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GEOTECHNICAL · MATERIALS · GEOSCIENCES
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January 30, 2025

Mr. Logan Sams, PE
Sams and DeGough Engineers, PLLC
211 North Main Street
London, KY 40741

Subject: Review of Site Work Geotechnical Report by CETCO
Estill County Middle School, Irvin, Kentucky
Proposal Number: 25.05.0010SHE

Dear Mr. Sams,

As requested, we have conducted a review of the Site Work Geotechnical Report conducted on the site by CETCO dated January 17, 2025. Our review is to provide an overall opinion of the recommendations made for support of the proposed new middle school based on the site geology. Our recommendations are based on experience with the geological conditions, review of published literature and experience in the Estill County area.

Project Information

From our review of the geotechnical report and our conversations with you, we understand that the proposed building and finished floor elevations are still in the planning phase. However, currently the proposed building will generally be an "X" shaped configuration with about 100,000 square feet of floor area. The proposed building will be a single story, concrete slab on grade floor, with CMU block load bearing walls and interior metal framing. The preliminary finished floor elevation will be about 780 to 785 feet mean sea level. We understand that the entire building will be situated on the proposed cut area along the ridge. The parking lots and drive lanes will most likely be in fill areas.

The site of the proposed building is a northwest to southeast trending ridge about 1000 feet southwest of the now closed existing middle school and west of the high school campus (Figure 1).

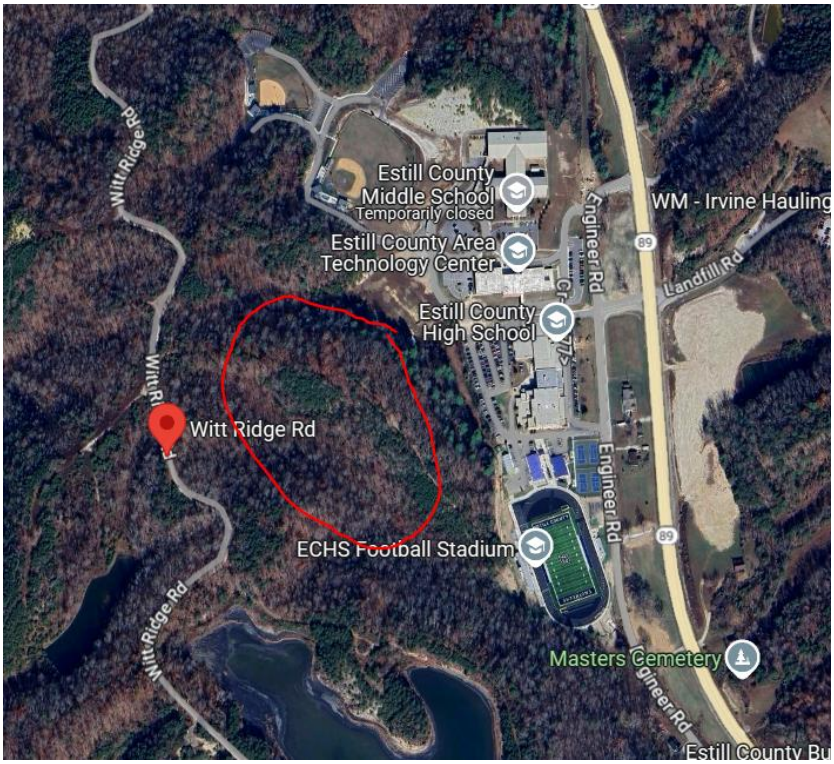

Figure 1: Aerial view of the general site location in red.

Information from the geotechnical report indicates the site preparation will consist of cutting the ridge down about 50 to 80 feet and filling the adjacent valleys about 20 to 40 feet. The site geology consists of New Albany shale which contains pyrite. The New Albany shale, especially in the Irvine area, has a history of swelling once exposed to air and water. Testing of five select shale specimens at the anticipated cut depths within the shale revealed pyritic sulfur contents of 2 to 4.2 percent. The pyritic sulfur content of a material is generally considered and indicator of its potential for volume expansion. In general, materials containing pyritic sulfur contents in excess of 0.1 percent (by dry weight) are considered to be potentially expansive, and materials containing pyritic sulfur contents in excess of 1 percent are considered highly expansive.

Background Information

There are numerous documented cases of damage related to pyritic shale expansion. In Estill County, as you know, the old middle school, the hospital, and the Carhart Facility has experience heaving issues related to the pyritic shale. Other parts of the region underlain by pyritic shale suggest expansion pressures ranging from 3000

to over 10,000 pounds per square foot. Heave magnitudes of up to two inches per foot of expansive shale thickness for lightly loaded floor slabs have been reported with sulfur contents of 3 to 5 percent. Floor slab uplifts of lightly loaded floor slabs and pavements can result with pyritic sulfur contents of about 0.5 percent.

