PROBLEM REGOGNITION
GEOTECHNICAL ENGINEERING: LESSONS LEARNED

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Professor G. A. Leonards parting words to me after I was a Teaching Assistant for his undergraduate geotechnical class and as I was graduating with my MSCE in Geotechnical Engineering (December, 1976) -- your biggest challenge as a geotechnical engineer will be to recognize what the problem is -- you already have the skills to solve just about any geotechnical problem.

The following projects, projects where failures occurred, demonstrate that this statement from Professor G. A. Leonards has proven to be so true.

GROCERY STORE

This grocery store was constructed on a site with alluvial deposits of sand intermixed with compressible organic material. The site grades had previously been raised, and were raised another foot or two for this project. The geotechnical engineering report for the project recommended supporting the building on piles, including use of a structure floor slab (pile supported slab). The final design by the A/E firm called for a slab-on-grade.

Several years later, the owner noticed that the floor slab was settling – but the pile caps and building were not – resulting in differential settlement and resulting in obstructions for the grocery store customers. The A/E firm didn’t realize that the fill placed on the site, both during construction and prior to construction, would cause the floor slab to settle and result in differential settlement from the pile caps. The floor slab required removal, installation of piling, and construction of a new structural floor slab – all after hours at night and at considerable cost – to fix the floor.

SEWER EXCAVATION NEAR RESIDENCE

A sewer was being replaced in a residential neighborhood. The invert for the sewer was about 24 feet below grade. The contractor used sewer boxes for excavation support due to the depth of the excavation. During installation, the base of the excavation blew up, resulting in movements and distress on an adjacent house. A review of the USGS topographic map of the area showed the ground surface at the site to be about 3 feet below the level of a nearby lake. A well installed in an attempt to dewater the excavation found water flowing from the well without any pumping – that is, they found artesian groundwater.

The geotechnical engineering report did not mention or look for artesian groundwater, the engineering plans did not address or mention artesian groundwater, and the contractor was not prepared for artesian groundwater. Aggressive dewatering using a combination of large diameter deep wells and small diameter shallow wells was required to lower that water level enough to install the new sewer. The house required underpinning.
ELEMENTARY SCHOOL GYM

A new elementary school gym was to be constructed next to an existing elementary school. The geotechnical engineering report found fill over a swamp (peat, over organic silt, over soft clay). The design called for removal of the fill peat, organic silt, and soft clay – including proper oversizing of the excavation – and replacement with engineered fill.

During construction, the geotechnical engineer of record was not retained to monitor the earthwork – rather another firm was selected based on low fees. A few years later, the owner noticed severe cracking in the gym walls, and the floor was no longer level. A basketball would roll all by itself from the center of the court to the gym corner.

Further evaluation of the site and a review of the construction records found that the soft clay was never removed, and the excavation was not properly oversized. The geotechnical engineering firm retained during construction staffed the project with an inexperienced summer intern – an intern not even in civil engineering – who did not understand even elementary aspects of geotechnical engineering. The gym required costly underpinning of two outside walls using micro-piles.

FREEWAY

A freeway was constructed over loess, a soil that is known to geotechnical engineers as quite strong when dry, but very unstable when it becomes wet. The freeway required engineered fill to be placed in a valley to level the site. Not long after construction, the freeway failed. The earthwork cut off a drainage channel (a culvert was not installed), resulting in the loess soil becoming wet and unstable and resulting in failure of the embankment. The designer did not realize the importance of keeping the loess soil dry. Had the designer understood how critical it was to keep the loess dry, conventional culverts could have been installed and the failure would not have occurred.

SEGMENTAL BLOCK WALL

A segmental block retaining wall was constructed on a shopping center site. Segmental blocks are blocks of cast-in-place concrete that are stacked on top of each other. The blocks are kept in place either by their own weight, or by providing lateral reinforcing behind the wall. For this project, the walls were designed using just the weight of the blocks alone. During construction, the walls failed. A geotechnical engineer viewed the site and discussed the construction of the wall with the contractor. It became evident that the wall was not constructed as designed. Some of the blocks were smaller than specified in the design. Some of the existing clayey soil behind the wall was designed to be removed and replaced with clean drainable sand – but was not. The contractor elected to remove the wall and reinstall it as designed. The contactor did not appreciate that the changes to the design would result in failure.
COMMERCIAL BUILDING SLAB

During the winter, the entrance slab to this commercial building would heave so much that the front door would not open. The owner figured there was a problem with the concrete, and replaced the concrete slab with a new concrete slab only to have the same problem reoccur. After contacting an experienced geotechnical engineer, the problem was found. It had nothing to do with the concrete. Rather, the problem was due to water from the roof entering the gravel landscaping next to the slab and the water flowing under the slab and freezing. When water freezes, it expands. The frozen water lifted the slab. Once the problem was identified, the solution was rather simple; drain the landscaping gravel to a nearby storm drain to keep the water from flowing below the slab and freezing.

