Rebuilding Mountains with Expanded Polystyrene

Brendan Stepek, EI[1]

[1]Schnabel Engineering LLC, 11A Oak Branch Drive Greensboro, NC 27407;
e-mail: bstepek@schnabel-eng.com

Yeager Airport in Charleston, West Virginia was constructed between 1944 and 1947 by leveling three mountain tops and filling in the valleys in between. In 2006 a 73 meter (240 foot) tall reinforced soil slope (RSS) was constructed at the end of Runway 05. The RSS was built to allow room for an emergency aircraft safety area in accordance with FAA safety regulations. However, in 2015 the RSS failed destroying the emergency aircraft safety area as well as blocking a road, damming up a creek, and damaging nearby properties. Yeager Airport retained an engineering consultant to oversee the emergency cleanup and stabilization of the failed slope, and to provide a design for restoration of the Runway 05 emergency aircraft area.

Rebuilding the emergency aircraft safety area was critical to restoring safe and efficient airport operations. However, the slope failure clean up and stabilization resulted in a 1.5H:1V slope and limited working area. The proposed solution included building a 25.6 meter (84 foot) tall anchored retaining wall. This retaining wall would allow for the emergency aircraft safety area to be restored to its original length pre-slope failure.

A major consideration during design was the lateral earth pressure exerted on the retaining wall by the backfill material. The pressure on a retaining wall is mainly a function of the backfill material density and fill height. Using conventional soil backfill behind this wall would have resulted in very robust and expensive structural wall elements. In an effort to improve long term wall performance by reducing vertical load on the slope and lateral pressure on the wall, the design consultants proposed partially backfilling the wall with light weight fill. Expanded Polystyrene (EPS) was selected as the backfill material in order to create a more economical and feasible wall design.

Expanded Polystyrene is a material manufactured by the expansion of closed cell polystyrene beads. The beads are expanded by the use of steam resulting in a foam that can be shaped using molds. EPS foam, or as it is known in the geosynthetic world, “geofoam”, is an ultra-lightweight fill material. It is typically manufactured with densities in the range of 11.2 kg/m^3 (0.70 lbs/ft^3) to 45.7 kg/m^3 (2.85 lbs/ft^3). The compressive strength ranges from 15 kPa (2.2 lb/in^2) to 128 kPa (18.6 lb/in^2). Most EPS design guidelines use a strain based limit of approximately 1 percent. This limits the allowable compressive strength to the linear elastic range of the EPS material’s stress-strain curve.

The geosynthetic solution was a 23,000 cubic yard EPS fill composed of multiple grades of geofoam with a protective geomembrane covering. The EPS fill has a maximum height of nearly 50 feet. Using multiple grades of EPS increased material efficiency by allowing the denser, stronger, and more expensive EPS blocks to be concentrated in areas of higher anticipated loading. The EPS mass was designed following the National Cooperative Highway Research Program (NCHRP) guidelines.

The project specifications included a Manufacturer Quality Assurance (MQA) and Manufacturer Quality Control (MQC) program. As part of the MQA, a representative sample from every delivery of EPS was selected for quality assurance field testing. The density and dimensions of approximately 304 blocks, or 5% of the EPS fill volume was measured. The field density measurement proved to be an important indicator of material quality and strength. In addition, 49 EPS samples were sent to a laboratory as part of both the MQA and MQC programs. These samples were tested for density, compressive strength, and flexural strength.

The EPS fill mass was installed by Orders Construction Company. With very limited staging area, the EPS block installers had to use a creative and highly coordinated effort to place approximately 6,000 EPS blocks at the end of an active runway. The installation of the blocks took approximately 3 months. The placement of the EPS blocks had to be balanced with other project structural elements including conventional fill adjacent to the EPS.

In July 2019, the rebuilding of the fill at the end of Runway 05 was completed. The reestablishment of an emergency aircraft safety area allowed Yeager Airport to be fully in compliance with Federal Aviation Administration safety requirements. The use of Expanded Polystyrene as a lightweight fill material allowed for a more economical and better performing wall system.

Figure 1. Aerial view of EPS backfilled retaining wall at Yeager Airport