

Use of routine geotechnical investigation reports

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ABSTRACT

Routine geotechnical investigation reports are the 'first' reports that present the results of subsurface soil and groundwater conditions for design. Typically, it will take more than one year from the first geotechnical investigation report to the construction stage, during which time the report may not have been updated to address all details shown in the detail design and construction plan. Nevertheless, a geotechnical investigation report is often expected to agree with the detail design and to be sufficient for construction. This could result in a design that may not be suitable and/or a contractor's claim that the soil and groundwater conditions presented in the report are materially different from those encountered in the field, despite the clearly-written limitations of the report. Suggestions for preventing the misuse of routine geotechnical investigation reports are provided in this paper.

RÉSUMÉ

Les rapports d'enquête géotechnique de routine sont les «premiers» rapports qui présentent les résultats des conditions de sol souterrain et d'eau souterraine utilisés pour le calcul géotechnique. Normalement, il prend plus d'un an entre le premier rapport d'enquête géotechnique et la construction, le temps pendant lequel le rapport n'a peut-être pas été mis à jour pour adresser tous les détails indiqués dans la conception détaillée et le plan de construction. Néanmoins, on s'attend souvent à ce qu'un rapport d'étude géotechnique concorde avec la conception détaillée et soit suffisant pour la construction. Cela pourrait donner lieu à une conception qui ne conviendrait pas et / ou à l'allégation du sous-traitant que les conditions du sol et des eaux souterraines présentées dans le rapport sont matériellement différentes de celles rencontrées sur le terrain, malgré les limitations clairement mentionnées dans le rapport. Le présent document contient des suggestions visant à prévenir l'utilisation abusive des rapports d'enquête géotechnique de routine.

1 INTRODUCTION

Routine geotechnical investigation reports, as typically prepared in Canada, are intended for design, not construction. However, they are anticipated by the users to provide all geotechnical information sufficient for both detail design and construction. The reports are expected to agree with the final design drawings, e.g., final grade elevations, footing types / sizes, etc. Construction contracts often include geotechnical investigation reports for contractors' usage. However, the geotechnical information provided for design are not necessarily sufficient for construction. This could result in misinterpretation / misuse of the report contents and claims against the difference between the actual field conditions and those shown in the reports.

It normally takes more than one year from the first geotechnical investigation report to the construction phase, during which time it may not have been revised to agree with the final design drawings. A typical process from the first geotechnical investigation to construction normally follows the path shown in Figure 1, during which the first geotechnical investigation report may not have been upgraded to correspond to the final design and construction.

A geotechnical investigation report is a lengthy report which readers can find it difficult to extract the information required. Readers who are not familiar with the geotechnical terms and meanings may not understand the implications of the information provided for design and construction. This could cause substantial additional costs in design and construction, leading to claims.

The approaches to promote the proper use of routine geotechnical investigation reports and prevent claims are suggested in this paper.

2 ROUTINE GEOTECHNICAL INVESTIGATION REPORTS

As shown in Figure 1, various geotechnical investigation reports should be obtained for a project, together with the authors' (geotechnical engineers') involvement at various stages of the project, as follows:

2.1 Preliminary Geotechnical Investigation Report

In general, a geotechnical investigation is required at the start of a project, with or without knowing the detail of the planned development (e.g., building footprint, structure locations, etc.). A typical geotechnical investigation report will provide a site and borehole location plan and recommendations for geotechnical aspects of the project as shown in Figure 2. The report contents are general in nature, i.e., foundation type, bearing capacity, slab-on-grade, road pavements, sewers, etc. The use of such report is typically for the following purpose(s):

- due diligence for property acquisition;
- reliance for property finance / transfer;
- preliminary cost estimate for planned development; and/or
- preliminary design of planned structures.

Such a geotechnical investigation report (typically called 'preliminary geotechnical investigation report', has sometimes been used for detail design and construction,

without informing the authors of the report and without upgrading the investigation program to address all information required for detail design and construction. This is normally limited to report users who are not familiar with the requirements for design and construction. A preliminary geotechnical investigation report should not be used for detail design and construction.

