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How to be a Functional on-site Geotechnical Engineer

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Abstract

This paper provides guidance to geotechnical professionals working on mine sites on how to be a Functional On-site Geotechnical Engineer. While such a concept may be perceived as uninventive, in the authors' combined 40+ years of working on-site for operating mines, proves otherwise. The concept of a Functional On-site Geotechnical Engineer stems from 'rules of thumb' for geotechnical professionals, that if followed will help prevent geotechnically related operational pitfalls.

While some junior geotechnical engineers enter the mining industry with support, guidance, and systems, many others do not. Depending on the quantum and quality of mentoring (if offered or available) and the level / maturity of geotechnical practice employed by the site, professional development of junior engineers varies greatly. At this early stage in a young professional's career, many good and unfortunate convictions of 'What Good Looks Like' are formed. Guidance provided within is the author's interpretation of "What Good Should Look Like" for on-site geotechnical engineering best practice.

Operational situations often pressure geotechnical engineers into decisions that may have immediate and/or cumulative and enduring material impacts on workplace safety and/or production, without sufficient time, data, and/or resources to fully assess a given situation. A Functional On-site Geotechnical Engineer knows what to focus on (Identification & Prioritisation), how much effort to expend (Planning), and when and for how long to focus on it (Scheduling) to make the most informed decision at the right time. While the guidance presented does not include revolutionary concepts, it does present decades of distilled geotechnical wisdom on "What Good Looks Like", which is beneficial to junior, some senior level professionals, and managers.

Keywords

Eurock2026, Rock Engineering, Skopje, Operational Engineering, Geotechnical.

1 Introduction

"Your job is to keep the Mine Manager out of jail". Having been put under pressure to achieve production goals with limited or no geotechnical justification, the Geotechnical Superintendent reminded the team of their responsibility. While the production team were driven by mining metrics and budgets, the geotechnical function was to manage the risks to an acceptable level. Was the statement correct and if so, why wasn't the author told this at the outset of their career? The statement was profound and right or wrong, changed one of the author's approaches to their role.

Each of the paper's authors have worked extensively on site and in recent years, as consultants, their cumulative experience with sites at a global scale has identified recurring problems which are common to many operations. Not all engineers have the benefit of a mentor or quality leadership or access to quality systems and tools as they develop. This paper is designed to help the reader identify and functionally manage the requirements of their role.

Many 'Best Practice' papers have been published but, in all cases, confidence in the basics is required from which to develop their excellence. A working assumption of this paper is that the reader is not the person with statutory responsibility for geotechnical engineering since by the time you are, full proficiency in the core competencies should have been achieved.

2 What is the role?

Geotechnical engineering tends to be a catch-all profession, with the freedom to pick up a range of work outside of the core discipline. The engineer can indulge in a range of interests, but risks becoming the dumping ground for work that no-one else wants to do or lacks specific skills to do.

The overarching objective of on-site geotechnical engineers is to manage the geotechnical risks to the mine plan. Determining core geotechnical competencies is critical to the effective management of workload and much of the skill is related to curating strong personal relationships. Excelling at mathematics, for example, does not translate into being an excellent engineer.

Core competencies include:

- Ensuring the mine is compliant with the geotechnically relevant aspects of the mine regulations within the operational jurisdiction and the site's relevant mining permit(s).
- Compliance of the geotechnical systems to relevant standards.
- Effective communication within the technical services and operating departments.
- Being present, comfortable, and knowledgeable about the geotechnical, mine planning, and operating aspects of the field.
- Reporting.
- Being the point of contact with the operational team and the mining crew. Getting to know as many of the operations team as possible.
- Maintaining records of inspections, development of work instructions, and designs.
- Having a clear understanding of all compulsory and recommended technical requirements for executing the mine plan and its designs.
- Stay ahead of production by anticipating potential problems to avoid being the bottleneck.

The crux of the on-site geotechnical engineering roles is to effectively communicate what is required and by when. Experience shows that developing quality rapport with site personnel is critical to on - site geotechnical engineers working effectively. Successful approaches include:

- Try and remember a fact about each person and their life in or out of work. Empathy, friendship, and enthusiasm help to build respect and a working relationship.
- Develop an understanding of the wider operation. Learn how the geologists sample or the challenges of dipping drillholes in 40°C heat. As the engineer develops an understanding of the operation, they can see how easily, or not, geotechnical engineering fits into the wider workload and identify opportunities to improve.
- Cross-skilling. Being able to assist with another role in parallel with your own is useful currency. For example, knowing how to clean fibrecrete fibres off a pump screen will involve getting wet, but buys you favour with the Mine Foreman.
- Demonstrate through your actions that you care about site personnel as individuals and the business.

