Geotechnology goes high-tech

Construction techniques and tools can help civil engineers develop efficient and successful designs.

By Bob Drake

Geotechnical engineering often is a key connection between a civil engineer's design and its successful construction and operation. "Any time infrastructure is going to be constructed, geotechnical problems must be considered in the design process," said Scott L. Deaton, Ph.D., president and chief software architect, Dataforensics. "Whether it is a levee-related issue in New Orleans; a landfill in Nebraska; or retaining walls, cut slopes, and fill embankments for highway designs in Nevada, site investigations are always performed to ensure the infrastructure can be constructed and [to determine] the required design and construction techniques."

In simple terms, problems commonly addressed by geotechnical investigations and tools are attributable to water; movement of soil or rock, including settlement; loads on structures or foundations; or a combination of these conditions. "Soils can offer unsuitable bearing capacities or excessive settlement from foundation loads, or be susceptible to liquefaction during a seismic event," said James Hussin, director, Hayward Baker Inc. "Geotechnical construction techniques can improve subsurface soils to increase bearing capacity, reduce settlement, add shear resistance, and reduce the liquefaction potential for planned or existing foundations."

Additionally, Hussin said, specialty underpinning techniques can solve settlement issues related to increased loading or inadequate subsurface soils and, depending on the rate of movement and site logistics, active landslides can be stabilized.

However, settlement and landslides may be symptoms of another problem. "Although we often refer to these as soil problems, I think they are more often water problems," said Frank Callanan, P.E., vice president, Geotechnology Inc. "Unanticipated or excessive quantities of water are often the cause of slope failures, block retaining wall collapse, premature pavement cracking, and building distress (settlement and heaving). Geotechnical engineers have a reputation for being conservative and using cautious language in our reports. When you have experienced the range of soil conditions and water-related problems, in particular, you start to appreciate why we need to err on the side of caution."

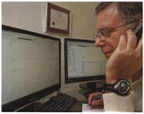
Nevertheless, monitoring soils and structures can help avert many of these problems, or at least prevent loss of life in critical situations. "People have utilized various sensors to monitor critical slopes in rainstorms to determine if a mudslide might occur or a hillside might wash away," said Ken Stevens, manager, Geotechnical & Structural Group, Campbell Scientific Inc. "People monitor ground saturation and can predict if flooding may occur in time to have people evacuate threatened areas. When it comes to foundations, geotechnical solutions include monitoring the movement of cracks in the foundation, an increase in load or stress on the foundation, earthquake damage, or erosion of soil surrounding the foundation."

Foundations are particularly challenging, according to Gina Beim, P.E., marketing department head, Pile Dynamics Inc. "They are structural

Geotechnology personnel monitor vibrocompaction ground improvement at a Missouri River floodplain site.

Pearson Piling fiber-reinforced polymer piles are used in coastal areas to elevate house foundations to protect the structures from flooding.

Pile Dynamics' SiteLink technology allows engineers using the company's Pile Driving Analyzer to observe dynamic foundation testing of piles remotely. Sensors attached to each pile transmit data wirelessly.



elements that not only cannot be visually inspected after installation, but once installed become part of a foundation-soil system in which one of the components (the soil) is non-homogenous and changes with time." Although engineers have developed creative solutions to analyze and monitor foundations, the field of foundation QA/QC is still evolving, Beim said. "There [now] is more incentive than ever to develop foundation testing solutions that are not only efficient and accurate, but also fast and economically viable," she said. "On one hand, new LRFD codes give incentive to projects in which more foundation testing is performed (by allowing a leaner design). On the other hand, there is less money for testing. The new products — or updates to existing products — that are popping up these days are coming from this mindset. The civil engineering projects that are early adopters are definitely reaping the benefits."

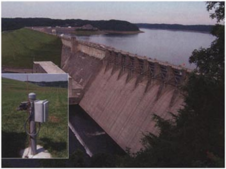
However, foundation problems often develop when changes occur in the surrounding soil caused by adjacent construction or demolition activities such as excavation, dewatering, and vibration, said Christopher Kavars, president and CEO, SENSR. He recommended that prior to construction, design professionals should survey the condition of properties adjacent to the construction site to understand their present condition and fragility, establish acceptable response limits, conduct soil-structure analyses of various earth-support systems, develop limits on their respective movements, and develop a monitoring strategy.

Dynamic monitoring capabilities have extended to three areas, according to Kavars: pre-construction and post-construction surveys, building-performance monitoring, and construction diagnostic monitoring. "All of these systems provide better analysis up front, better assessment during the project, and better mitigation plans, reducing potential problems," Kavars said. "Whether used to measure the sway of a building, or the vibration caused by construction, or the angle of a bridge pier during a scour event, it provides the solution to assist an engineer's decision-making, ensuring safety in a structure and protecting all involved in a construction project."

During construction, computerized data acquisition systems (DAQ) can help ensure that product quality is maintained and specifications are met, Hussin said. "Historically, these systems have been used simply to record," he said. "Today, DAQ systems allow the operator to monitor parameters in real time, and the computer takes control of the equipment based on inputted parameters to increase consistency, efficiency, and quality of the work."

Geotechnology impacts design

Modern geotechnology not only helps protect adjacent structures and enhances safety during construction through use of pre- and post-construction surveys and continuous-monitoring systems, but also can provide civil engineers with greater design flexibility by supporting leaner, less-expensive foundation designs and allowing construction in less suitable areas, including on slopes and in poor soils.



URS engineers remotely monitor water seepage through a dam with a Campbell Scientific CR1000 datalogger (inset photo) and AVW206 wireless vibrating-wire interface.