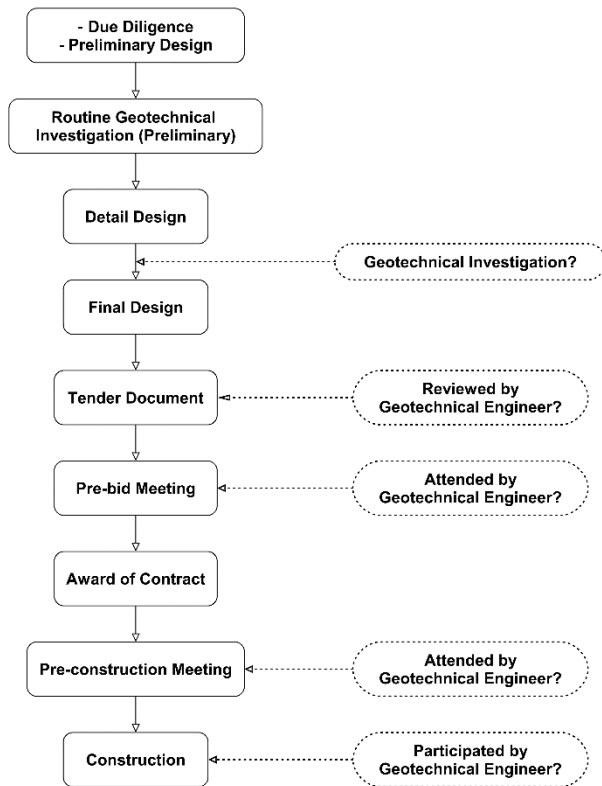


Figure 1. Geotechnical input at various stages of a project



Figure 2. Typical borehole location plan

2.2 Geotechnical Investigation Report

Knowledgeable project planners will specify a detail scope of work and report contents, e.g., Terms of Reference, for a geotechnical investigation program in order to provide sufficient information for a specific structure of which its preliminary design has already been developed. The resulting report, typically called 'Geotechnical Investigation Report', may be the only report for the project. The report contents provide more details than those included in the preliminary geotechnical investigation report, for examples, foundation type and size for the planned structure with corresponding bearing capacity and settlement, design of floor slab, design of retaining structures, slope stability analysis, design soil parameters, etc. General comments on construction methods are also provided in such report, although not specific for contractors (e.g., equipment type, problem areas, etc.).

The geotechnical investigation report is generally used for the following purposes:

- detail design;
- geotechnical information for construction; and/or
- a document in a tender package for construction.

The geotechnical investigation report could be the only report for the project which is used by both designers and contractors. The intent of such report is typically for designers, not for contractors. This could lead to claims by contractors as the geotechnical information provided in the report may not be sufficient or may be misinterpreted for construction.

2.3 Claims against geotechnical investigation reports

Unfortunately, a routine geotechnical investigation report can be subject to claims by a contractor for the following reasons (as examples):

- The soil types and conditions found at the site are different from those shown in the report, e.g., thinner topsoil, no granular soil, wrong soil type, etc.
- The soil strength at the site is softer / looser than that shown in the report.
- Boulder sizes found at the site are larger than those shown in the report.
- Groundwater flow and quantity are more than those mentioned in the report.
- Measured soil / rock strength method used in the report does not necessarily indicate the actual soil / rock strength at the site.

The preceding examples of claims do not cover all claim types against geotechnical investigation reports. Assuming that all parties participated in a project are involved with good intention and in good faith, the reasons for these claims are often caused by misunderstanding / misinterpretation of the intention / information of the geotechnical investigation report used which are preventable.

3 VALIDITY OF GEOTECHNICAL INVESTIGATION REPORTS

By the nature of naturally-occurring subsurface soil and groundwater conditions, it is not realistic to obtain the exact soil conditions for the entire site. The limitations of geotechnical investigation with respect to determining soil conditions are as follows:

