement Experienced by a Hockey Arena.

This involves a hockey arena in Russell Township, Ontario, which experienced unacceptable settlements.

The Arena was of conventional design and located in an area characterized by soft, lightly preconsolidated sensitive clay, (known as Leda clay) overlying granular till and limestone bedrock. The clay has a reputation for dramatic consolidation and resultant settlement when loaded above the preconsolidation pressure (e.g. Burn and Hamilton, 1968). Based on geotechnical studies carried out initially in 1974, the foundation support selected was end-bearing piles for the building with interior concrete floor slabs carried on a thin lift of engineered granular fill used to raise grade. Construction was completed in 1975 and up to about 1979 the grade-supported elements experienced settlements which were acceptable. However, by 1984, differential settlements of floors relative to the pile-supported elements had significantly exceeded design expectations. In the course of a mandated structural inspection of the Arena by a structural team which included a geotechnical engineer, the Owner requested an opinion on the cause of the settlement. The initial assessment by the geotechnical "inspector" focussed strongly on only the clay and surcharge loading from fill used to raise the grade. This set off a train of events which progressively fed on each other and unfortunately led to initiation of litigation by the Owner against the original design Geo-Consultant.

Two detailed geotechnical investigations were carried out by the defending Geo-Consultant, one in 1990 and a second in 1994, as described in Matich et Al, 2007. At the same time, precise settlement surveys were initiated. The defendant Geo-Consultant also commissioned independent expert hydrogeological studies of groundwater conditions in the Russell Township area, together with a forensic study and overview of the evidence relating to the distress. The results indicated that the cause of the settlement was a significant lowering of the groundwater table in the area by pumping from wells for town water supply purposes. By this time, however, litigation was already under way involving lawyers, insurers, and a variety of independent experts.

From a performance standpoint, the evidence was clear that the rink slab had settled uniformly. However, in the administration area, (lobby, dressing rooms, concessions, etc), masonry partition walls supported on concrete slabs on grade had suffered damage. This raised a significant question as to why this difference in performance. A geotechnical study of the granular fill in this area was carried out. The results suggested that the settlement was possibly caused by inadequate compaction of the fill. This implicated the second geotechnical Firm which was responsible for geo-monitoring during construction. In 1985 the concrete slab and internal non-bearing partitions in the Administration area were removed and replaced at a total cost of about $50,000. Settlement of the replacement floor slab area continued unabated.

In terms of overall remedial measures, structural engineering specialists were engaged by the Owner to study potential long term options. Not unexpectedly, they were influenced by the conclusive evidence for continuing settlements of the grade-supported concrete slabs, including the extensive documentation from the geotechnical investigations which was zeroing in on the usual “suspect”, namely, consolidation of the Leda clay, albeit without explaining conclusively as to the “why”? The structural engineers’ assessment of potentially feasible remedial methods was qualified by the underlying principle that any support of the floor slab on the existing subsoil, including the sensitive clay, would involve a degree of uncertainty. Three types of repairs were indentified, namely:

(a) Structural slab with grade beams and piles
(b) Light weight fill with slab replacement
(c) Urethane foam injection under the slab.

Estimated costs were approximately $2,000,000; $1,500,000 and $250,000, respectively, with structural rehabilitation recommended by the geotechnical “inspector” as the only viable option. In this instance, only minor remedial work was shown, by the original Geo-Consultant, to be required.

Several factors are significant to this discussion as follows:

(i) The geotechnical studies by the geotechnical “inspector” Firm were unfortunately deficient in a number of respects; (a) they focussed only on the Arena site without considering the geological and subsurface conditions in the site environs (the most important deficiency in this case); (b) they did not appreciate that piezometers were indicating that the clay was being consolidated from the bottom up; (c) they did not notice that settlement had also been experienced by houses in the Township of Russell; (d) they failed to appreciate that site conditions had changed since the original investigation, particularly with respect to a regional drawdown of the groundwater table due to pumping (for water supply purposes) from the granular till formation underlying the clay. Large scale pumping began in the mid-1970’s and was discontinued in 1989 when a municipal system was installed.

(ii) The settlement of the Arena stopped after pumping was discontinued. It was agreed among the parties that if no further settlement occurred in the following six months, the case would be resolved through a minitrial.

(iii) In practice settlements did cease and appropriate resolution was reached through a minitrial in November, 1994 which lasted only two days. The Judge reportedly had first-hand experience in construction, and had requested a meeting on-site with technical representatives of both parties, in advance of the minitrial.

