TWINING

Geotechnical Engineering Evaluation Report

Pierce Hall Classroom Addition
And Building Renovation Project
University of California Riverside

Prepared for:
University of California Riverside
1223 University Avenue
Riverside, California 92507

July 8, 2016
Project No.: 160060.3

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6. GEOTECHNICAL ENGINEERING RECOMMENDATIONS

6.1. General Considerations

Based on the results of our field exploration and engineering analyses, it is our opinion that the proposed development is feasible from a geotechnical standpoint, provided that the recommendations in this report are incorporated into the design plans and are implemented during construction.

The site is underlain by a thin layer of undocumented fill followed by relative uniform medium dense to dense very old alluvial fan deposits. We expect that the upper 3 feet of soil will be disturbed during demolition of the existing onsite structures, trees and vegetation. It is our opinion that the proposed building should be supported on conventional spread footings embedded in compacted fill approved by Geotechnical Engineer during construction.

Our geotechnical engineering analyses performed for this report were based on the earth materials encountered during the subsurface exploration for the site. If the design substantially changes, then our geotechnical engineering recommendations would be subject to revision based on our evaluation of the changes. The following sections present our conclusions and recommendations pertaining to the engineering design for this project.

6.2. Site Preparation and Earthwork

In general, earthwork should be performed in accordance with the recommendations presented in this report. Twining should be contacted for questions regarding the recommendations or guidelines presented herein.

6.2.1. Site Preparation

Site preparation should begin with the removal of any utility lines, asphalt, concrete, vegetation, and other deleterious debris from areas to be graded. Tree stumps and roots should be removed to such a depth that organic material is generally not present. Clearing and grubbing should extend to the outside edges of the proposed excavation and fill areas. We recommend that unsuitable materials such as organic matter or oversized material be selectively removed and disposed offsite. The debris and unsuitable material generated during clearing and grubbing should be removed from areas to be graded and disposed at a legal dump site away from the project area.

6.2.2. Overexcavation

It is expected that surficial soil will be disturbed due to removal of the existing site structures and vegetation. To prepare a relatively uniform support for foundation and slab support, overexcavation should be at least 3 feet below the existing ground surface, or 1 foot below the proposed bottom of footings, whichever is deeper. The lateral extent of the overexcavation should be at least 5 feet beyond the edge of the building footprints, where space is available. Deeper excavations may be required in areas where loose or unsuitable materials, for example, tree root balls or undocumented fill are encountered.

Other site improvements, such as pavement, sidewalk and hardscape, should be overexcavated to a depth of at least 1 foot below the existing ground surface or at least 1 foot below the proposed subgrade, whichever is deeper.

The extent and depths of removal should be evaluated by Twining's representative in the field based on the materials exposed during grading. Additional removals may be recommended if loose or soft soils are exposed.

6.2.3. Materials for Fill

On-site soils with an organic content of less than 3 percent by volume (or 1 percent by weight) are suitable for use as fill. Soil material to be used as fill should not contain contaminated materials, rocks, or lumps over 4 inches in largest dimension, and not more than 40 percent larger than ¾ inch. Utility trench backfill material should not contain rocks or lumps over 3 inches in largest dimension. Larger chunks, if generated during excavation, may be broken into acceptably sized pieces or may be disposed offsite.

Any imported fill material should consist of granular soil having a "very low" expansion potential (that is, expansion index of 20 or less). Import material should also have low corrosion potential (that is, chloride content less than 500 parts per million [ppm], soluble sulfate content of less than 0.1 percent, and pH of 5.5 or higher). Materials to be used as fill should be evaluated by a Twining representative prior to importing or filling.

6.2.4. Compacted Fill

Prior to placement of compacted fill, the contractor should request an evaluation of the exposed excavation bottom by Twining. Unless otherwise recommended, the exposed ground surface should then be scarified to a depth of approximately 6 inches and watered or dried, as needed, to achieve generally consistent moisture contents at or near the optimum moisture content. The scarified materials should then be compacted to 90 percent relative compaction in accordance with the ASTM Test Method D1557.