2.1 General approach

Be present, available, and approachable. The key to gaining traction in the operation is to get known by everyone for the right reasons. Attending the mining crew pre-start meetings without fail will ensure familiarity, and getting to know key personnel such as the Shift Bosses and the Mine Foreman will yield positive results, even though your personal takeaways may be immaterial.

Be compliant. At the most basic level of geotechnical engineering, the aim is to ensure compliance with the mine's legal and other operating requirements. The requirements might be prescriptive or open to interpretation; therefore, the engineer must familiarise themselves with the legislation, permits, and guidelines. Do not solely rely on the work of others (e.g., a commitment register), as the author's experience has proved that such registers and or lists are often materially incomplete. While legislation and permits are absolute, guidelines are there to be followed and should only be deviated from if sufficient engineering justification is documented and approved by the responsible person.

Have a roadmap. Many sites are required to have a Ground Control Management Plan (GCMP) as the main point of reference for geotechnical engineering. It is typically the on-site geotechnical engineer's responsibility to maintain the document and ensure it is signed off. If a GCMP is not compulsory for the site's operating jurisdiction, having one consolidates the material roles and responsibilities for managing geotechnical risk in the mine. If one is not in place, examples of standard document content are available on the Internet including some that are publicly available from mining companies. You need to record somewhere where the operation has been, where it is going, and the material threats it is exposed to along with clearly communicating roles and responsibilities. If you are creative, there are ways of having sections of a GCMP be "living" content (e.g., reference shared folder where procedures exist, rather than listing each procedure) that does not require formal updating of the GCMP when a non-material change occurs.

Understand the work required and the resources to do it. One of the consistently misunderstood aspects of on-site geotechnical engineering is the identification of all work required of the profession and the resources required to do the work. In the author's experience few mines have adequate geotechnical staffing to manage the work and risks on site adequately or in a timely manner. This is typically wholly due to an incomplete understanding of all the tasks required and the required resources. When the requirements are formally assessed in detail (e.g., workload assessment), the result is consistently inadequate resources and/or skilling. It is only after such an assessment that a lean on-site geotechnical engineering team can laser focus their effort on priorities of the operation.

Plan the work and work the plan. With all work quantified, the work can be prioritized, planned and then executed. At the end of the day, some work will not get done. A functional on-site geotechnical engineer can triage and navigate the workload quickly to address the most pressing concerns: workplace safety and compliance. If a seemingly material task cannot be completed, document and communicate this accordingly to ensure there is a paper trail.

2.2 Engineering process

The application of critical thinking and documenting findings provides justification for engineering decisions, a point of confidence from which to defend the work and a source of reference should problems occur. Documentation does not need to be fancy (e.g., type-written inspection reports), but it does need to be reasonably available.

Documentation, documentation, documentation."*If it does not have a paper trail, it did not happen*" is a common saying the authors have heard over their decades of experience on operating mine sites. Both corporate and human memories fade with time. The biggest professional disservice an engineer can do to a mine site is not documenting their work. In the author's experience the most common form of this is photographs. The authors have witnessed years of photographic records missing due to staff departures and photographs not being correctly filed or not at all on the network. When you are in the field, as a bare minimum take photos and make a physical record of where you went, what you saw, and any issues you found. While some young professionals may not see the value in this, from the author's experience, when (only a matter of time) an incident investigation occurs, not having reasonable documentation available benefits no-one or the company. If a young professional is in the wrong place at the wrong time without reasonable documentation, this can permanently damage their career. If an incident should occur this is the only means to protect the mine and yourself.

Standardize and simplify. Don't create problems for yourself and the site by having an onerous number of standards. For example, ground support standards should be developed to simplify mining instructions. For an underground operation, there might be 3-4 standards, with one or two accounting for >90% of the ground support installations. Non-standard applications should be addressed on a case-by-case basis and justified through the engineering design process.

2.3 Compliance

The first step in determining compliance is to state what compliance is. Once the scope and thresholds are understood, the engineer can evaluate where they are now and determine what steps are required to achieve compliance. In the authors experience, compliance is required on the following fronts:

- Operating jurisdiction legal requirements.
- Site operating permit commitments.
- Business (e.g., corporate, site) standards and expectations.
- Technical / design level requirements (e.g., consultant report execution requirements).

Identify and quantify gaps. When starting a new position, perform a compliance gap analysis and apply a triage approach to improving the engineering standard. Experience has shown that undertaking a gap analysis, developing an implementation plan, documenting the findings and reporting to management is an effective way to ensure the person with statutory responsibility (typically the Mine Manager) is fully aware of the situation. Once aware, most professionals will authorise the work to be done. If not, there will be documented evidence to prove that you made them aware.

