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Learning to speak Geotech – the importance of communication between geotechnical and structural disciplines during project delivery

C.A. Williams & B. Simms

GHD, Wellington.

G. Farquhar

GHD, Auckland

ABSTRACT

Successful project delivery of multidisciplinary projects requires all disciplines to work in harmony. For structural engineers it often feels like our geotechnical counterparts are speaking a different language and are working to a very different set of rules.

This paper outlines some key conversations to have between the disciplines as a project progresses. These conversations begin with taking the time to understand the different terms and frames of reference that each discipline may be working with. The following milestones are discussed in reference to both the NZCIC project documentation guidelines and the NZGS guidelines. These conversations can relate to the delivery of both new designs and seismic assessments.

Continual dialogue between the disciplines starts with mapping out what design parameters and reporting are needed, what they will be based on and how this may shift and develop through the delivery of a project. Mapping out these areas early in a project facilitates clear communication between design teams and communication of these shifting risks to clients throughout the project.

1 INTRODUCTION

Structural and geotechnical disciplines are often required to work closely together in both design and assessment of structures. It is critical that these two disciplines are talking the same language.

In the course of recent projects it has become apparent that the two disciplines are often talking very different languages. Examples include disciplines progressing independent of each other - structural engineers reporting that assessments are almost complete just as the site liquefaction analysis is getting underway. In some instances, key design elements are obscured within a report and not discussed until late in the project - whole building platforms being lifted in the last week of detailed design on the basis of site details that while included in the depth of a report were not communicated. Design processes and standard are also causing confusion, with design team or projects progressing for a considerable length before realising that the structural and geotech engineers are using different standards to assess or design for the same site.

This pitfall is all too common as two disciplines have a common interest, but very different areas of concern when trying to find the answer. Poor communication between the disciplines has an impact on both seismic assessment and detailed design. This paper outlines some tools and conversations that help in establishing a common understanding between geotechnical engineers and structural engineers and improve project delivery.

Following the introduction of key terms that both sides of the table need to understand, we look at the key conversations to have in the delivery of both seismic assessments and design of new structures.

The authors represent perspectives of both Geotech (B Simms, G Farquhar) and Structural (C A Williams) engineers.

2 TERMS TO UNDERSTAND AND DISCUSS

At the outset of any project it is important that each discipline is understood. The following section highlights some areas where each discipline will need to look beyond the terms and references that they are accustomed to using in order to determine what is best suited to the project at hand.

2.1 Loading Standards

There is more than one standard available for use in determining peak ground acceleration and seismic loads. Any discussion of loading needs to begin by asking and coming to agreement on what standard will be used and how. Seismic design parameters for structural and geotechnical design differ. Often both structural and geotechnical engineers don't realise this and thus both misinterpret each other. Structural engineers use spectral accelerations. Geotechnical engineers use peak ground accelerations (i.e. at zero period).

Both New Zealand Transport Agency bridge manual (2013, SP/M/022) and New Zealand Structural Design Actions, Earthquake Actions, Part 5 (NZS 1170.5 2004) have strengths and particular types of structures that they are best suited to. Earthquake Actions, NZS 1170.5 has been developed with above ground structures and their design in mind. In contrast, Bridge manual (2013), focuses on the loading on bridge type structures including 'locked in' elements, abutments, retaining walls and other elements that are sensitive to movement with the surrounding ground structure. While the Bridge manual (2013) references Earthquake Actions, NZS 1170.5 throughout, care needs to be taken when interchanging the two standards.

The Peak Ground Accelerations (PGAs) derived using NZS 1170.5 are magnitude weighted to correspond to an earthquake magnitude of 7.5. The hazard studies conducted for the development of the NZS1170.5 spectra used magnitude-weighting of the spectra for periods up to 0.5s. The magnitude-weighting method scales the expected accelerations for any event according to earthquake magnitude M , by a factor $(M/7.5)^{1.285}$. Magnitude-weighting recognises that for a given maximum acceleration, damage potential increases with the duration of shaking. Duration of shaking generally increases with magnitude. The magnitude-dependent scaling factor is intended to produce spectral acceleration estimates that are equivalent to magnitude 7.5 values in terms of damage potential, scaling down accelerations for magnitudes less than 7.5.