Fill materials should be moisture conditioned to approximately 2% above optimum moisture content prior to placement. The optimum moisture content will vary with material type and other factors. Moisture conditioning of fill soils should be generally consistent within the soil mass. Continue to place the compacted fill in horizontal lifts of approximately 6 to 8 inches in loose thickness. Each lift should be compacted by mechanical methods, using multiple-wheel pneumatic-tired rollers, sheepsfoot rollers, or other appropriate compacting rollers, to a relative compaction of 90 percent as evaluated by ASTM D1557 test method. Successive lifts should be treated in a like manner until the desired finish grades are achieved.

6.2.5. Temporary Excavations

Temporary excavations for the demolition, earthwork, footings, and utility trenches are expected to be up to 4 feet in height. We anticipate that unsurcharged excavations with vertical side slopes less than 4 feet high will generally be stable; however, some sloughing of relatively loose to medium dense, cohesionless sandy materials encountered at the site should be expected.

Where the space is available, temporary, unsurcharged excavation sides over 4 feet in height should be sloped no steeper than an inclination of 1.5H:1V (horizontal:vertical). Where sloped excavations are created, the tops of the slopes should be barricaded so that vehicles and storage loads do not encroach within 10 feet of the top of the excavated slopes. A greater setback may be necessary when considering heavy vehicles, such as concrete trucks and cranes. Twining should be advised of such heavy vehicle loadings so that specific setback requirements can be

established. If the temporary construction slopes are to be maintained during the rainy season, berms are recommended to be graded along the tops of the slopes in order to prevent runoff water from entering the excavation and eroding the slope faces.

Excavations should not undermine the existing adjacent footings. Where space for sloped excavations is not available, temporary shoring (trench box) may be utilized. Additional temporary shoring recommendations will be provided up on request once detailed information becomes available.

Personnel from Twining should observe the excavation so that any necessary modifications based on variations in the encountered soil conditions can be made. All applicable safety requirements and regulations, including CalOSHA requirements, should be met.

6.2.6. Excavation Bottom Stability

In general, we anticipate that the bottoms of the excavations will be stable and should provide suitable support to the proposed improvements. Unstable bottom conditions may be mitigated by overexcavation of the bottom to suitable depths and replacement with an18-inch-thick layer of gravel, aggregate base or lean concrete mud mat. Any loose, soft, or deleterious material should be removed prior to placement of gravel or lean concrete. Recommendations for stabilizing excavation bottoms should be based on evaluation in the field by the geotechnical consultant at the time of construction.

6.2.7. Construction Dewatering

Due to the absence of shallow groundwater, dewatering measures are not anticipated to be necessary during excavation operations. If needed, considerations for construction dewatering should include anticipated drawdown, volume of pumping, potential for settlement of nearby structures, and groundwater discharge. Disposal of groundwater should be performed in accordance with guidelines of the Regional Water Quality Control Board.

6.2.8. Rippability

Based on our subsurface exploration of the site, the fill a materials should be generally excavatable with heavy-duty earthwork equipment in good working condition. Some gravels or cobbles or man-made debris should be expected within the fill soils.

6.2.9. Shrinkage/Bulking Due to Compaction

Based on our review of the in-situ density of the near surface soils, we estimated the volumetric shrinkage as a result of compaction of onsite soil is expected to be on the order of 5 to 10 percent.

6.3. Foundation Recommendations

A shallow foundation system may be used for support of the proposed building, provided that all the footings are placed on engineered fill prepared as described in the “Site Preparation and Earthwork” section of this report. Our geotechnical design parameters are presented in Table 2.

Table 2 – Geotechnical Design Parameters for Continuous and Spread Footings

Minimum Footing Dimensions	• Square footing should be at least 24 inches in width and the bottom of footing should be embedded at least 24 inches below the lowest adjacent grade. • Continuous footing should be at least 18 inches in width and the bottom of footing should be embedded at least 24 inches below the lowest adjacent grade.
Allowable Bearing Pressure	• For the minimum dimensions shown above, an allowable bearing pressure of 2,500 pounds per square foot (psf) can be used. • Bearing capacity can increase 300 psf for each additional foot of width, and 450 psf for each additional foot of depth to a maximum allowable capacity of 4,000 psf • The allowable bearing values may be increased by one-third for transient live loads from wind or earthquake.
Estimated Static Settlement	• Less than ½ inch total settlement with differential settlement estimated to be less than ¼ inch over 30 feet.
Allowable Coefficient of Friction Below Footings	0.35
Unfactored Lateral Passive Resistance	300 pcf (equivalent fluid pressure)

The total allowable lateral resistance can be taken as the sum of the friction resistance and passive resistance. The passive resistance values may be increased by one-third when considering wind or seismic loading.

