Solidification of hazardous wastes using portland cement

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For every person in the United States an estimated 2600 pounds of hazardous wastes are generated each year. Over the past 30 years repositories for the residues of the manufacturing industry are reported to have accumulated to over 170,000 pits, ponds, and lagoons. While it is clear that billions of dollars will have to be directed toward the cleanup of these sites, the best methods for doing this are not so clear.

The use of cementitious materials for solidifying hazardous substances has recently shown considerable promise. The advantages of solidification, sometimes called stabilization, include:

- safer transport and easier burial
- less pollution of the environment caused by leaching and evaporating of hazardous constituents
- improved physical properties of the wastes for easier handling
- potential for recycling wastes into construction material
- detoxification of substances for protection of workers(Reference 1)

Sludge shown in the first photo was treated and stabilized with portland cement. Within two days, the material was stable enough to drive on, as shown in the second photo.

In the solidification process portland cement, proprietary additives and, in some cases, fly ash are mixed with the waste to produce a solidified mass for disposal. When the waste is mixed with cement, a gel is initially formed, then fibrils develop as silicate compounds hydrate. These interlocking fibrils bind the cement and various hydration products into the hardening mass.

Solidification with portland cement is most applicable to inorganic wastes such as incinerator residue, road wastes, and heavy metal wastes. The high pH of the cement keeps metals in the form of insoluble hydroxide of carbonate salts. While materials such as plastic, metal filings, and asbestos increase strength of the matrix, other organic and inorganic compounds can retard setting, cause swelling, and reduce final strength. Proprietary additives containing clay, vermiculite, and sodium silicate may be incorporated into the mixtures to counterbalance the effects of these materials (Reference 2). Low-level radioactive wastes and organic wastes can also be solidified using portland cement.

A case study

About 18,000 tons of portland cement were used during 1983 to stabilize more than 20 million gallons of sludge produced by the Velsicol Chemical Corporation's Marshall, Illinois plant. Stored in ponds that covered about 19 acres, the sludge contained nearly every type of waste generated at the manufacturing facility over more than 40 years, including organic chemicals, resins, oils and water, in a homogeneous mass.

The sludge stabilization technology used at the Marshall Plant site was developed by Bituminous Materials Inc. and by Velsicol's Memphis Environmental Center located in Tennessee. As developed, the process centered on the use of certain moderately reactive materials (reagents) being mixed with sludge with high organic content. The materials initially absorbed the organics, including the oils and resins in the sludge, rendering the sludge a granular, clay-like material. A setting reaction took place, and the stabilized sludge did stiffen but remained very workable.

The reagents were stockpiled outside the actual waste site so they were available as needed without risking contamination of the delivery trucks. Berms were created between the ponds to improve accessibility of equipment and materials. The reagents were hauled by dump truck to the sludge and pushed into it by a wide-track bulldozer. The sludge and reagents were then thoroughly mixed by a dragline or a backhoe, depending on the depth of the sludge and the operating conditions.

During the mixing process the liquid sludge began to thicken. Portland cement was then pumped from the truck through a pressure hose connected to a cyclone separator specially designed and constructed for this project. Using centrifugal forces, the device separated the cement from the pressurized air and reduced the amount of cement dust created during application. To produce the desired cement content in the mixture, cement was applied in a layer of uniform thickness. Once the cement was applied and mixed, the sludge achieved a soil-like consistency. To ensure that no small pools of sludge were left below the stabilized material, the backhoe dug all the way down until soil was reached.

After mixing the stabilized material became much like heavy clay and, within two days, the material was solid enough to drive on. At that time, equipment was moved onto the surface to work on other areas farther into the pond. The process was then repeated. The stabilized sludge exhibited a permeability of 7x10-5 to 3x10-6 centimeters per second, a California Soil Bearing ratio of 10 to 14, and an expansion ratio of less than 1 to 1.1. Other characteristics included a wet density of 91.3 to 132.9 pounds per cubic foot (pcf) and a dry density of 60.0 to 109.2 pcf.

The knowledge gained by Velsicol has produced a process that lends itself to the economical treatment of similar sludge ponds with a broad range of composition. For the Marshall project, the expense was a cost-effective $0.30 per gallon of sludge treated. The volume increase of treated material ranged from 0 to 15 percent, very little compared to the 100 to 200 percent expansion resulting from several other processes. The treated waste can be readily relocated or put into an on-site disposal system. Samples from other sites have been evaluated, and it has been found that a wide variety of industrial organic sludges can be stabilized using this technology (Reference 3).

Mix designs are a necessity

Each waste material will react differently with the many possible combinations of cement and additives, depending on both the chemistry and the concentration of the waste. For proper stabilization to take place it is necessary to develop a laboratory mix design suitable for the specific hazardous waste. The Construction Technology Laboratories, a division of the Portland Cement Association in Skokie, Illinois, has developed cement systems to solidify hazardous wastes and can provide clients with a testing and development program designed for a particular material. The program includes such items as selection of hydraulic binders; chemical analyses of waste materials and cements, selection of system additives; collection of rheological data on slurry mixes; measurement of strength, setting time, and volume stability of the hardened mass; performance of an Environmental Protection Agency leaching test; analysis of leachate or generated waste water; and evaluation of possible reactions between the stabilized mass and groundwater or soil.

Other companies that develop mix designs using portland cement and additives are Chemfix Technologies Inc., Kenner, Louisiana; Stablex Corporation, Radnor, Pennsylvania; and the Velsicol Chemical Corporation, Memphis, Tennessee.

References

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PUBLICATION#C850781