Expect the unexpected. In one of the author's experiences a provincial geotechnical inspector arrived on site unannounced. The first question from the inspector was for the author to demonstrate that they have addressed all the consultant recommendations for their designs. While not compulsory from a regulatory perspective this put the author in an interesting position being new to the site and the site not having previously employed a geotechnical engineer. "An ounce of prevention is worth a pound of cure" in such situations.

2.4 Question everything

Following instructions is not good enough. A functional geotechnical engineer must question each task and scrutinise their own work whereas without doubt, someone else will. Knowledge is key when defending a decision, and self-assessment leads to preparation for the likely questions. Engineering designs must be justified, documented and approved before implementation and critical thinking is required to ensure you have resolved on the most viable (if not best) solution.

Trust but verify. While it is important from an efficiency perspective to rely on the work of others, humans and computers make mistakes. In the author's experience, while working at a greenfield underground mine using an internationally known geotechnical consultant to develop ground support standards, the author asked for the Rocscience UnWedge source files to save them time for doing a discrete support design. Upon opening one of the files and checking the inputs, the author found a materially incorrect rock density value had been used in the analysis, which was different from the report documentation, which stated the correct value. The result was re-estimating of the ground support standards due to this consultant's error.

Don't cross the invisible line. All professionals need to be cognisant of the fine line of trusting but verifying, as crossing that line can create the appearance of not trusting personnel on site. Check your work but no need to be vocal about it.

2.5 Design responsibility

The site always *"carries the can"*. The site is liable for designs developed by current and former employees. One of the authors learned an important lesson after a fall of ground when the Mine Inspector arrived to inspect the area. Ironically, the Mines Inspector used to be the geotechnical engineer responsible for the site and it was one of his designs that failed. While being questioned about the failure, it seemed like a good idea to remind the Mine Inspector it was his design, implying that he should ask the questions of himself. The conversation took an unfortunate turn and resulted in an improvement notice being issued to the site. The lesson learned was that there's no use in blaming your predecessors. You are the site; you are the geotechnical engineer; it's your problem.

You own it from start to finish. Once the thinking is done, document the design, including an allowance for variance. Ensure a chain of custody for the design so you know that the work is signed off and issued to the ground support installer at the correct time in the sequence. Once complete, maintain a record of the work, including photographs, in case the design needs to be defended.

2.6 Soft skills

In the author's experience, being able to effectively communicate observations is key to achieving desired outcomes. Fig.1 presents fictitious monitoring data and the same data set is used in each graph.

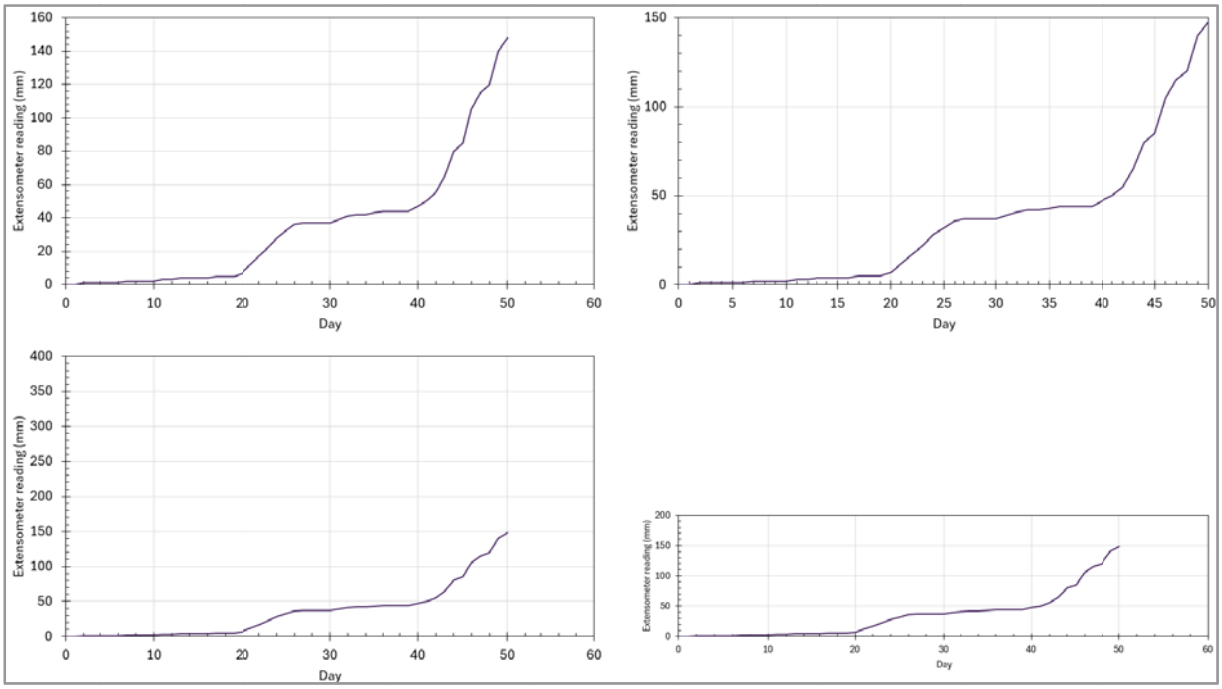


Fig.1 Presentation bias. Scale matters: Same data, different scales.