6.4. Concrete Slabs

Slabs should be supported at grade on engineered fill in accordance with the recommendations of this report. For design of concrete slabs, a modulus of subgrade reaction (*k*) of 150 pounds per cubic inch (pci) may be used for slabs on compacted, engineered fill.

Floor slabs should be designed and reinforced in accordance with the structural engineer's recommendations. However, for slabs not supporting heavy loads, we recommend that the concrete should have a thickness of at least 4 inches, a 28-day compressive strength of at least 3,000 pounds per square inch (psi), a water-cement ratio of 0.50 or less, and a slump of 4 inches or less. Slabs reinforcement and control joints should be designed and constructed in accordance with recommendations from the structural engineer or architect. For slabs supporting equipment, a minimum thickness of 5 inches is recommended. Additional thickness and reinforcement recommendations may be provided by the structural engineer.

The topmost 12 inches below the slab subgrade should be maintained in a moisture condition of approximately 0 to 2 percent above optimum moisture content. The slab subgrade should be tested

for moisture and compaction immediately prior to placement of the gravel or sand base, if any. All underslab materials should be adequately compacted prior to the placement of concrete. Care should be taken during placement of the concrete to prevent displacement of the underslab materials. The underslab material should be dry or damp and should not be saturated prior to the placement of concrete. The concrete slab should be allowed to cure properly and should be tested for moisture transmission prior to placing vinyl or other moisture-sensitive floor covering.

Table 3 provides recommendations for various levels of protection against vapor transmission through concrete floor slabs placed over a properly prepared subgrade. Care should be taken not to puncture the plastic membrane during placement of the membrane itself and the overlying silty sand.

Table 3 – Options for Subgrade Preparation below Concrete Floor Slabs

Primary Objective	Recommendation
Enhanced protection against vapor transmission	• Concrete floor slab-on-grade may be placed directly on a 15-mil thick moisture vapor retarder that meets the requirements of ASTM E 1745 Class C (Stego Wrap or similar). • The moisture vapor retarder membrane may be placed directly on the subgrade (ACI302.1R-67); if required for either leveling of the subgrade or for protection of the membrane from protruding gravel, then place about 2 inches of silty sand[1] under the membrane. • Special consideration for curing the concrete, such as wet curing, should be made if concrete is placed directly on the impermeable vapor retarder.
Above-standard protection against vapor transmission	This option is available if the slab perimeter is bordered by continuous footings at least 24 inches deep, OR if the area adjacent and extending at least 10 feet from the slab is covered by hardscape without planters: • 2 inches of dry silty sand[1]; over • Waterproofing plastic membrane 10-mil thick; over • At least 4 inches of ¾-inch crushed rock[2] or clean gravel[3] to act as a capillary break
Standard protection against vapor transmission	• 2 inches of dry silty sand[1]; over • Waterproofing plastic membrane 10-mil thick. If required for either leveling of the subgrade or for protection of the membrane from protruding gravel, place at least 2 inches of silty sand[1] under the membrane.

Notes: [1] The silty sand should have a gradation between approximately 15 and 40 percent passing the No. 200 sieve and a plasticity index (PI) of less than 4.

[2] The ¾-inch crushed rock should conform to Section 200-1.2 of the latest edition of the "Greenbook" Standard Specifications for Public Works Construction (BNI Publications, Inc., 2012).

[3] The gravel should contain less than 10 percent of material passing the No. 4 sieve and less than 3 percent passing the No. 200 sieve.

The recommendations presented above are intended to reduce the potential for cracking of slabs; however, even with the incorporation of the recommendations presented herein, slabs may still exhibit some cracking. The occurrence of concrete shrinkage cracks is independent of the supporting soil characteristics.