The time duration for the expansion to occur can take many years depending on the exposure to air and water. Some cases in West Virginia, floor slab heave was not identified for several years after a facility was constructed. In some structures the damage was reported over periods of 30 years or more. Pyritic shale oxidation and volume expansion are initiated when the shale is exposed to air and moisture by excavation. Flow of water through shale occurs largely by means of secondary permeability through discontinuities (bedding planes, joints, fissure, and fractures) in the rock mass. The water permeability of intact shale may be as low as 10^{-8} to 10^{-12} cm/sec and in the discontinuities as high as 10^{-2} cm/sec.

Where expansive shale is excavated and used as fill, a very large surface area becomes accessible to air and moisture. Pyritic shale fills are particularly susceptible to oxidation and significant volume expansion. Facilities built over relatively loose fill may not exhibit have as quickly after construction as facilities over intact shale since some compression or consolidation of the fill may occur before the fill develops sufficient uplift pressure to lift the structure.

Discussion and Recommendations

Due to numerous cases of problems associated with building performance when built on pyritic shale, the owner must understand and accept the risk associated with this site. The recommendations provided are to assist in reducing the owners' risk not eliminate them.

As previously mentioned, the pyritic shale expands once exposed to air and water. The excavation of the soil overburden above the shale bedrock will enhance the oxidation of the sulfide minerals. By cutting the site up to 80 feet, removal of any weathered bedrock will occur exposing fresh bedrock that probably contains higher concentrations of sulfide materials. Additionally, removal of overburden pressure can cause rebounding and fracturing the underlying strata, further exposing the sulfide materials

to air and moisture. Furthermore, a secondary effect of excavation is that the building is founded closer to the sulfide layer, which may cause a loss of any insulation of the sulfide bearing stratum from the heat of the structure. This insulation from heat given off by the structure is important to minimize a temperature gradient (vapor drive) that may cause an upward migration of water and dissolved oxygen which could accelerate oxidation of the sulfide mineral.

There are several options to reduce the exposure to air and water of the exposed pyritic shale. Ideally, leaving the soil overburden in place to maintain the buffer zone would be most desirable, however, as mentioned, this site requires extensive cutting and filling. Therefore, exposure of the pyritic shale will occur. Past experience indicates that foundation bearing loads of over 3000 psf are generally considered adequate to confine the swelling pressure of the pyritic shales, at least in the short term. However, slab loads are not adequate to counteract the swell pressures. There are options to reduce the swell potential. Several options are as follows:

1. Designing rock bolts in combination with a reinforced "mud mat." The rock bolts would be installed to equal the expected expansion stress of the shale. Due to the size of the building, this option would not be economically feasible.
2. Limit the exposure of the bedrock to prevent the oxidation process. Remediation measures include the use of bituminous spray sealants, thin mud mats, limit the use of calcareous subbase materials (dense graded aggregate) on top the shale, and construction structural slabs. Again, this option is not a cost-effective solution.
3. Undercut the pyritic shale several feet below the anticipated elevations of structural elements and backfill with a low permeable clay soil. This option would reduce the amount of water and air exposure and provide a uniform bearing material for the building and pavements. This recommendation was provided in the geotechnical report.
4. Other options include applying an impermeable liner over the exposed bedrock before placing structural fill to reduce the exposure to air and water. However, due to the size of the building, this option would not be cost effective.
5. With the assumption that the foundation bearing pressures will be sufficient to resist the swell pressures, the slab could utilize void boxes similar to what is used on highly expansive clay sites to allow some expansion to occur without damaging the slab. This option would be used in conjunction with the undercutting and use of clay cover over the shale.

We understand a definitive construction schedule has not been provided and the project is still in the preliminary phase. The main items to consider on this project are to make sure the building is over the cut bench and not straddling a cut/fill line. If some of the buildings must be over fill material, the fills should be less than 4 to 5 feet thick.

Also, it is imperative to minimize the time the shale cut surface is exposed to the elements, therefore sealing the shale surface should be initiated within days of exposure. If the exposed shale is left open longer than a week or if excessive rainfall occurs, the activation of the sulfate can begin the expansion process. We agree with the CETCO recommendations of using a 4-foot soil fill over the site. However, since a borrow area has yet to be identified an option would be to grade the ridge cut several feet high and allow it to be exposed to the elements until the fill is ready to be placed. The longer the shale is exposed to the elements, the deeper the pyritic sulfate expansion will occur. Once the fill is to be placed, remove the upper portion of the shale that has begun to oxidize to non-exposed shale. The low permeable clay fill should be placed over the entire fill area prior to placing subsequent lifts of additional fill to achieve the full 4 feet depth.

Proper drainage is also important to reduce the risk of exposure of the shale. In the fill areas, the pyritic shales will still be subjected to expansion when exposed to air and water, therefore, before placing the shot shale fill, a durable rock drainage blanket should be placed allowing subsurface water from side slope springs, and possible groundwater to escape from the fill.

Let us know if you would like to meet to discuss the site specifics.

Respectfully Submitted,
VECTOR ENGINEERS, INC.

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References

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6. “Embankment Construction Using Shale by Tommy Hopkins and Tony Beckham, Kentucky Transportation Center, Research Report KTC-98-2, dated January 1998.
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