- Top left: Axes unconstrained and show the full dataset.
- Top right: By clipping the axes to the data, the reader cannot develop a clear picture of the trend as the reader does not know what (if anything) extends beyond the data presented.
- Bottom left: Fixed Y axis which creates an illusion that the extensometer is not accelerating as fast as it is, and that there might be more acceleration before failure.
- Bottom right: Graph Is compressed to fit onto the lower 1/3 of a presentation, suggesting that the acceleration is increasing but not at a critical point.

In the first year of working in an open pit, one author needed to alert management to an imminent slope failure on the pit wall. A meeting was held to inform the technical services team and to fit all the data onto the slide, the graph was presented as shown in the lower-right of Fig.1. Instead of alerting site to the likely failure, the graph was interpreted as showing deformation but no imminent threat. In hindsight, the graph shown in the top-left should have been used.

2.7 Work as part of the team

Communicate effectively. Working relationships are key to getting the job done. Where possible, discuss concerns, upcoming work, and recommendations in person prior to sending a memo or email so that the intended recipient is clear of the intent. Including them in the decision-making progress will also smooth the workflow. A functional on-site geotechnical engineer should know, or learn, how all stakeholders prefer to communicate both important and non-important information. Depending on the workforce, to effectively communicate you may have to use multiple forms of communication for the same message, to convey important issues to personnel that need to know.

Time is precious. An eight-paragraph email might be interesting to you, but is the Mine Manager going to read it? Normally, the Mine Manager is interested in solutions, not how you got there. Any justification can be written up separately and provided on request (or attached to the email as appropriate). Keep emails to a maximum of three lines and if asking questions, only ask one per email.

If more than one question is asked per email, the reader will only answer the easy ones or the ones they want to and carry on.

2.8 The power of internal review

A problem shared is a problem halved, or a cynical person would say that the blame can be spread more evenly.

All documents should be Peer Reviewed. Developing your thoughts in isolation can be misguided and an alternative perspective usually results in a better outcome. Prior to issuing any work, seek a review from peers or reach out to others that might help (Peer Review) to pick up on technical, spelling, grammar, structure, and messaging issues. The way the document is written might not seem as important as getting the work done, but if the message is not clear you will not find success. All that is required for a technical report is to state the issue, explain the solution, and summarise the answer. Embrace the peer review process and remember the comments are not personal.

Don't assume the outcome will be bad. While working in operations, one of the authors highlighted geotechnical deficiencies to the Mine Manager, and a plan was put in place for improvement. Safety critical items were prioritised and during the improvement process, a corporate level geotechnical audit was undertaken across the company's mine sites. While the audit score for the author's site was poor, the corporate geotechnical engineer was satisfied that positive action was being undertaken and in subsequent audits, the improvements were noted and commended. Similar outcomes were noted when visited by the Mine Inspector.

2.9 The power of external review

As a site engineer, the authors would avoid using consultants given the time taken to brief them, hand over data, show them around, and have them not answer the question of which they were asked. However, as a consultant, the authors have learned from the failings of others.

A consultant typically performs three functions for the site team.

- As a point of expertise or someone to undertake a task that cannot be performed on site.
- As a source of labour when you're too busy to get the work done.
- As a voice of authority.

The first two points are self-explanatory, but the third is a nuanced approach to achieving the required outcome. Very often, the mine management team will not fully accept the work of a site employee when making an important recommendation. Engaging a consultant to reinforce the same message will often deliver the result you need as an external opinion often carries more weight with management.

3 Closing comments

The key to being a functional on-site geotechnical engineer is ensuring compliance with standards, minimising delays, and building solid working relationships within the organisation. Remember that the geotechnical engineer is a small part of a big organisation and that you cannot single-handedly change the direction of the site.

Working long hours often results in poor performance and will take its toll on those around you, work smarter to be focussed and efficient rather than slavishly occupy the role.

Manage the expectations of those whom you built relationships with on site. If asked to make a decision for which you are not qualified or feel comfortable to make, speak honestly and point in the direction of those that can help. Leave your ego at home.