WASTEWATER TREATMENT PLANT

Construction of a clarifier tank for a wastewater treatment plant required dewatering of the site using large diameter deep well with submersible pumps. Even before all of the concrete for the tank was completed, the contractor notice the tank was no longer level. In fact, there was a large void visible under on side of the tank large enough to extend an arm beneath the concrete footing. Soil borings were requested, since it was thought that some compressible soil must be present below the tank. However, the borings encountered competent clay over sand. Another cause for the settlement had to be found. A sample of water was obtained from the discharge hose of a nearby dewatering well and sand was found in the water. The wells were pumping sand along with the water. Had the contractor understood that sand could be pumped along with the water, installing a proper filter could have prevented the undermining of the site.

HOUSE ON SAND DUNE

A multiple-story residential structure was constructed on the top of a sand dune. A geotechnical evaluation was not performed for this project, even though the structure was many stories high, had pre-cast concrete and steel beams, and was located in a precarious geological setting. After construction, cracks were observed within the structure. With time, the cracks became bigger and more severe. In an attempt to stabilize the structure, the building was underpinned. However, the structure continued to move and crack.

Finally, a geotechnical engineer was retained to evaluate the site. The structure was located on top of a sand dune near the backside (steep slope) of the dune. Monitoring of the structure and the sand indicated the sand was very unstable. The back slope of the sand dune was too steep for long-term stability, resulting in “creeping” of the sand with time. Because of the sloughing of the sand, the structure was moving along with the sand dune, resulting in severe distress of the structure.

Several alternatives were evaluated for fixing the structure, including underpinning, reinforcing the slope of the dune, moving the structure further from the backside of the dune, as well as demolition of the structure and starting over. The cost for repair became cost-prohibitive. Therefore, the decision was made by the owner to demolish the structure.
SHOPPING CENTER

A shopping center was to be constructed on a site near a major highway. Two geotechnical evaluations were performed – one preliminary evaluation prior to purchasing the site by Geotechnical Engineering firm A, and a second evaluation for design by Geotechnical Engineering firm B. During construction Geotechnical Engineering Firm C was retained to provide density testing of engineered fill, since the site needed to be leveled (cut and fill). As much as 15 feet of fill was placed. After the fill was placed, there were questions regarding the quality of the engineered fill and the underlying soil – especially since all three geotechnical engineering firms were retained base on low bids.

Geotechnical Engineering firm D was then retained and additional soil borings performed. Not only was the “engineered” fill found to be questionable, but compressible organic soils were found below the fill. The organics were somewhat “hidden”. During construction of the nearby highway many years’ prior, the highway department placed fill on the site covering the organics soil. Geotechnical Engineering firms A, B, and C never realized there were problem soils lurking below the old fill. The fix was expensive; requiring removal of the new “engineered” fill and buried old fill and organic soil and replacement with engineered fill.

PARKING STRUCTURE

A parking structure was constructed near a river. The elevation of the lowest floor of the parking structure was located several feet above the normal river water level, and the parking structure was surrounded by earth when constructed. Several years after the parking structure was built, there was a desire by the City to provide better access to the river and a new ramp was constructed next to the parking structure. This resulted in removal of soil from one corner of the parking structure.

Many years later, the adjacent river flooded, rising over 20 feet from the normal flow elevation. The lower floor of the parking deck was lifted by the water pressure from the nearby river, resulting in flooding of the lower floor area of the parking deck – and flooding of many cars that couldn’t get out plus flooding of the electrical control room of an adjacent residential tower. The fix required removal of the floor slab, and installing a cutoff wall and a new underdrain system.
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Robert (Bob) C. Rabeler, PE graduated from Purdue University with a MSCE (geotechnical) degree in December, 1976. Mr. Rabeler was a Teaching Assistant for Professor G.A. Leonards, and Dr. Leonard’s was Mr. Rabeler’s Major Professor.

Mr. Rabeler is now a Senior Vice President with SME, an engineering firm specializing in geotechnical, environmental, pavements, building and construction materials. SME has staff of over 250 located in offices in Michigan, Indiana, and Ohio. For more information about SME, visit www.sme-usa.com.

Bob is a licensed Professional Engineer in six mid-west states. Because of his expertise, Bob has been sought out to perform over 25 GBA/ASFE peer reviews of other firms across the USA and Canada. Mr. Rabeler also serves on SME’s Board of Directors. Mr. Rabeler has been active in many professional organizations, including ASCE, NSPE, and GBA/ASFE (he was chair of the Peer Review committee and member of the Board of Directors).

Mr. Rabeler has 40 years of experience on thousands of projects throughout the Midwest. Bob has seen this play out over and over again – many failures have occurred because those involved did not recognize the problem. Today, Mr. Rabeler’s presentation titled: “Problem Recognition – Geotechnical Engineering: Lessons Learned” will show why lack of problem recognition is often the key factor in failures.

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