

Stabilization of Shade Landfill Deep Mine Workings

Mine voids and overburden fractures are grouted.

Waste Management wished to permit an expansion for Shade Landfill, located in Somerset County, PA. The expansion area encompasses about 118 acres, of which 70 acres overlie abandoned deep mine workings of the Upper Kittanning coal mine. Design-phase investigations indicated mine workings were present within 20 to 120 feet beneath proposed excavation grades. While much of the mine roof had collapsed and mine workings were gob-filled (That part of a mine from which the mineral has been partially or wholly removed and now filled with the waste left in old workings.) voids averaging two feet in thickness were still

present throughout the area.

To permit the expansion, Civil & Environmental Consultants, Inc (CEC, www.cecinc.com) evaluated the potential impact mine subsidence could have on the performance of a liner system. Evaluations showed the area remained susceptible to subsidence, with resulting surface strain magnitudes incompatible with geosynthetic liner materials. To allow for landfill expansion, CEC developed a mine stabilization plan designed to stabilize mine voids and overburden fractures. The plan required drilling barrier holes around the stabilization area perimeter, with production holes drilled within the barrier hole perimeter. Barrier holes were to be filled with high

slump (non-flowable) grout to create a curtain, while production holes were to be filled with flowable grout. The plan also required corehole drilling to confirm the adequacy of stabilization. The Pennsylvania Department of Environmental Protection (DEP) approved an expansion permit providing Shade Landfill with 31 million cu yd of additional airspace, contingent upon stabilizing the mine workings.

First Stabilization Increment

Construction of the first stabilization increment, encompassing 8.3 acres, occurred in 2007. CEC was retained to prepare construction documents and provide construction quality assurance. Howard Concrete Pumping Company, Inc. (Pittsburgh) was contracted to construct the mine stabilization increment. Based on spacing requirements of the plan, CEC laid out 195 barrier holes and 218 production holes. Howard subsequently air-rotary drilled each hole to a depth slightly lower than the mine floor. CEC's technician logged each hole, and CEC's management used the information to assess mine conditions and adjust drilling as appropriate. In total, 24,800 ft of drilling was completed, with conditions ranging from intact coal (50 percent of boreholes) to gob-filled zones (40 percent of boreholes), to voids (ten percent of boreholes).

Grout, consisting of fly ash, sand, cement, and water, was mixed on-site. Grout consistency was adjusted to provide high slump barrier grout or flowable production grout. A concrete pump truck was used to deliver grout to the



Panoramic view of grouting operations at Shade Landfill in Pennsylvania.



Grout column between intact rock layers.

bottom of each borehole using a tremie hose. CEC's technician logged grout placement, verified grouting was conducted in accordance with the plan, prepared test cylinders, and conducted slump flow cone tests. A total of 11,600 cu yd of grout was placed, ranging from

minimal takes to 675 cu yd per borehole. Generally, grout volumes corresponded with borehole conditions. Large grout volumes were generally placed in boreholes with voids, followed by smaller volumes in boreholes containing mine gob, and minimal grout volumes were placed in boreholes with intact coal.

Confirmation coring was conducted through-

out the stabilization area to evaluate the adequacy of grouting. Eleven coreholes were drilled throughout the stabilization area. Observations during coring indicated there were no drill rod drops, decreases in drill stem down pressure, excessive drill stem chatter, or loss of drill water.

These observations provided indirect evidence grout had infilled gob, fractures, and voids. Direct evidence was provided in core samples that contained grout ranging from thin lenses between fractures, conglomerates of grout mixed within gob rubble, or columns of void-filling grout.

Based on observations, testing, and sampling, CEC concluded the deep mine stabilization mitigated subsidence that could have potentially impacted the proper functioning of the overlying liner system. Total project cost, including engineering, materials, drilling, grouting, and coring, was slightly more than \$100,000 per acre. This cost represents about two percent of the value of the airspace created by being permitted to expand over the deep mine workings. **GE**

The preceding was excerpted from the fall 2007 issue of Elements, published by Civil & Environmental Consultants, Inc. (www.cecinc.com).