Given that the performance of soils, earth structures, slopes and retaining walls exhibit a step-wise behaviour (where a critical acceleration results in a sudden loss of stability, i.e. dramatic change in behaviour), use of 1170.5 PGAs may be non-conservative. Therefore geotechnical engineers use unweighted PGAs in the assessment and design of soil structures for earthquakes. Unweighted PGAs are derived from NZTA's NZ Bridge Manual. They are not back calculated from NZS 1170.5 magnitude weighted PGAs as doing so gives rise to inconsistencies due to the approximations that are inherent in the 1170.5 site hazard spectra. Unweighted estimates have no scaling of the expected accelerations.

For liquefaction assessments geotechnical engineers need both a PGA and a magnitude which they can get from the Bridge Manual. For retaining wall design and slope stability assessment only the PGA is required. There are also other factors, such as topographical factors, that can influence PGA for geotechnical designs.

Choice of site subsoil class is critical for 1170.5 especially when on the boundary between classes C and D. Structural engineers should ask the geotechnical engineer to provide this.

It is important too that both disciplines are involved in discussions to determine what standard is best for a project. Any results, such as peak ground acceleration, also need clarity about the standard used. This also serves to reduce the confusion that can arise when a parameter is derived from one standard and then translated or misinterpreted as being from another.

2.2 NZGS/MBIE Earthquake Geotechnical Engineering Practice Guidelines

The NZGS/MBIE 2016 practice guidelines outline geotechnical engineering principles and practises in plain English. There is a significant benefit in structural engineers taking the time to familiarise themselves with the Guidelines and the description of the framework and processes behind geotechnical delivery.

Much of the Guidance focuses on geotechnical practice and how this fits into the overall delivery of a project. Further to this, the modules outline methods of best practise and areas of project delivery that can be enhanced by better understanding and collaboration between structural and geotechnical disciplines.

2.3 The Seismic Assessment of Existing Buildings – Technical Guidelines

The interaction between geotechnical and structural professionals in the delivery of seismic assessments is outlined in The Seismic Assessment of Existing Buildings, Parts A & B. Project delivery is enhanced by both of these disciplines being familiar with the frame work within these guidelines with particular attention being paid to the overarching principal in section A and Part C04 – geotechnical considerations. This common frame work establishes a common language of assessment, reporting and a unified approach in the delivery of any assessment project.

2.4 Different Types of Geotechnical professionals

The influence of a Geotechnical professional extends from project inception through to compliance. However in essence, the difference between an Engineering Geologist and a Geotechnical Engineer is outlined below.

An Engineering Geologist is generally more actively engaged and leading from the inception through to the ground model i.e. defining and presenting geotechnical risk associated with the land parcel. Typically, their role is mostly complete after the ground model parameters have been selected.

A Geotechnical Engineer is actively engaged and leading from the ground model parameter selection through the design process to project certification.

In reality, the Geotechnical profession has a lot of crossover through the various project phases and there is a select group of individuals who can cover the entire project lifecycle. For example, both an Engineering

Geologist and a Geotechnical Engineer are involved in the production of a Geotechnical Interpretive report. As mentioned earlier the clearest delineation is the Engineering Geologists scope finishes after the ground model parameter selection is made.

In some instances, an Engineering Geologist carries out many of the tasks that are typical of a Geotechnical Engineer and vice versa.

2.5 Geotechnical reports

There are a wide range of geotechnical reports. Briefing discussions between the disciplines need to step beyond “We need a geotech report” to outline the objectives and end uses of the report. This allows those involved to tailor the report to meet the identified needs.

In general terms, geotechnical reports have a common progression and include:

- Desktop Report – existing site information relating to the site and project
- Factual Report – raw data resulting from site investigations
- Interpretive Report – interpretation of ground conditions and potentially recommendations and options for site development, building foundations and design parameters.

The NZGS/MBIE Guidelines (module 2) gives some further guidance as to how geotechnical reports vary as they develop. There is no definitive list of features for each type of report, and the level of reporting may vary between geotechnical practises. This makes it equally important for there to be robust discussion around the objectives and end uses of any reports.

2.6 Compliance with NEW ZEALAND BUILDING CODE

There are multiple means of complying with the New Zealand Building Code. In many instances, the simplest way to demonstrate this is using B1/VM4. Verification Method B1/VM4 provides a means of compliance with Building Code Clause B1 Structure. This document covers the ultimate limit state design of foundations, including those of earth retaining structures. However, due consideration should be given to selecting the method of compliance that best suits the needs of the project. B1/VM4 has limitations and reflects the state of design at its time of publication. Engineers need to be aware of the limits of this methodology when scoping each project. NZGS/MBIE modules 4 & 6 outline the current understanding of both foundation and retaining wall design. It is important that the design team is familiar with or at least willing to explore methods and processes outside of their business as usual delivery.