- It is not financially practical to investigate every 'square inch' of the site. Soil conditions between investigated locations can be different. Boreholes, sometimes as close as 15 m intervals, may not encounter all soil conditions within the site.
- Even at the same investigated location (e.g., same borehole), soil conditions between sampling intervals can be different.
- A naturally-occurring soil, which is not a man-made material, can vary in properties from those tested.
- Small sizes of soil samples collected may not be representative of the entire soil mass.
- Continuity of certain soil type, i.e., soil layer (stratum), cannot be confirmed between investigated locations.
- Sizes of boulders cannot be determined in a small diameter borehole.
- Soil / rock strength cannot be determined by direct testing if a representative sample cannot be collected. For example, a thin layer of hard rock interbedded within a soft rock cannot be subject to uniaxial compression test as 'direct testing'. However, an indirect testing method (e.g., point load testing) can be used instead.
- Estimated engineering values (e.g., bearing capacity, settlement) may not be the same as those experienced in the field.
- By nature, geotechnical engineering is a combination of applied science and philosophy. Geotechnical engineers have to interpret the results of limited knowledge of soil conditions and apply engineering principles for design and construction of planned structures. The 'philosophy' applied by each geotechnical engineer on the same investigation results can be different. Therefore, the readers of any geotechnical investigation report should, by themselves, interpret the information in the report, if they do not accept the information and/or recommendations provided in the report.

In recent years, the use of geotechnical investigation reports has been expanded from the initial purpose of the reports which is mainly for foundation design. Reliance has been demanded on a geotechnical investigation report for financial support and the success of the project. Furthermore, reliance on a geotechnical investigation report for foundation design has been requested to be valid for other purposes, e.g., ground improvement design. Such reliance extends the liability of the report authors and in case of problems, it will be difficult to prove and defend.

4 SUGGESTIONS FOR PROMOTING THE REALISTIC USE OF ROUTINE GEOTECHNICAL INVESTIGATION REPORTS

In order to prevent misinterpretation / misunderstanding of the information provided in a geotechnical investigation report, the following approaches for the various phases of the project are suggested for consideration. It should be noted that some suggestions below have already been adopted by a number of project planners.

- a. Prior to finalizing the design, report authors should be engaged to review the final design in order to confirm that the soil information provided is sufficient and recommendations provided have been incorporated in the design.
- b. Prior to tendering, report authors should be given an opportunity to review the contract specifications / packages for tender in order to comment on the contractual use of the geotechnical investigation report / results.
- c. During tendering, report authors should meet with all potential contractors to explain the soil and groundwater conditions found within the project site and their effects on construction methods.
- d. During tendering, contractors should engage geotechnical engineers to study the information provided in the geotechnical investigation report with respect to construction method and cost. If contractors find the information insufficient for construction, contractors should be allowed sufficient time to carry out additional investigation.
- e. Prior to construction, report authors should meet face-to-face with designers and contractors in order to explain the finding of the geotechnical investigation and their effects on the design and construction, if such a meeting has not yet been conducted.
- f. During construction, report authors should be involved in confirming the soil types encountered and providing recommendations for specific problems.

As for documentation, the following report types and contract terms should be considered for design and construction:

- a. Prepare a Geotechnical Baseline Report (GBR) for both design and construction. The GBR should clearly qualify and/or quantify all potential problematic soil and groundwater conditions, e.g., boulder sizes, frequency of boulders, hard rock strength and frequency, etc.
- b. Prepare construction contracts with clauses that clearly indicate the validity and reliability of the geotechnical investigation report which has been included in the contract package. In particular, any third party using the geotechnical investigation report shall unconditionally accept the report limitations included in the report.
- c. Prepare contract payment which includes unit costs for extra works that are necessary when the site conditions are different from those

- mentioned in the geotechnical investigation report, e.g., removal of obstructions.
- d. Prepare contract clauses that all engineering values (soil strength, soil parameters, recommended / estimated values) as provided in the geotechnical investigation report shall be considered as valid for both design and construction. As an example, the uniaxial compressive strength of rock obtained by point load testing shall be considered as valid for the rock mass.
 - e. Prepare a separate geotechnical report / contract section specifically for contractors, in order to highlight the soil and groundwater conditions at the site.

5 CONCLUSIONS

Over the last few decades, the use of a routine geotechnical investigation report has been expanded from its initial purpose for foundation design to become an instrument for financial reliance and claim. It is not realistic that geotechnical engineers can know all soil and groundwater conditions within a project site from a limited investigation program. Soil and rock are naturally-occurring materials that can vary in properties across the site, which cannot be thoroughly investigated without considerable cost and time. It is therefore unrealistic to assume that a routine geotechnical investigation report will provide all necessary information for design and construction.

Is it time to impose additional measures, through legalization and/or 'industrial standard', to promote the realistic use of geotechnical investigation reports in order to prevent lengthy and costly claims?

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