A NEW APPROACH TO GEOHAZARD MITIGATION

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A new approach to Geohazard Mitigation is proving to be both successful and economical in dealing with haul lease road washouts, slips and rockfall; pipeline slips and erosion; landslides on well pads; scour at creek crossings; and, also, substandard bridges and box culverts. These geohazards are common upstream and midstream challenges in the Eastern United States.

Typically the answer has been to enlist the support of various technical/construction trades to provide a collaborative solution using traditional tried and true contracting and excavation techniques. These conventional solutions oftentimes cannot address constantly changing ground conditions and many times they create ongoing and costly maintenance problems that significantly impact maintenance budgets in an already constrained operating environment.

A new approach to geohazard mitigation combines design/build/warranty project delivery with a variety of new innovative technologies, not yet in common practice. These include hybrids of soil and rock anchoring and nailing as well as Geosynthetically Confined Soil (GCS®) walls and abutments. These techniques combined with an experienced and dedicated workforce can provide quick, efficient, high quality, guaranteed repairs at costs that were previously unattainable.

INNOVATIVE CONTRACTING METHODS

The common themes for geotechnical issues throughout the oil patch in the Eastern United States involve problems associated with terrain that is remote, steep, and typically somehow involve critical highways to towns and/or communities. Heavy hauling of rock and fill can be problematic. Most likely any solutions involving road/pipeline/facility closures are not an option; time and again traditional methods prove to be too inconsistent; and the job must be completed yesterday.

Innovative solutions are best accomplished when there are synergies between the designers and construction crews, and where the contracting mechanism allows for design and construction changes to be made to “best fit” the application. This flexibility of system and process is critical to allow for field alteration as required. Ground conditions that are believed to exist may be vastly different than what lies underneath the ground’s surface. Oftentimes to obtain a robust design, an iterative process must be incorporated to derive the most robust solution. Figure 1 indicates the initial site characteristics that would be incorporated in the modeling scenario to stabilize a haul road.

Additionally, the existing geomorphic conditions coupled with changing atmospheric phenomena can change the projects’ complexity overnight – or even by the hour. Therefore design flexibility along with customer input are necessary to overcome these challenges and provide lasting solutions to the kind of pressing geotechnical problems illustrated above in Figure 2. This collaborative effort between the design team and construction crews even extends to the actual construction process. Many instances can arise in the construction process where the as-found conditions vary greatly and cause the original design to be “unworkable”.

Open communication and trust between the owner, designer, and contractor is the key to ensure that the constructed solution will indeed fully mitigate the geohazard. To facilitate this open communication and trust, a design/build/warranty contracting approach enables the optimal design be implemented and constructed with the oversight of the project owner. The warranty ensures that the designer/contractor works in the best interest of the owner so they won’t have to preform rework at their own cost.

This differs from a fixed-price contract where once a project impediment is realized; the work often stops while a change order is negotiated. This delay often causes worsening of the project conditions and a much greater contract cost to fix the greater challenges. Additionally the contractor can be locked into a work methodology that is immediately outdated once the “real” conditions are determined during the onset of construction – again leading to change orders and delays.
Launched Soil Nails:
Soil nailing is a reinforcement technique for inserting tensile members into a soil mass. These members provide tensile strength to unstable or potentially unstable soil. The nails resist slope movement by providing bending and shear resistance, but provide their largest contribution by acting in tension to increase forces normal to the slip plane (See Figure 3).

In order to install soil nails rapidly, at low cost, and in the caving and actively moving soil conditions found in landslides, European engineers developed launched soil nail technology in the 1980s. Actuated by compressed air at pressures up to 3000 psi, the cannon typically fires a 20 foot long, 1.5-inch diameter bar or tube into the ground in a single shot at velocities exceeding 250 miles per hour. The compressed air technology used to fire launched soil nails was originally developed by the British military to launch chemical weapons, but later repurposed for civilian applications.

Conventional (solid-bar) soil nails typically are installed using a drill to produce an open hole in which a nail is inserted and then filled with cementsitious grout. In landslides caving holes can present difficulties and necessitate drilling with a cased hole, which generally increases cost and project time. Because drilling cased holes in actively moving landslides pose safety and installation difficulties, solid-bar soil nails are rarely used for landslide repair.

Like conventional drilled and grouted soil nails, these rods reinforce an unstable or potentially unstable soil mass by transferring the nail's tensile and shear resistance into the sliding soil. Unlike traditional soil nails, launched soil nails are dynamically inserted into the soil without pre-boring a drill hole. This dynamic installation generates a shock wave that causes the soil particles to elastically deform around the nail tip and the bars enter the earth without significant abrasion or loss of exterior corrosion protection. When perforated, the tubes can also serve as horizontal drains. Pressure grouting of perforated launched soil nails can also increase bond strength values between 110 to 300 percent, with higher increases seen in granular soils with high porosity. Shallow landslides often exhibit surficial erosion as well. In those cases, erosion control blankets, meshes, or mats can be tied to the protruding nail tips to address surface erosion. In extreme cases, reinforced shotcrete can also be tied to the protruding nail tips, creating a truly structural solution to the landslide and associated surficial erosion.

Geosynthetically Confined Soil (GCS') Walls:
Thousands of years before the concept of “Reinforced Soil” became widely accepted, ancient people had already used soil with vegetative tensile inclusions to build structures. As early as 1000 B.C., Mesopotamians used layers of reeds and packed clay to build the cores of their ziggurats. Portions of the Great Wall in China were reinforced using the twigs of tamarisks trees between layers of gravel and clay. As shown above in Figure 6, the design attributes of GCS' walls is the closely packed soil that essentially locks the soil particles together and provides its strength. Limiting the distance between each “lift” ensures that the forces will keep the soil interlocked and will not dissipate the locking force; causing the wall's failure.

The use of these walls in the energy plays enable haul roads to be rebuilt in place and even provide additional shoulder width for guard rails and/or pull off lanes; reduce the footprint of well pads and other facility foundations; provide a fast and efficient vehicle bridge construction; and alleviate the permitting and zoning requirements as all construction can be accomplished on solid ground.

CONCLUSION
Traditional earthwork solutions used to mitigate geohazards that impact upstream and midstream infrastructure often create recurring and costly maintenance problems, negatively impacting maintenance budgets and enticing the wrath of regulators. Innovative, non-traditional solutions utilizing design/build/warranty contracts with experienced geohazard mitigation engineers and constructors can provide a cost effective solution, and assure lasting stabilization.

**Figure 4: Launched Soil Nail Installation**

Installation rates for launched soil nails vary between 100 to 250 nails per day. Assuming 80% average penetration, this equates to 1,600 to 4,000 feet of nail length per day; compared to conventional drilled soil nail installation rates of 1,000 feet and 300 feet using open hole and cased drilling techniques, respectively.

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