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EPA

Project Summary

Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities

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This Technical Resource Document is a compilation of available information on the design, construction, and evaluation of clay liners for waste landfills, surface impoundments, and wastepiles. The information was obtained from the literature and from in-depth interviews with design and construction engineers and other knowledgeable individuals in both the private and government sectors. As a consequence, some of the information is being presented in print for the first time in this document. The broad topics covered are: clays, with emphasis on their composition, fabric, and hydraulic conductivity; the compatibility between clays and chemicals, including a discussion of the mechanisms of interaction and a comprehensive compilation of test data from the literature and private, unpublished sources; design and construction methodology and construction quality assurance; and clay liner transit time prediction models. The technical resource document also incorporates public comments received on a draft that was published in 1986.

This Project Summary was developed by EPA's Risk Reduction Engineering 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).

Introduction

The U.S. Environmental Protection Agency (EPA) is developing three types of documents for preparers and reviewers of permit applications for hazardous waste facilities. These are RCRA Technical Guidance Documents, Permit Guidance Manuals, and Technical Resource Documents (TRDs).

The TRDs present state-of-the-art summaries of the technologies and evaluation techniques determined by EPA to constitute good engineering practices, designs, and procedures. They support the RCRA Technical Guidance Documents and Permit Guidance Manuals in certain areas (i.e., liners, leachate management, closure covers, and water balance) by describing current technologies and methods for designing hazardous waste facilities or for evaluating the performance of a facility design. Although emphasis is given to hazardous waste facilities, the information presented in these TRDs may be applied to nonhazardous waste facilities as well.

This is a TRD prepared by the Risk Reduction Engineering Laboratory of the Office of Research and Development at the request of and in cooperation with the Office of Solid Waste and Emergency Response. The TRD was first issued as a draft for public comment under the title, *Design, Construction, and Evaluation of*

Clay Liners for Waste Management Facilities (EPA/530-SW-86-007) dated March 1986. The draft TRD was also made available through the National Technical Information Service (Order No. PB86-184496/AS). All comments received on the draft TRD have been carefully considered and, if appropriate, changes were made in this final document to address the public's concerns. With issuance of this document, all previous drafts of the TRD are obsolete and should be discarded.

The objective of this TRD was to provide, in a single document, all of the available information on the design, construction, and performance of clay lined waste management facilities. The broad topics that were covered are: clay properties and characteristics (chapter 2); geotechnical testing of soils (chapter 3); the compatibility of clays and chemical wastes (chapter 4); the design, construction, and construction quality assurance of clay liners (chapter 5); potential failure mechanisms (chapter 6); the performance of existing liner systems (chapter 7); and methods of predicting the useful life of liner systems (transit time) based on the modeling of leachate flow through soils (chapter 8).

Discussion

Chapter 2 of the TRD contains a general discussion of the structure of clay soils and continues on to a discussion of the main types of clay minerals (e.g., kaolinite, illite) and how clay soils were formed. A section on clay chemistry deals with the electrical double layer theory, cation-exchange capacity, and cation affinity. A short discussion of the significance of the double layer theory to clay liners is also included. Other subjects discussed are related to clay soil fabric and hydraulic conductivity. These include soil porosity, macrostructure and secondary porosity, and the structure and hydraulic conductivity of compacted soils.

The third chapter presents the soil test methods currently used in the design and construction of clay liner systems. The chapter starts with a discussion of the fundamental relationships between the solid, liquid, and air phases of soil systems. The Atterberg limits and the methodology for determining them are discussed. The Unified Soil Classification System is presented in sufficient detail to provide the nontechnical reader with an understanding of how the system works. In the section on measuring density and moisture content in the field, the traditional methods are presented along with a detailed discussion of nuclear density gauges and the problems that can be encountered in their use on certain soils. Much of the chapter is devoted to describing the current methodologies employed in measuring the hydraulic conductivity of compacted clay soils in the laboratory and in the field. Included is a discussion of factors that can influence the results of permeability tests. The field permeability testing section contains descriptions of several new tests that have recently been introduced and thus have not been extensively discussed in the open literature.

In the fourth chapter, "Interactions Between Clays and Chemicals", the mechanisms of the interactions, and the effect they have on permeability are discussed. The bulk of the chapter presents the results of published and unpublished research studies, some of which are published for the first time in this document, having been obtained from the files of private soil testing firms. The studies are summarized in a large table organized on the basis of the chemical or waste stream that was tested. This table quickly references the effect that a given chemical can have on specific clays.

The fifth chapter of the document is a detailed discussion of the current practices employed in the design and construction of clay liner systems. Much of the information was obtained from interviews with design and construction professionals and appears in print for the first time in this TRD. All aspects of liner design and construction are discussed including site investigation, liner material selection, facility design, clay liner installation, and quality assurance and quality control.

Chapter 6 covers the mechanisms that potentially cause clay liner systems to fail. Mechanisms such as desiccation cracking, slope instability, freeze/thaw cycling and others are discussed theoretically, since there is little hard evidence to suggest which if any of these are consistent sources of failure in clay lined systems.

Information about the performance of clay liners is contained in chapter 7, which is a presentation and analysis of 17 case studies. The data for the sites were obtained from state and federal agencies, commercial waste disposers, clay liner design and construction firms, and the industrial sector. The information presented for each site includes geological and hydrogeological site characteristics, types of waste in the site, geotechnical characterization of the clay, leachate collection, leak detection, or groundwater monitoring data, physical description of the site, liner description, construction methods used in building the liner.

Methods for predicting the useful life of a liner are described in chapter 8. Several mathematical models are presented for predicting the transit time of leachate through a compacted clay liner.

The full report was submitted in fulfillment of Contract No. 68-01-7310 by NUS Corporation under the sponsorship of the U.S. Environmental Protection Agency.

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***Michael Roulier** is the EPA Project Officer (see below).*
The complete report, entitled "Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities" (Order No. PB89-181 937/AS; Cost: $49.95) will be available only from:

National Technical Information Service
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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