Factoring in the possibility of an earthquake or seismic event when evaluating soil conditions for a bridge replacement near the Kentucky and Tennessee border is not usually a consideration. However, for the $449 million Lake Bridges project in the Land Between the Lakes region in western Kentucky, it was crucial.

Seismic loading demands had to be taken into consideration for this project due to the proximity of Kentucky Lake and Lake Barkley to the New Madrid Seismic Zone, also known as the New Madrid Fault Line. As the first lake crossings below the lakes’ dams, the possibility of added seismic stress on the bridges’ structural elements due to the nearby fault line had to be included in a thorough geotechnical evaluation.

Considered vital to the region’s economy when complete, the two new bridges will have four, 11-foot-wide lanes as well as four-foot-wide shoulders and a 10-foot-wide multi-use path for pedestrians and cyclists. The project will make travel in the area much more convenient and open up recreation and economic development opportunities in western Kentucky.

**UNIQUE SOLUTIONS:**

Accommodating Fault Line, Soil, and Rock Conditions

As one of Terracon’s largest ever geotechnical transportation projects, the Kentucky Lake Bridge project is a showcase of Ron Ebelhar’s experience and a career highlight.

ONE-OF-A-KIND PROJECT

With nearly 40 years of environmental and geotechnical experience to draw on, Terracon’s Ron Ebelhar says this project was one to remember. While serving as 2015 chairman of the board for ASTM International, an authority on manufacturing and materials standards, he also spent time closer to his home in Cincinnati – managing the geotechnical construction phase.
for the Lake Bridges project, one of the largest geotechnical projects ever undertaken by the Kentucky Transportation Cabinet (KYTC). “The large differences in soil and rock conditions between the two lakes and the presence of liquefiable soil, bedded chert, and karst bedrock added up to some unusual challenges for design and construction and made this project memorable,” he stated.

The Terracon team of engineers, scientists, and technicians, provided the geotechnical site characterization and design parameters for the new bridge foundations. Using a suite of site characterization tools, our team evaluated the alluvial clay, sand, chert, and limestone stratigraphies. The team used a combination of data gathering methods including shear wave geophysical work (seismic reflection and downhole tests), Standard Penetration Tests (SPT), Cone Penetration Tests (CPT), Pressuremeter Tests (PMT), and rock coring, all simultaneously conducted from up to three barges.

Working in the lab, the team conducted a variety of soil and rock classification tests, strength and compressibility, resonant column, and cyclic simple shear tests to assess soil response under both static and dynamic loading conditions and to identify the specific site conditions. Selection for each bridge foundation type was influenced more by the soil and rock conditions than the New Madrid seismic zone. Ron’s take on this: “Most projects have a relatively short cycle from start to finish. We’ve been working on this since 2007 and will see completion of the second bridge in late 2017. But what makes it doubly memorable is the range of site characterization tools, complexity of the soil and rock conditions, seismic analyses, and foundation design considerations, all of which rolled together into a tremendous opportunity for us to showcase our skills and resources.”

APPLYING A UNIQUE DESIGN SOLUTION

Site characterization results made way for a unique design solution. The Kentucky Lake Bridge piers are supported on 6-foot-diameter driven pipe piles with constrictor plates positioned about 50 feet above the pile tips. As an alternative to shafts, these allowed enough pile penetration to develop lateral resistance to barge impact and earthquake loads, needing then only to be driven a relatively short distance to develop the required axial resistance by forcing a soil plug inside the pile. Terracon developed plans for a design phase pile load test program, contract notes for installation and monitoring of the pipe piles, and assisted KYTC with the review of contractor submittals and pile monitoring data for the acceptance of the piles.

With the right design solution in hand, the 550-foot-long main span arch, constructed on barges, was able to be floated out and lifted into place in just one day, a sight Ron now adds to his list of career highlights. “Seeing the bridge lifted onto the piers and knowing the years of preparation that went into the project was incredibly rewarding for our entire team,” said Ron.

The Kentucky Lake Bridge was completed in August and construction is under way on the sister bridge over Lake Barkley. As one of Terracon’s largest-ever geotechnical transportation projects, it is a showcase for not only Ron, but also KYTC and our entire company.

Ron Ebelhar

Ron is a senior principal in our Cincinnati office. As a project manager for geotechnical and environmental engineering projects worldwide, Ron has provided design, consulting, and diagnostic engineering services for commercial, industrial, transportation, waste disposal, and public utility projects; geotechnical engineering design and construction, including site soil response under seismic, cyclic, and dynamic loading; and marine geosciences and engineering field explorations. He is a registered professional engineer in eight states.
A tight schedule and unexpected challenges called for real-time problem solving for this moisture intrusion project.

“We can’t close the bank in order for you to fix our soggy floor issues,” said the manager of a longtime national retail banking client. This statement had Terracon’s facilities team focused on figuring out how many hours we could squeeze out of the fast-approaching Memorial Day weekend – the only option to make the needed floor repairs and meet the client’s deadline. The other catch: “You can’t start repairs until 6 p.m. Saturday night.”