B1/VM4 gives clear guidelines and methods for use in the design of shallow foundations and consideration of eccentric loading on foundations. While some of the term and approaches have been superseded by the later NZGS/MBIE modules, B1/VM4 gives a clear outline of terminology used in foundation design. In the event of selecting a method other than B1/VM4 the processes and terminology need to be understood, recorded and clearly communicated amongst the design team.

3 KEY CONVERSATIONS IN SEISMIC ASSESSMENTS

Seismic assessments are typically led by a client’s requirement to know more about their building. As such, structural compliance is typically the top a client’s mind, with the structural engineer as the first point of contact. Seismic assessments can benefit significantly with discussions between the structural and geotechnical disciplines. Further to this, it is a requirement of the NZGS/MBIE guidelines that this collaboration occur.

3.1 While scoping the assessment

Initial conversations between the disciplines need consider how the assessment will be delivered.

3.1.1 What is already known about the site?

In many instances, the answers may be able to be determined by reference to readily available subsoil maps. However, in many parts of New Zealand, maps determining subsoil class are not readily available, or of a suitable refinement. Structural engineers need to be aware that there are areas along the margins of these maps where site specific investigation is highly recommended. This could be due a range of factors, including abrupt and localised changes in subsoil classes.

3.1.2 What do we still need to know?

A discussion around what still needs to be known needs to look which of the three categories the building falls into, ranging from

1. Structurally dominated,
2. Interactive, or
3. Geotechnically dominated.

For structures in the last two categories, conversations about the site might include determining parameters and risks, including liquefaction and lateral spread. This leads into the questions of what levels of site investigation and analysis are required to fill in the gaps of information relating to the site.

3.1.3 Importance Level

It is crucial to determine the importance level of the structure early and ensure you have the client's agreement to this. While for structural assessment, a change in importance level may be a matter of scaling up or down results, for geotechnical investigations the implications are significant. The importance level will drive both the number and depth of any bore hole required as part of the investigation.

3.1.4 What standards are appropriate for the assessment?

The standards used in assessment need to be agreed and documented early in an assessment. In addition to this, the methods for analysis and assessment of influences the geotechnical site parameters that will be needed.

Discussions between structural and geotech should focus on selecting the most appropriate standards and processes for the site and structure type. We need to shift away from selecting a method on the basis that "this is how we have always done it".

3.2 Can geotechnical investigation and assessment be excluded from the scope?

The decision to exclude geotechnical assessment from a seismic assessment needs to be made with care. There are often budget pressure from clients wanting to limit their expenditure in assessment stage. It is important to ensure that the client is fully informed about the risks that they are accepting in choosing to reduce the scope of their assessments.

Warning signs that geotechnical assessment should not be excluded from scope may include the following:

- **The scope includes concept design or detailing of remedial works** – in this instance, geotechnical information will play a critical part in determining any means of ground anchorage/hold down required in the remedial design.

- **The site conditions indicate geotechnical vulnerabilities** – In instances where the site has identified risks such as liquefaction, the assessment is of very little value to the client if these features are not considered.

In the event of excluding the assessment of geotechnical site features from the scope of delivery, this exclusion and its associated risks need to be clearly communicated to the client. A provisional sum can often be included in order to give the client visibility of the impact of this exclusion. This records the likely cost implications should the initial investigation indicate that these risks may be present and require further investigation.

3.3 Conversations to have as an assessment progresses

As the assessment progresses, it is important to continue the discussions between structural and geotechnical disciplines.

When risks are identified during site investigation, open communications help in shaping the evolving assessment and in keeping the client informed. This open communication allows the two disciplines to work better together and creates opportunities to discuss the evolving assessment and requirements with the client.

As an assessment progresses there can often be a pressure to report prior to completion of both disciplines. Care needs to be taken in these instances, especially if the structure is likely to have a combined or geotechnical dominated response. Interim updates to the client need to be in a language that the client understands while including appropriate caveats around what remains to be completed in the assessment.

4 KEY CONVERSATIONS IN DESIGN

Design projects require the structure to develop in parallel with the geotechnical investigation and reporting. It is crucial for the disciplines to establish good lines of communications and continue to use them throughout the project.

The following discussion of project progression is based on the NZCIC guidelines (2016).

