LESSONS LEARNED:

GEOTECHNICAL ENGINEERING

OBSERVATIONS AND LESSONS FROM THE SCHOOL OF EXPERIENCE

ENGINEERED FILLS

All building projects employ engineered fills and/or engineered backfills. Earthwork usually consists of a combination of two processes; cutting the existing overburden to reach proposed grades, and placing and compacting engineered fills. While cut operations can be relatively straight forward, they have problems that differ from engineered fills. The focus of this "***Lessons Learned***" is engineered fills, also commonly referred to as "controlled" fills or "structural" fills.

Generally, dense controlled fill is stronger and exhibits better engineering properties than the same soil placed at a lower compaction level. For example, a well compacted soil will result in less settlement, higher bearing capacities, higher subgrade modulus values for slabs and pavements, and lower permeability, etc. If the process of placement and compaction is not carefully planned and executed, problems can include excessive settlement, cost overruns, and project delays, among others. The question is: How much compaction is sufficient, where it is specified, and how is it measured in the field?

The first steps in the design phase incorporating engineered fills includes identifying appropriate soil types, performing laboratory classification and compaction tests, and specifying the level of compaction needed in the field during construction. Soils vary in their engineering properties; therefore selecting the appropriate soil types to meet the needs of the project is important. Sources of fill can be from onsite and/or offsite sources.

The laboratory test for compaction is called a Proctor test, with the Standard Proctor and Modified Proctor (higher compaction energy) methods being the most common. The Proctor test determines how dense a soil can be compacted for a specified amount of compaction energy, and the range of moisture contents that yield the highest densities. If the soils are too dry or too wet, high densities cannot be achieved. The "maximum dry density" is achieved at a moisture content called the "optimum moisture content". The laboratory tests for the Standard Proctor method are ASTM D-698 and AASHTO T-99, and ASTM D-1557 and AASHTO T-180 for the Modified Proctor method. State highway departments often have their own designations for these tests, or variations of the tests.

When soils are compacted in the field, varying levels of compaction energy are imparted to the controlled fill, unlike the laboratory setting where the energy is controlled. In addition, recognizing that the soils in the field are usually not at the optimum moisture content, a percentage of the laboratory maximum dry density and corresponding range of moisture contents are specified for the project. The density measured in the field is compared to the maximum density obtained from the laboratory test and the ratio of the densities is expressed as a percentage. A common minimum percent compaction specified is 95% compaction, but the range can typically be 90% to 100%. The percent compaction is meaningless without knowing the specified method. For instance, 95% compaction using the Standard Proctor method may yield the same density as 93% compaction using the Modified Proctor method.

Another very important aspect of engineered fill construction is the placement of soil in "lifts" (layers), compacting each lift, and verifying that the specified minimum compaction percentage has been achieved by field compaction testing before the next lift is placed. If the lift is too thick, the lower portions of the lift will not achieve the desired compaction level. The lift thickness is dependent on the size of the compaction equipment. Lift thicknesses must be reduced when using small compaction equipment.

To answer the question posed, the project geotechnical engineering report identifies appropriate soil types, lift thicknesses, Proctor compaction method, and minimum percent compaction to be achieved in the field during construction. These are specified based on the engineering properties desired for the intended construction. The frequency of field compaction testing is often also specified. The project specifications should be reviewed by the geotechnical engineer of record prior to issuance to confirm that the engineered fill recommendations from the geotechnical report have been properly incorporated into the specifications.

During construction, the first steps are to verify that topsoil and unacceptable soils have been removed, then verify that the exposed soil subgrade is suitable for the placement and compaction of engineered fill materials. A common practice is to "proofroll" the exposed soil subgrade with a piece of equipment such as a fully loaded dump truck or other heavy wheeled (typically not tracked) vehicles. "Proofrolling" is performed to identify soft soils, rutting, or deflection of the subgrade surface under the wheel loads. If the exposed subgrade is soft or yielding, sometimes called "pumping", it will be very difficult to achieve compaction. A "pumping" subgrade is similar in concept to trying to compact something on a mattress; difficult if not impossible. Proper subgrade preparation is very important for engineered fill performance so unstable fill subgrade soils should be stabilized in place or removed prior to the start of fill placement.

Finally, it is critical that field compaction testing of the fill materials be performed during earthwork operations to confirm that the design engineered fill parameters are achieved. The most common type of field compaction testing uses a nuclear density gauge, which contains very small amounts of several radioactive materials to determine the density and moisture content of the soils being tested. It is best to have experienced geotechnical personnel on site on a full time basis during placement and compaction of engineered fills to verify that the fill is being placed in accordance with the project specifications. Experienced geotechnical personnel can also assist the earthwork contractor in solving problems related to subgrade preparation, and engineered fill compaction.

We hope this "***Lessons Learned***" has increased your understanding of engineered fills. Please contact your nearest ECS office for additional information on this or other topics of interest.

Respectfully,
ECS Corporate Services, LLC