Faced with this tight schedule, our team set to work determining the steps involved, literally hour by hour, from 6 p.m. Saturday of Memorial Day weekend to 9 a.m. the following Tuesday when the bank would reopen.

FINDING THE RIGHT PARTNERS
For more than three years, the bank had been coping with a moisture intrusion problem. After trying several “quick fixes” to no avail, they called Terracon. As the project manager, we assessed the situation and, with a firm understanding of the timeframe required, developed a solution to resolve the issue once and for all.

Our first calls were to epoxy sealer and concrete patch product representatives to identify the materials with the fastest cure time available. With a cure time confirmed at a pace that would not delay the project, we next secured local waterproofing companies that routinely perform these types of slab-sealer projects. After emphasizing that the schedule was not adjustable, contractor representatives quickly embraced the challenge and confirmed their commitment.

REAL-TIME PROBLEM SOLVING
The day finally arrived, and the subcontractors were spot-on with their initial work. We were on schedule approaching midnight on Saturday. However, as the vinyl composite tile (VCT) and other materials were being scraped off the floor, two abandoned Walkerducts were found in very different condition from those we saw in the mock-up exploration. These underfloor ducts were completely deteriorated, filled with water, and needed to be removed.

Standing in the middle of the bank at midnight on Saturday with the carpet already pulled up, our team decided to remove the ducts, knowing it might extend the schedule. The ducts were corroded to the point that they simply couldn’t remain. It was “all hands on deck” to pull them out prior to patching the concrete floor.

FAST AND RIGHT
Once the floor was patched, the epoxy waterproofing sealer was applied, new carpet installed, and all furniture moved back into place. We were even able to pick up some time on the schedule from what was lost during removal of the Walkerducts. The last steps of reconnecting wires and cleaning up were completed in time for the bank to open Tuesday morning—with several hours to spare.

We delivered a solution to a chronic moisture intrusion issue by bringing together a group of professionals to keep the project on track. Using pre-task planning coupled with resourcefulness to solve unforeseen challenges, this project was completed in 60 hours; no problem!

The lobby floor was replaced in just 60 hours and the bank reopened the Tuesday after Memorial Day with time to spare.

ANDREW WEBER, AIA, NCARB
Andrew is a senior architectural consultant with our Oakland, Calif., office. He has extensive experience in exterior building enclosure investigation and repair of both historic and contemporary buildings. Andrew has been involved with concept and design development, construction document coordination, construction administration, and comprehensive project management. His portfolio includes work for industries including banking, residential, hospitality, retail, offices, healthcare, prisons, and museums.
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LEARN MORE AT terracon.com

Spanning Lake Champlain and adjoining the cities of North Hero and Grand Isle, Vt., is the only functioning drawbridge in the Vermont Agency of Transportation’s (VTrans) highway system. The historic 63-year-old structure was slated to be redesigned in 2017, but due to the volume of both vehicle and ship traffic, repairs were needed to keep the bridge open until construction could begin. VTrans called Terracon to perform underwater investigations to get the data needed to make repairs.

DIVING INTO THE CHALLENGE

One of the first tasks for the Terracon team was to locate any buried submarine cables near the drawbridge structure and make sure they were secure. After reviewing location device options, our team decided to use a handheld, underwater metal detector to locate the cables, a quick and cost-saving option.

The team’s biggest challenge was to cut and extract twelve 4-inch-diameter cores from the existing foundation of the bridge. Working 10 days straight in extreme conditions, we were able to collect all the information the design engineer requested, under budget and on time. Coring was the most difficult and time-consuming part of the process. The aggregate in the concrete of this bridge was difficult to get through, and coring became an underwater battle.

The project began in the middle of May when water temperatures ranged from 35-38 degrees. To keep our divers warm, a system was used to pump hot water to them while working, allowing them to stay in the water for longer periods of time. A three-person dive team was assembled to perform the underwater tasks. With a dive supervisor, diver, and tender cross-trained to perform all jobs, a rotation was developed to keep all members fresh and able to perform the work.

DIVING DEEP:
Diving for Data in an Icy Underwater Investigation

KEEPING THE PROJECT — AND THE DRAWBRIDGE — MOVING

The team also had to contend with the drawbridge opening every hour to let ships pass through. Each time the bridge was moved, we had to disconnect all air hoses, adding a time-intensive extra step to the planning process. The lost time had to be recovered in the schedule by working early and staying late to ensure all work was complete for the day.

Despite high winds, rain, and even snow, the Terracon dive team delivered the necessary data to get the job done. The team collaborated with VTrans and all project participants to thoroughly plan and determine the most effective approach to perform the work including addressing the challenges of frigid water temperatures and ongoing drawbridge operations. Through these partnerships, the project was completed safely within the estimated timeframe and under budget.

Frigid temperatures required a three-person dive team to safely perform underwater tasks.

To keep our divers warm, hot water was pumped to them while working, allowing them to stay in the water for longer periods of time.

JASON HICKEY, P.E.