Table 1: NZCIC Guidelines (2016) delivery stages and associated geotechnical reporting

Stage	Reporting
Establishment	Establishing base parameters – IL & issues driving ground investigation
Concept Design	Desktop Report
Preliminary Design	Completing ground investigation & draft factual report
Developed Design	Finalising factual & interpretive reports
Detailed Design	Review of design against geotechnical reporting recommendations including interaction between geotech and structural engineers, with geotechnical input into design reports required

The professionals involved and leading each stage of the project vary throughout the delivery. An indication of this development is given below.

Stage	Leading Disciplines
Establishment	Engineering Geologist/Geotechnical Engineer/Structural
→ Project Definition	Engineering Geologist/Geotechnical Engineer/Structural
Concept Design	Engineering Geologist/Geotechnical Engineer/Structural
→ Geotechnical Desktop Study	Engineering Geologist
→ Structural Desktop Study	Structural Engineer
→ Structural / Geotechnical Meeting	Geotechnical Engineer / Structural
→ Geotechnical Site investigation	Engineering Geologist
Preliminary Design	Structural
Developed Design	Structural
Detailed Design	Engineering Geologist/Geotechnical Engineer/Structural
→ Structural Analysis and Assessment	Structural Engineer
→ Geotechnical Analysis and Assessment	Engineering Geologist / Geotechnical Engineer
→ Geotechnical Report	Engineering Geologist / Geotechnical Engineer
→ Structural Report	Structural Engineer
Consenting	Engineering Geologist/Geotechnical Engineer/Structural
Construction Monitoring	Engineering Geologist/Geotechnical Engineer/Structural
Certification	Geotechnical Engineer / Structural

4.1 When scoping

At the project scoping it is important to get agreement between the disciplines on the overarching design criteria including:

- Importance level of the structure
- Design standard for determining Peak Ground Acceleration
- What parameters will be required to enable design

These items tie in with the structural/geotechnical items identified in the NZCIC Guidelines (2016) establishment stage.

4.2 Project kick off

At project kick off it is important to understand how the level of information known about the site will develop through the design stages.

This project progression indicates that the agreed geotechnical parameters are not typically available until near the end of the developed design. With this in mind, we have found it useful to record what design parameters will be used at different project stages and what they will be based on. An example of such is given below. As well as reaching agreement with the disciplines, it gives the rest of the design team (architects, QS, client) visibility of how the design of ground works may be subject to change during the course of the project.

Table 2: Sample summary of design parameters and their basis at different stages

Parameter	Developed Stage	Detailed Stage
Subsoil class	Based on desktop study	Based on GI reports
Bearing capacity & associated Φ factors	300 KPa ultimate assumed	Based on GI results
Site build up	Philosophy to be discussed & agreed at developed stage	Confirmed in conjunction with GI results
Depth to good ground	Philosophy to be discussed & agreed at developed stage	Confirmed in conjunction with GI results
Liquefaction & lateral spread	Based on desktop study	Based on GI
Shallow vs deep foundations	Based on desktop study	Based on GI
Review of applied loads		Based on calculations

4.3 Project delivery

Conversations between the two disciplines need to continue throughout the delivery of the design. These discussions need to complement regular design team meetings. The above table of project progression can be used as a framework for the discussions as a project progresses. As the design and site investigation develop, it is important to identify where the project is varying from the initial plan or expectations. Timely conversations around these minimise surprises later in a project and improve delivery.

4.4 Iterative design of elements

It is important that the final design be reviewed by the geotechnical discipline against the original recommendations of the interpretive report. As well as providing confidence in the design it is an essential part of the review process required for proving producer statements for the design. This review should include the final configuration of the foundations, including loads and points of application.

Piles and similar deep foundation types may require a more interactive communication between the disciplines. In many instances the modelling of the foundations and their interaction is carried out by geotechnical specialists, resulting in stiffness and deflection parameters to be included in the structural models.

5 CONCLUSION

Structural and geotechnical engineers can improve project delivery by taking the time to talk, to understand each other and communicate.

Improved communication starts with understanding the different frameworks that each is working within. This creates the basis for agreeing on how to best deliver the assessment or design.

The regular communication needs to continue throughout the project delivery. This includes regularly checking in on the project plans established at the beginning of the project with the actual progress.

Improved communication reduces the frustration between disciplines as projects progress, reduces surprises or promotes proactive identification of them before they escalate, and allows the design team to present a cohesive delivery progress to our clients.

6 REFERENCES

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