The Benefits of Early Geotech Risk Mitigation

Of all the risks engineers, contractors, and owners face on construction projects, unknown ground conditions are some of the most critical and costly. Expansive or corrosive soils, depth to bedrock, high groundwater, and a number of other geotechnical challenges can jeopardize the integrity of any structure — as well as the budget and timeline of any project — from highways and bridges to buildings large and small. Unfortunately, these geological weaknesses are too often discovered after construction begins.

Geotechnical engineering is undeniably complex. It impacts the majority of engineering disciplines, including the work of structural, construction, transportation, environmental, earthquake, hydraulic, civil, and mechanical engineers. In every case, bringing in geotechnical expertise early in the project is key to mitigating subsurface risks and the potential damages they may cause.

When geotechnical risks are investigated appropriately well before construction starts, essential knowledge about subsurface conditions can be used to inform construction methods, materials, and budgets. However, preliminary investigations may not have the benefit of knowledge about the final design, and issues may be missed, leading to change orders, project delays, disputes, and claims.

The High Costs of Unforeseen Ground Conditions

Construction is a cost- and speed-driven industry. In many cases, the lowest bidder wins the work, leaving little room for expenses or measures that are not deemed necessary. Project budgets and timelines naturally factor into line items for soil investigation but may only focus on meeting code requirements and may not necessarily address potential construction issues. For example, the New York City Building Code for structures built on deep foundations requires a minimum of one boring for every 2,000 square feet.[1] Project budgets and timelines typically do not include costs or time for further geotechnical exploration, such as additional borings or more extensive investigation methods that might

be needed to assess problem soils or provide more insight into the unique geotechnical conditions at a site.

The cost for a geotechnical engineering investigation typically ranges from $5,000 to $100,000, depending on the project size and location, but can exceed $1 million for large, complex projects and structures. The cost of a thorough geotechnical investigation can be greatly outweighed by the expenses that stem from delays and changes caused by unknown subsurface conditions.

Multimillion-Dollar Disputes and Project Delays

HKA's CRUX Insight report, an annual publication analyzing the root causes of claims and disputes, cites "unforeseen physical conditions" as the leading cause of claims and disputes on U.S. construction projects where HKA provided geotechnical expertise as part of its claims consulting and dispute resolution services. These projects were scheduled to be under construction between 2010 and 2023 and had a total capital expenditure (CAPEX) value of close to $3 billion. According to the data, on average, claims were filed for more than one-third of a project's total CAPEX, representing a staggering $28.7 million per project.

In addition to the budget implications, issues on these projects led to an average extension of time claimed of 9.9 percent of the original project timeline.[2] These major issues likely could have been mitigated and, in some cases, avoided altogether with a comprehensive understanding of the geological site risks and plans to manage them upfront.

A Sizable Opportunity Cost

The opportunity cost of limited geotechnical investigations must also be weighed. While soil testing beyond code requirements calls for more time and capital, the information it provides allows geotechnical engineers to evaluate the feasibility of alternative, less expensive construction methods.

"Identifying subsurface risks at the start of a project and working collaboratively to minimize those risks are the most effective ways to prevent delays and cost overruns."

Consider the construction of a three-span bridge. If the code requires one boring per pier, three standard penetration test (SPT) borings would technically suffice. The work could proceed with a drilled shaft deep foundation solution, which is typically used in difficult soil conditions such as areas with thick layers of gravel and shallow bedrock. A strategic geotechnical engineer would advise investing in two or three more SPT borings – or a different method like a cone penetrometer test (CPT) – because the additional subsurface analysis may support the use of a less expensive driven pile or shallow foundation solution.

Even with a drilled shaft foundation, two additional borings, costing approximately $4,000–$6,000 each, could ultimately deliver greater savings by revealing that the drilled shafts could be reduced by two or three feet each. If each drilled shaft costs $3,500 per foot in the example of the three-span bridge, that would translate to a savings of $7,000–$10,500 per shaft. Assuming two shafts per pier, the savings amount to $42,000–$63,000, less the expense of the extra borings. The net savings would be in the ballpark of $30,000–$51,000. Adding extra borings also reduces uncertainty by providing additional data points and provides a higher probability of identifying anomalous zones that might be missed in a limited investigation.

Getting to the Root of Geotechnical Risks

Encountering unforeseen ground conditions is a common occurrence on construction sites. In Global Arbitration Review's *The Guide to Construction Arbitration*, attorneys Ellis Baker, Richard Hill, and Ibaad Hakim acknowledge, "The risk of unforeseen ground conditions is well known to the construction industry." They add, "Certain types of work have a greater propensity for being affected by ground conditions, but most structures have subsoil foundations of some kind so the phenomenon of unforeseen ground conditions is widely applicable."[3]

Not only are these risks ubiquitous, but they are also a primary cause of litigation. CRUX data on projects where HKA provided geotechnical expertise indicated "unforeseen physical conditions" were the cause of two-thirds of disputes, surpassing any other source, including installation failure, incomplete design, contract management and/or administration failure, change in scope, spurious claims, and workmanship deficiencies.[2]

Various factors can hinder the identification and management of these risks.