Jason is a project manager in our Cincinnati office. He has experience with all aspects of construction materials testing and inspection including soil, concrete, asphalt, and steel. Jason coordinates and manages large testing and inspection projects including staffing, training, coordinating with contractors, quality assurance, and quality control. He has managed private commercial and public transportation projects such as highways and airfields.
**VAPOR INTRUSION:**
How to Identify and Resolve Risk

Environmental regulations can require property owners to take proactive steps to protect stakeholders when site buildings are being acquired or sold. Recently, a client was in the process of selling a portfolio of multifamily apartment sites which included two, 93-year-old, three-story apartment buildings located in Minneapolis. As required by the buyer and the lender, a Phase I Environmental Site Assessment was performed at the site resulting in the identification of recognized environmental conditions (RECs). RECs included historical use of underground storage tanks containing fuel oil for heating as well as the potential for impacts from up-gradient area-wide sources, which led to a Limited Site Investigation (LSI).

During the LSI, Terracon collected soil gas samples from the building footprints outside and from beneath the building slabs to evaluate whether impacts were present in soil vapor and if an exposure potential existed from vapor intrusion. The identified concentrations of volatile organic compounds (VOCs) in soil gas exceeded regulatory risk thresholds, requiring immediate action to prevent exposure to the buildings’ occupants. A partner with the expertise and resources to develop and implement an effective solution in a challenging situation was needed. Terracon answered the call.

**EFFECTIVE SOLUTION**

Based on the soil gas results, the regulatory agency required mitigation of the soil vapors. Our team overcame numerous challenges on the project, which included the lack of existing building drawings, unknown footing design and layout, variability in floor slab condition and thicknesses, limited access to tenant occupied spaces, identification and abatement oversight of asbestos-containing materials, presence of lead-based paint, and the ongoing use of the site as an apartment complex.

With these challenges in mind, we prepared a Response Action Plan for approval by the regulatory agency, which included an initial design and a phased pilot testing plan for a sub-slab depressurization or mitigation system. A phased approach was necessary given the buildings’ ongoing occupancy and unknown subsurface conditions.

Pilot testing allowed us to assess soil conditions beneath the slabs and identify areas where vapor collection existed. We then used these results to begin a mitigation system design to vent accumulated vapors from beneath the building slabs efficiently and effectively.

Our phased approach to the pilot testing revealed the need for additional suction points in occupied spaces to effectively cover the entire buildings’ footprints. The final mitigation system design included 11 suction points in the lower level of each building connected through a network of piping leading to exhaust fans installed in each of the buildings’ unused coal rooms. Vented exhaust was discharged above the third-story roofline.

**VAPOR INTRUSION** is the migration of volatile gaseous contaminants, generated from impacted soil or groundwater, into a building via cracks in walls and floors, around utility lines, at floor drains, and other pathways. As regulatory requirements related to vapor intrusion evolve, it has become an important issue for our clients who are often acquiring or changing the use of a property.

**COMPLIANCE ACHIEVED**

Post-mitigation diagnostic testing and sampling confirmed effective sub-slab air flow, decreased concentrations of VOCs beneath the building slabs, and indoor air concentrations meeting regulatory standards. Based on these results, the site was issued a No Further Action (NFA) letter from the Minnesota Pollution Control Agency with long-term system operation and maintenance required as a condition of the NFA. The system design and performance allowed our client to meet post-closing obligations as well as provide a protective environment for the occupants.

**JASON GELLING, CPG**

Jason is a senior geologist in our Minneapolis office. He has more than 19 years of environmental consulting experience related to environmental assessments, tanks, spills, investigations of petroleum and non-petroleum impacted sites, and management of hazardous materials in various regions of the U.S.
Factoring in the possibility of an earthquake or seismic event when evaluating soil conditions for a bridge replacement near the Kentucky and Tennessee border is not usually a consideration. However, for the $449 million Lake Bridges project in the Land Between the Lakes region in western Kentucky, it was crucial.

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Considered vital to the region’s economy when complete, the two new bridges will have four, 11-foot-wide lanes as well as four-foot-wide commercial, industrial, retail, residential, office, medical, and hospitality projects throughout the Northern Virginia, Maryland, and Washington, D.C., metropolitan area.

**COAST-TO-COAST CAPABILITIES INCREASED BY RECENT ACQUISITIONS**

**CHJ Consultants (CHJ) and Geotechnical Consulting & Testing, Inc. (GC&T) Join Terracon**

Through the recent acquisitions of CHJ and GC&T, we have expanded our capabilities nationwide, bringing additional resources, expertise, and services to our clients from California to Virginia.

On the West Coast, CHJ provides our clients with geotechnical and materials testing services from three additional Southern California locations: Colton, Victorville, and Palm Desert. With a portfolio of projects that includes major hospitals, roadways, schools and universities, power projects, and flood control projects, CHJ brings 55 talented employees to the Terracon team.

On the East Coast, GC&T establishes our first Virginia offices with locations in Woodbridge and Dulles, adding well-regarded laboratory testing capabilities and 52 GC&T employees. GC&T is primarily dedicated to providing geotechnical and materials testing services for transportation and infrastructure.

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