AUSTRALIAN GEOMECHANICS SOCIETY

Report and Reflection on "Practical Applications of Generative AI in Geotechnical Engineering"

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Summary

On 10 September 2025, the Australian Geomechanics Society (AGS) – Sydney Chapter, in collaboration with ISSMGE TC309, organised a technical session on Practical Applications of Generative AI in Geotechnical Engineering. The session showcased how generative AI is already being integrated into geotechnical workflows, with examples spanning automation of borehole log digitisation, laboratory test result summarisation, natural language–driven soil classification, drone-enabled site assessments, and AI-assisted numerical modelling using platforms such as PLAXIS and Python. Discussions highlighted the tangible benefits of AI adoption, including significant time savings, improved consistency, and greater scalability of analyses, alongside the challenges of verification, data security, skill development, and the need to safeguard engineering judgement. The dynamic session revealed a profession at the cusp of transformation, where generative AI is not replacing engineers but augmenting their capacity to deliver faster, more reliable, and more innovative solutions. The session concluded with an emphasis on the importance of responsible adoption, robust validation, and

ongoing dialogue to ensure the safe and effective integration of generative AI into geotechnical practice.

1 - Introduction

Generative Artificial Intelligence (GenAI) is rapidly emerging as a transformative force in engineering, offering new ways to automate tasks, interpret data, and support decision-making. In geotechnical engineering, where projects often rely on large volumes of test results, descriptive logs, design charts, and numerical modelling, the potential of GenAI is particularly compelling. Traditionally, engineers have spent considerable time on repetitive yet critical processes such as transcribing borehole data, collating laboratory results, preparing reports, and running multiple design scenarios. These tasks, though essential, are labour-intensive and limit the time available for higher-level analysis and engineering judgement.

The advent of large language models (LLMs) and AI-enabled workflows is changing this landscape. Engineers can now digitise and interpret core photos, automate laboratory test summaries, generate scripts for numerical modelling, and even develop knowledge systems capable of retrieving decades of archived geotechnical information. Early applications have shown that processes taking days can be reduced to hours, while ensuring greater consistency and scalability across projects.

At the same time, the integration of GenAI raises important questions. How do we verify outputs when AI models may hallucinate? What safeguards are needed to protect sensitive data? How can engineers strike a balance between automation and the professional judgement that underpins safety and reliability? These questions framed the discussion in this session, which focused on real-world applications rather than theoretical possibilities. The conversation highlighted both the immediate opportunities and the broader implications of adopting generative AI in geotechnical engineering, setting the stage for a profession that is being reshaped by technology at an unprecedented pace.

2 - Highlighted Practical Applications of Generative AI in Geotechnical Engineering Practice

The session placed strong emphasis on real, hands-on applications of generative AI that are already being trialled or adopted in geotechnical engineering practice. These examples demonstrated how AI is being used not as a futuristic concept, but as a practical tool for improving efficiency, accuracy, and scalability in everyday workflows. The highlighted applications covered a wide spectrum, ranging from routine data handling and reporting through to advanced numerical modelling, knowledge management, and field integration.

2.1 Automating Routine Processes

A recurring theme was the value of GenAI in reducing time spent on repetitive tasks. Borehole logs, for instance, can now be digitised from scanned images using a combination of computer vision and Optical Character Recognition (OCR). Instead of manually transcribing data, AI agents convert logs into digital formats that can be pushed directly into modelling platforms such as PLAXIS through APIs. This approach significantly reduces errors and improves consistency.

Similarly, laboratory test reports that previously required manual data entry, such as particle size distributions, can be processed automatically. With simple prompting in platforms like ChatGPT or integrated workflows in n8n, AI reads the report, extracts the key parameters, and compiles them into structured CSV or Excel outputs in seconds. These efficiencies save hours of repetitive work on every project and ensure standardisation across large datasets.

2.2 GenAI as a Coding Partner

One of the clearest shifts enabled by GenAI is in coding and automation. Many geotechnical engineers are not advanced programmers, yet increasingly need scripts for handling complex modelling and data analysis. Generative AI now acts as a virtual coding assistant, bridging this gap. Using tools such as ChatGPT, GitHub Copilot, and Python APIs, engineers can translate modelling commands into functional scripts, debug errors, and even scale simulations with loops that would otherwise take days to develop manually.

For example, a team used GenAI to create a loop that extracted structural forces from 80 embedded piles connected to a raft slab across 10 different load combinations. What once required several days of manual effort was completed in just one hour. This shift empowers engineers to focus on analysis and judgement rather than syntax and debugging, while also creating institutional memory in the form of reusable, auditable code. Importantly, it reduces the overall cost of analysis for clients and removes the time barriers that previously limited the extraction of extensive results for further design scenarios, enabling faster decision-making and more innovative solutions.