The Limitations of Soil Borings

Although they provide extremely valuable insight into the properties of the ground beneath a site, borings have their limitations. A geotechnical boring provides a sneak peek into the subsurface conditions of a project. While the boring provides valuable information about soil and rock properties at a specific location, it is like reading a few pages of a book rather than reading the whole book. SPT borings are relied on heavily as a relatively low-cost geological testing method and, in some cases, provide sufficient information for skilled geotechnical engineers to make sound recommendations.

Alternative methods for soil investigation provide additional information about subsurface conditions and enable more detailed analysis, allowing construction decisions to be made based on a more complete understanding of what lies beneath. These include CPT, whereby a cone is pressed into the ground to measure the penetration resistance at the tip and friction in the shaft, as well as pore-water pressure; dilatometer testing (DMT), whereby a flat plate is pushed into the soil and a membrane is expanded to measure the deformation properties of a soil; and geophysical methods, which use tools like seismic wave testing and ground penetrating radar to more closely evaluate the depth and density

of problematic soils, thickness of soil layers, proximity to groundwater, and other geotechnical properties of that nature. Where groundwater is a concern, the installation of piezometers that monitor water levels over time and slug or pump tests will provide a much better picture than the single water levels measured in boreholes.

A Narrow Focus on Building Code Requirements

Construction stakeholders must come to terms with the fact that, in many cases, following the minimum requirements of the building code is not enough to uncover major geotechnical risks. Simply checking the box to meet the code is a dangerous game. An example would be doing the required number of borings around the perimeter of an existing building but skipping soil investigation within the footprint of the structure. The untested area could present vastly different subsurface conditions than the surrounding area. In other situations, more borings beyond those required by code may be needed to address known geological hazards in the area.

This is not a new revelation. In 1998, engineers at the International Association for Engineering Geologists Congress warned, “Very careful planning of each stage of the site investigation program is essential and a recipe-book approach which requires one borehole every X meter should be avoided at all costs.”[4] Yet, despite their admonishment, this continues to happen frequently in practice.

Factors may also be at play that make one site notably different than all the other projects built in the area. Making the proper investment to uncover subsurface risks saves both time and money on the back end.

Fragmented Communication

The importance of coordination and communication among project managers, structural engineers, and geotechnical engineers cannot be overstated. Despite the best intentions, breakdowns can happen easily, especially given mounting demands and the increasingly rapid pace of work. The consequences have the potential to be catastrophic, as in a recent case that HKA was called to consult on, where a $10 million change order was issued due to a geotechnical engineer’s recommendations failing to be incorporated into the final engineering plans.

While not every case will be this extreme, it underscores the need for engineers and construction teams to be in lockstep with a clear delineation of responsibilities and due dates, strategic alignment on scope and tools for geological investigation, and plans to discuss findings and risk mitigation measures. Communications should continue throughout construction since geotechnical considerations are important to the selection of construction methods by contractors. Contractors ignore geotechnical concerns to their peril.

Effective Risk Mitigation Requires Early Action

Identifying subsurface risks at the start of a project and working collaboratively to minimize those risks are the most effective ways to prevent delays and cost overruns. This means

bringing in the expertise of a seasoned geotechnical engineer at the bid or proposal phase so they can advise on feasibility, best practices, and budget considerations before it is too late to influence high-level decisions. Bringing in a geotechnical engineer after the project is awarded and handing them a fixed budget based on minimal work scope unduly limits the value they can provide.

Best Practices

At HKA, our experienced geotechnical engineers consult with a broad range of engineers, contractors, and owners on geotechnical risk mitigation at all stages of construction. Over the past four decades, several key measures have emerged that enable construction professionals to work most productively with geotechnical engineers and successfully control risks:

- Engage geotechnical experts early in the project.
- Structure contract provisions so geotechnical engineers have the means to identify conditions and conduct an appropriate investigation to meet the needs of the project, not just arbitrary minimums.
- Facilitate coordination between geotechnical and structural engineers from the outset of the project.
- Allocate sufficient time to review and discuss geotechnical baseline reports.
- Look proactively for data gaps and misinterpretations of data.
- Enhance the visibility of risks with a risk register with appropriate input from all disciplines.
- Be on the lookout throughout construction for design errors and omissions that may impact the geotechnical integrity of the final structure.

Due to the highly complex nature of subsurface risks, many organizations choose to engage geotechnical consultants who have the knowledge and experience to advise them when a project kicks off or as problems arise. They can confirm that potential issues are brought forward and dealt with appropriately.

In the high-stakes world of construction, there is no margin for error. Investing in geotechnical risk management is an investment in measurably reducing a project's overall risk and avoiding preventable surprises, costs, and delays during construction.

[1] https://www.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2022BC_Chapter18_SoilsFoundationsWBwm.pdf&section=conscode_2022

[2] https://www.hka.com/crux-interactive-dashboard/

[3] https://globalarbitrationreview.com/guide/the-guide-construction-arbitration/fourth-edition/article/allocation-of-risk-in-construction-contracts

[4] https://www.rocscience.com/assets/resources/learning/hoek/Geotechnical-Risks-on-Large-Civil-Engineering-Projects-1998.pdf

Contact details

Bill Thompson
Associate Director
billthompson@hka.com
Ph: +1 267 831 2900