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Hazardous Waste Engineering
Research Laboratory
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Project Summary

Prediction/Mitigation of Subsidence Damage to Hazardous Waste Landfill Covers

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This report describes the causes and effects, prediction methods, and technologies that may be applied for the prevention of subsidence in hazardous landfills. The information should be of assistance to those involved in evaluating landfill permit applications. The goal is to help prevent damage to, and resulting leaks through, landfill covers caused by subsidence-induced stresses.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

Section 3004 of the Resource Conservation and Recovery Act (RCRA) of 1976 requires the Administrator of the Environmental Protection Agency (EPA) to establish standards applicable to owners and operators of hazardous waste treatment, storage, and disposal (TSD) facilities. Among the standards are requirements for "treatment, storage, or disposal of all such waste received by the facility pursuant to such operating methods, techniques, and practices as may be satisfactory to the Administrator." The implementing regulations for landfill covers are found in 40 CFR 264.310, "Closure and postclosure care," which states that the final cover must be designed and constructed to (1) provide long-term minimization of migration of fluids through the closed landfill; (2) function with minimum maintenance; (3) promote drainage and minimize erosion or abrasion of the cover; (4) accommodate settling and subsidence so that the cover's integrity is maintained; and (5) have a permeability less than or equal to the permeability of any bottom liner system or natural soils present.

Monitoring and maintenance, including necessary cover repairs, are also required throughout the postclosure period. The postclosure period is designated in 40 CFR 264.117 as 30 years after completion of closure.

EPA recognizes the need to provide guidance in implementing the cover requirements. This document addresses the fourth requirement listed above regarding settlement and cover subsidence.

Purpose

The final report summarized herein, presents technical guidance directed at predicting, reducing, and preventing landfill settlement and related cover damage by subsidence. The final report is intended to be used by regulatory personnel and by operators of hazardous waste landfills.

Scope

The information presented in the final report pertains to hazardous waste landfills designed, constructed, and operated within the United States under the RCRA regulations. Landfills constructed and capped before the passage of RCRA in 1976 may not meet RCRA's relatively stringent waste placement, liquid waste limitations, liner specifications, and leachate collection and control requirements, and thus may not be amenable to the analytical, construction, and remedial guidance presented in the final report.

Conclusions and Recommendations

Hazardous waste landfills meeting RCRA requirements have physical characteristics that influence their potential for settlement and subsidence. Attention to those characteristics can minimize postclosure subsidence damage.

Data on physical properties of real and simulated hazardous waste are available to assist the landfill operator or permitting agency in assessing long- and short-term settlement potential.

Landfill subsidence results from primary consolidation and secondary compression of the waste mass, and from collapse of voids or cavities in the fill and around containers by corrosion, oxidation, combustion, or biochemical decay of landfilled materials.

Rarely, a landfill may be a monofill; that is, it may contain uniform layers of drummed wastes or uniformly placed bulk wastes. More often, the landfill consists of different types of wastes placed nonuniformly across the landfill in layers separated by intermediate covers of soil. The potential for differential settlement is greater in landfills with nonuniform wastes and waste placement procedures.

Bulk wastes behave differently from containerized (e.g., drummed) wastes in settlement characteristics. Bulk wastes behave relatively predictably, much like soils, becoming increasingly consolidated with time, but at a decreasing rate. Containerized wastes may remain relatively underformed until the containers degrade and collapse, at which time voids will be created, and consolidation will begin.

Settlement by consolidation and secondary compression of bulk waste landfills in which drainage layers are provided will probably be essentially complete before final closure. Compaction of waste materials and installation of drainage layers are recommended to lessen the potential for postclosure settlement and cover subsidence.

The approximate time required for primary consolidation to occur can be estimated for a waste or soil layer if the liquid limit is known for the material and if the shortest distance to a drainage path (e.g., a drain layer) is known. Time, for any degree of consolidation, can be computed more precisely if the compressibility or coefficient of consolidation has been determined for the material.

Of the controlling factors, the distance to a drainage path has the most pronounced effect on consolidation time for a waste layer. This fact indicates the desirability of including frequent drainage layers and of removing liquid from the landfill mass so that most of the consolidation will occur before closure.

The time required for ultimate settlement of containerized (drummed) waste to occur cannot be computed without knowledge of the drum deterioration time. The time cannot be determined, although it is expected to be several years, perhaps several decades, if water infiltration is prevented by an impervious cap and liner system.

The void space around drums or other containers in a landfill can be a major contributor to total postclosure settlement and should be filled with solidifying agents or a free-flowing backfill to minimize the void component of total settlement.

The surest way of avoiding problems associated with postclosure deterioration of drums and the delayed settlement and cover subsidence associated with it may be to ban drums from landfills. Instead, drums can be emptied and crushed or reclaimed. Drum contents can be treated and disposed as bulk waste.

Equations for calculating settlement time should be used more to identify operational landfilling and waste treatment procedures that will minimize settlement time than to predict precise values from theory.

Differential settlement across relatively short distances that may occur within subcells comprising a larger landfill cell is more threatening than relatively uniform settlement across longer distances that may occur across large monofills. For the former, tensional stresses may be sufficient to cause cracks in the cover resulting in leakage of water into the landfill. Those tensional stresses may not develop over longe distances, but ponding of water ma occur on the cover barrier, weakening it ability to repel water.

Similarly, tensional stresses are antic ipated to cause few or no problems wit flexible membrane barriers over larg subsidence areas. Locally severe differ ential subsidence can cause strai sufficient to rupture a flexible membran or otherwise cause its premature failure

Two or more central column model for analyzing landfill deformation (settle ment) can be used to predict differentia settlement between columns and there by to determine the effect of differentia subsidence on the final cover.

Expressions for analyzing the deflec tion of a beam can be used to identif parameters controlling the deformatio of a landfill cover subjected to differentia settlement. Once identified, the parame ters can be adjusted by cover design an construction procedures to minimiz distress to cover components.

Differential settlement can be mini mized by compacting wastes durin placement, eliminating void space withi the landfill, stabilizing liquids befor placement, and other considerations The length of the cover (represented a a beam) subjected to subsidence can b reduced by placing wastes as uniform as possible to provide uniform suppor to the cover. The cover soil component can be made more resistant to distres by compacting the cover barrier soils we of optimum water content.

Final cover components will stretc under differential settlement and mus be constructed to withstand tensil strain. The average tensile strain in th cover can be computed, and the maxi mum value of the differential settlemer that can be tolerated by the cover soil can be estimated from that computatior

Plastic soils (soils with high plasticit indexes) should be selected for use a cover components to produce a cove resistant to tensile strain.

Laboratory investigations by other indicate the flexible membrane liner (FML's) (components of the barrier laye in covers) may fail at lower strains tha would be expected from manufacturer data. Every effort should be made t reduce differential settlement potenti of the landfill and to design the cove to resist tensile strain.

Landfilled wastes should be con pacted or treated where possible reduce potential settlement. Compactic

methods include standard compaction techniques, vibratory rollers, and precompression (preloading and surcharging). Waste treatment methods include addition of fixative agents to render the wastes permanently less compressible.

The stabilization of liquid wastes with pozzolanic materials has been shown to increase compressive strength and lessen settlement potential. Such stabilization could be especially beneficial for containerized wastes.

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The complete report, entitled "Prediction/Mitigation of Subsidence Damage to Hazardous Waste Landfill Covers," (Order No. PB 87-175 378/AS; Cost: $18.95, subject to change) will be available only from:
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