A number of important lessons derive from this case:

- From the standpoint of the geotechnical “inspector”. Undertake such an assignment with care and realistic assessment of professional experience and capabilities to do so. Make sure that facts that you base your findings on are correct, and that your work is carefully checked and peer reviewed. These are important principles in all geotechnical studies, and even more so where forensic dispute resolution is involved.
- It is of some importance to note how a geotechnically straight forward project such as this one can “go wild” and have significant unexpected adverse consequences, including a heavy commitment on the part of the original Geo-Consultant in terms of time of senior personnel spent against this unwarranted claim and high non-recoverable costs to defend itself together with potentially perceived loss of professional reputation.
- An important lesson learned is that this dispute could have been resolved from the beginning without resort to litigation.
- The merits of the mini-trial method of ADR for a practical technical matter under a presiding Judge with relevant experience, was demonstrated.

4.2 “Fireman to the Rescue” Type Assignment

This summary focuses primarily on lessons learned by the participating Geo-Consultant. It illustrates pitfalls which can be encountered through limited involvement in a potential dispute situation. A more detailed technically related account is given by Rowe and Seychuk (1995).

A young geo-engineering consultant received an “SOS” call from a Municipal Consulting Engineer stating that construction of a sewer was experiencing wet ground conditions during trench excavation and that assistance was urgently required. Without hesitation, or any previous involvement in the subject project, the keen young engineer proceeded to the site. The engineer’s expeditious participation, in a satisfactory design resolution of the problem, unfortunately became a “Horror Story” as discussed later.

Upon his arrival on site he noted that the base of the trench excavation in silty to sandy soil was in a "quagmire" condition with only dewatering (sump pumping) in use for groundwater control. Furthermore, examination of available records indicated that the invert of the sewer had been lowered below the depth of available geotechnical information. The "rescue" engineer requested additional borings and piezometers to depth. The Constructor negated this requirement on the grounds of time constraints and instead excavated a test pit which could not be taken to the necessary depth because of the high groundwater "soupy" conditions.

After a proper wellpoint system was agreed upon and employed, the disturbed soil in the trench problem area was able to be removed and replaced with lean concrete to invert level. Dewatering to below invert level was maintained throughout the remainder of trench excavation operations, along the sewer route, but the Constructor objected (on the basis of cost and workability issues) to the use of well-graded granular material for the trench bedding and insisted on "clear stone". The geotechnical engineer did not agree with this on the grounds that the surrounding sandy silt subsoil fines could migrate into the "clear" stone and cause settlement of the pipe. The Prime Consultant came up with a compromise solution with the use of gravel but with a filter fabric "wraparound" to prevent soil fines migration into the stone around the pipe and detrimental impact on basal ground support. Trench excavation and pipe installation continued in that manner (with "prior" wellpoint dewatering) along the route. The geotechnical engineer monitored construction operations for a short while in the problem area, and the Municipal's engineer then took over all site monitoring and compliance responsibility.

About a year after completion of construction, several "sink-holes" developed beneath the roadway surface at locations where the Geo-Consultant had not been involved. The site Developer initiated a lawsuit against all parties involved – including the "rescue" engineers consulting organization, whereupon the Constructor and Prime Consulting Engineer "combined" their defence forces. In its "lone" defence, the "rescue" engineering Firm carried out extensive field and laboratory testing that conclusively showed that the filter fabric was effective in preventing soil fines migration into the clear stone at the failure locations where the natural subsoil was coarser grained than at several other nearby locations tested where the surrounding soil was finer grained and where no failures occurred.

So at the trial, the basic issues in the dispute "boiled" down to:

(a) Whether the failures were the result of inadequate design and selection of the filter cloth;
(b) Or whether they were related to movement of the subgrade soil through tears, or open gaps between the geotextile sheets (construction related).

The "rescue" Geo-Consultant argued alternative (b) while the Constructor/Prime Consultant took position (a). Notwithstanding the compelling presentations by the Geo-Consultant's Team, the Judge concluded that:

- The geotextile permitted migration of the natural soil through it and should not have been used;
- There was no evidence of inadequate overlapping, or the presence of gaps or tears in the geotextile.
- The "rescue" Geo-Consultant gave opinions based on inadequate information and did not stress the importance of, borehole investigations, but relied on a shallow test pit which did not go down to at least sewer pipe invert level;
- If the Geo-Consultant was pressed to proceed without adequate subsurface information, he should have either refused to do so, or written a qualification report stating that his opinion is provided on insufficient information, together with a clear warning of the risks involved; and
- The Geo-Consultant did not give adequate instructions to the Prime Consultant, or the Contractor, on good practice procedures for geotextile installation prior to leaving the site.

Based on his findings, the Judge ruled that there was no evidence that either the Contractor or the Prime Consultant was negligent. The Geo-Consultant was therefore solely liable for all the costs in conjunction with the damages incurred, including associated Legal and Expert witness costs.