2.3 Numerical Modelling and Parametric Studies

The most striking applications lie in advanced numerical modelling. Parametric studies that previously required days or weeks of work can now be scaled to dozens of scenarios in a matter of hours.

One case study focused on excavation-induced ground displacement in Sydney sandstone. Traditionally, engineers relied on interpolating values from design charts and running limited scenarios in PLAXIS. With AI assistance, base automation scripts were developed, converted into Python using GenAI, and expanded into workflows capable of generating synthetic datasets. A process that normally spanned several days of manual work was reduced to a single hour.

A second case study examined pipeline and shoring wall interaction under excavation and climate impact scenarios. By varying pile diameter, embedment depth, anchor prestress, and groundwater level, 60 design cases were simulated. The AI-assisted workflow produced all outputs in about an hour, compared with an estimated several days manually. This capability enables far richer sensitivity analyses and supports better-informed design optimisation.

2.4 Data Interpretation and Knowledge Systems

Generative AI also shows promise in handling unstructured and qualitative data. Natural Language Processing (NLP) was applied to classify soils from descriptive trial pit logs. In one project, more than 400 labelled descriptions were used to train a model that could map new descriptions to South African foundation site classes. Accuracy rates ranged from 86% at group level to 63% at detailed class level, offering a scalable tool for rapid site classification.

A Retrieval-Augmented Generation (RAG) system was explained to unlock archived geotechnical data such as site investigation reports, lab results, and correspondences. By embedding documents in a vector database and combining them with LLMs, engineers can now query decades of archived material and receive context-aware responses, complete with source references for verification. Tested against 21 geotechnical questions, the system provided accurate, verifiable answers that would have been prohibitively time-consuming to retrieve manually.

These approaches demonstrate how AI can act as both a knowledge management system and a quality control assistant, surfacing insights from hidden archives and supporting more consistent site interpretation.

2.5 Integration with Field Technologies

Another frontier discussed was the integration of AI with drones and field data acquisition. Drone surveys were used to capture geotechnical site conditions in difficult terrains such as deep gorges with vertical rock faces and dense vegetation. The captured data, when processed with machine learning and AI, enabled rapid 3D modelling and hazard mapping. When combined with mined geotechnical databases, this creates a powerful pipeline for both site investigation and ongoing monitoring.

2.6. Engineering Analysis with Digitised Charts

Engineers also demonstrated how digitised design charts, when integrated into customised GPT frameworks, allow AI to perform engineering analyses that were once cumbersome. For example, charts for settlement of shallow foundations were digitised and embedded into a custom GPT. Engineers could upload an image or input parameters, and the AI produced the interpolated values instantly, validated against PLAXIS 3D outputs. This shows how AI can extend beyond text processing into calculation workflows, provided the knowledge base is structured and validated.

3 - Benefits, Challenges, and Reflections

The accumulated benefits of these applications are substantial:

- ✓ Dramatic reductions in time for data entry, modelling, and reporting.
- ✓ Boosts overall productivity by focusing skilled resources on more complex, high-value tasks.
- ✓ Consistency and scalability across projects.
- ✓ Lower barriers for engineers to develop and use automation.

- ✓ Better utilisation of underused data resources.
- ✓ Enhanced opportunities for interdisciplinary innovation.
- ✓ Reduces costs, making project delivery more cost-effective.

However, several challenges remain. Verification is essential, as AI systems can still hallucinate or misinterpret. Engineers must remain accountable for outputs and ensure validation against field measurements or known standards. Data governance and security are pressing issues, especially when handling sensitive client data. Adoption also requires cultural change, training, building trust in AI systems, and aligning commercial models with the efficiencies AI introduces. Above all, the balance between automation and engineering judgement must be carefully managed.

4 - Conclusions

This session illustrated that generative AI is no longer a futuristic concept but an active force in geotechnical engineering practice. From digitising borehole logs to scaling numerical modelling, from NLP-based site classification to RAG-driven knowledge retrieval, the technology is already solving specific, high-value problems. The outlook is one of augmentation rather than replacement: AI takes on repetitive and mechanical tasks, allowing engineers to focus on creative design, safety, and resilience. As this transition unfolds, many roles will likely shift away from repetitive tasks toward overseeing, guiding, and interacting with AI systems. With responsible adoption, clear governance, and continuous validation, generative AI has the potential to fundamentally reshape geotechnical practice in the years ahead.