The lessons learned from the Geo-Consultant's involvement in the project can be summarized as follows:

- If you are called to assist in such a "rescue" problem consider carefully whether or not to undertake the assignment. Seek direction from a senior colleague(s) who has more experience in dealing with the various parties involved in such situations. If the decision is to proceed, try to obtain (at the outset) liability indemnification for the provision of your services. Alternatively, as a minimum, get your professional liability limited to a quantum not to exceed your fees on the assignment;
- Do not provide an opinion or solution based on inadequate base information.
- If in doubt, present a safe conservative solution.
- If obliged to accept a compromise or expeditious solution, which in your opinion cannot be technically substantiated, state this clearly in a report, together with the risks involved;
- Document major points of discussion and opinions provided at meetings and during telephone conversations;
- Insist on being allowed to continue monitoring the whole of the geotextile installation operations. If not permitted such ongoing monitoring, provide written detailed instructions to the Prime Consultant regarding proper geotextile installation procedures, together with the provision of a departing "non-involvement" statement clearly absolving youself of liability;
- Last, but not least, it is stressed (particularly for young Practitioners) that direct assistance on site by a senior colleague(s) experienced in dealing with designers and contractors, is important.

5.0 DEFENSIVE MEASURES

An obvious defensive measure is to ensure that geotechnical work is accurate, to a high standard of care, and adequate for the needs of the end-user.

Whereas avoidance of formal dispute resolution activities should be the priority, younger members of the geotechnical profession should also be aware of such methods since despite all precautions they are likely to be encountered. Geotechnical Engineers in consulting practice, and in Owners or Contractor organizations, should be encouraged to incorporate into contractural arrangements, appropriate provisions for resolution of disputes by ADR methods. In a sense, this becomes a significant defensive measure. Its value to all parties is demonstrated by an example where such provisions were made in a contract and where dispute resolution was achieved by application of "reverse engineering" (Fielding et Al. 2012). The various dispute resolution methods are covered in the literature (e.g. Naismith, 1986 and XL Insurance, 2004) and are therefore not detailed herein except to mention that they include ADR Methods through organizations such as the ADR Institute of Ontario (ADRIO); PWC's Contract Disputes Advisory Board (CDAB); and the International Dispute Adjudication Board (IDAB), as well as minitrials and comprehensive litigations. The Authors have collectively been involved in all of these Methods and consider that active participation by suitability qualified geotechnical engineers in organisations such as ADRIO and IDAB has considerable merit. It is timely to also keep in mind the important role played by experienced members of the legal profession in the use of the ADR Method because of the legal issues that are generally associated with dispute situations.

The value of professional liability insurance as a defensive measure is well known to Geo-Consultants. Some Firms elect to be self-insured. In most cases, however, Geotechnical Consultants obtain insurance through Insurance Companies. As might be expected, such Companies see first-hand the problems that their Clients encounter, in the process of defending them in litigation proceedings. In the case of XL Insurance, it makes available to the Insured copies of excellent publications such as the 2004 "Lessons in Professional Liability, A Loss Prevention Handbook for Design Professionals". Such a document covers the many areas important to lowering exposure to claims and the best methods to prevent or mitigate claims.

Some Authors cover the insurance aspects, e.g. Naismith; XL Insurance; ASFE and self-insurance which can be referenced in the context of "recommended to at least know about" for younger geotechnical engineers. To quote from XL Insurance (2004), *"First try to resolve your dispute through one or more of the non-adjudicative DR procedures. These include mediations, mini-trials, settlement conferences, and advisory arbitrations. In these procedures participants work to solve their own problems rather than place their collective fates in the hands of someone else."*

For firms engaged in geotechnical consulting it is, for all practical purposes, essential in this day and age to have professional liability insurance coverage. It is a mandated requirement, for example, for a Certificate of Authorization and designation of Consulting Engineer status by Professional Engineers Ontario. Some client organizations require that a contracting party maintain, at its sole expense, minimum substantial insurance on its own behalf, including errors and omissions insurance (sometimes referred to as professional liability or professional indemnity insurance), amongst other insurance coverages. Irrespective of how the profession got into this situation, the effect is becoming such that insurance premiums are a significant cost burden. Time to reflect on this matter more and find a way out of this dilemma.

A defensive measure common to many (if not most geotechnical reports in Canada at least) is the use of "fine print" in the form a disclaimer type section at the end of the report titled "Statement of Limitations and Conditions" (or similar) dealing with such topics as standard of care; use of the report; interpretation of the report; risk limitation; services of sub consultants and contractors; control of work and job-site safety, etc. Another example of this, is that drawings generally include notations to the effect that the soil conditions have been established only at borehole locations and that they may vary between boreholes.

An important defensive measure for younger engineers (whether in the consulting field or employed by Owners, Designers or Contractors) is to be familiar with in-house precedent. This can be accessed through study of archives, or through individual senior representatives or internal review boards. It begins with critical checking and review of all phases of the work on a given project, including the administrative aspects. Review by external, independent experts is also a well-established prudent measure whether initiated by engineers in the consulting field or by Owners who establish Advisory Panels or Geotechnical Review Boards, e.g. Syncrude Canada Ltd's Geotechnical Review Board. (McKenna, 1998). In larger Geotechnical consulting organizations, special mentoring sessions can also be used to advantage.

A matter of considerable importance identified by many authors on the topic of dispute resolution, is communication in a number of significant respects. Firstly, in maintaining close contact with the client and thus the project on which service has been provided, and then in the follow-through liaison with the Designers, involvement during construction in a monitoring role, and in post-construction monitoring. (Geotechnical Engineers associated with organizations, other than those in the consulting sector, may have good opportunities to see projects through all of these phases). Secondly, in recording via appropriate written communication all relevant aspects and discussions of the consultant's involvement in the project and thirdly, in the choice of terminology used in engineering reports or other project correspondence. Good advice on possible pitfalls is provided by Insurers e.g. XL Insurance 2004 and the Legal Profession, e.g. Stieber, 1997 and the Loss Control Bulletins by Legal Experts contained in Naismith, 1986. A quote from this Reference is of particular interest, namely *"Problem solving in engineering is principally by means of numerical and graphical procedures while problem solving* *in law is almost entirely by means of words."* Significantly, XL Insurance 2013 indicates that communications issues are a primary factor in 39% of claims count and 29% of claims dollars.

Various geotechnical experts have presented standards, rules, guidelines, or "commandments" purportedly to assist geotechnical engineers to stay out of difficulty but also to benefit Owners, Designers and Contractors, as end-users. Cases in point include Koutsoftas, 1998, Naismith, 1986, and Matich, 1997.

6.0 COMMENTARY

In terms of resolution of disputes involving geotechnical projects, it is pertinent to note that within the Authors' collective experience, several thousands of such projects have been completed successfully, including some where significant problems were encountered and resolved expeditiously and to the satisfaction of all of the parties involved. A comparatively small number of projects became contentious with potentially serious consequences and required resolution by ADR methods or, in the extreme, resolution through litigation. The Authors believe that this experience is probably representative of others in consulting geotechnical engineering practice in Canada.

Comments by way of summing up are listed in brief below.

(i) Effective communications with the End-user: This is important particularly in the early stages. Ideally, it should continue throughout the service life of a project.

(ii) Research the site background: A good understanding of the local (site) and regional geology together with the history of the site and environs is vital.

(iii) Scope of the Site Investigation: This should be adequate enough to investigate site features reflected in the geological and historical assessments, as well as the requirements of the Project from design, construction and operational standpoints.

(iv) Know End-User Requirements: Applied Geotechnical engineering is generally not carried out in isolation but for a specific end use. It is important to know the design, construction, and operational aspects of a Project (as applicable) and the particular characteristics of the many end-uses to which geotechnical engineering is applied.

(v) Know Specialized Techniques: These interface with applied geotechnics in a wide range of ways.

(vi) Maximize Involvement: Take advantage of every opportunity (preferably through direct means such as work on specific projects) to learn about the various end-uses to which geotechnology is applied.

(vii) Adequate Documentation: It is of vital importance to cover all aspects of applied geotechnical engineering on a given project with appropriate documentation, obviously in the contractural terms of reference, but also in all other steps throughout involvement in the Project.

(viii) Technical Findings: Adequacy and accuracy of the facts are obviously essential, as are application of appropriate analytical techniques tempered with experience-based judgement. To the extent possible, liaise with parties who will use the report data, e.g. Owner, Designer, Contractor, etc. Check and recheck terminology. Include carefully considered conclusions and, only where clearly appropriate, make a qualified recommendation by providing a range of solutions with a corresponding degree of risk, from the standpoint of the geotechnical factors involved. To the extent possible, follow up with the end users.

(ix) Checking and Review: The value of this at all levels cannot be over-emphasized. A good internal review policy is important, as is independent peer review where warranted. However, checking and review at the levels where factual data is generated and analytical work is carried out, is fundamental.

(x) Administrative Factors: In the context of running a business, these are obviously important. So are aspects of staff training and technical issues such as establishing standards, operating manuals, etc.

(xi) Potential Problems: Exercise preventative vigilance. Ensure prompt, constructive attention if they occur.

(xii) Alternate Dispute Resolution Methods: Know them and encourage their inclusion in contractural arrangements.

(xiii) Expert Evidence: If involved, obviously be well-prepared not only in terms of the technical aspects, but also in how to communicate effectively in a litigation setting. Be fair and objective.

(xiv) Continuous Learning: Stay abreast of developments and diversify experience. But also remember that applied geotechnical engineering is a service. It is only successful if the project to which it is applied is successful. Therefore learn to cooperate with the other parties involved to achieve this objective.

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