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# General Report Session No. 10, 11 and 12: Case Histories of Geotechnical and Hydrological Management and Remediation of Solid, Hazardous and Low-Level Radioactive Wastes

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# Case Histories of Geotechnical and Hydrological Management and Remediation of Solid, Hazardous and Low-Level Radioactive Wastes

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The papers presented in the Geotechnical and Hydrological Management, Remediation, and Liner and Final Cover Systems for Solid, Hazardous and Low-level Radioactive Wastes sessions are a part of the general topic of geo-environmental engineering. This general report briefly outlines the scope of geo-environmental engineering followed by a summary of the papers. The report concludes with comments related to issues that need further explanation and/or clarification.

## GEO-ENVIRONMENTAL ENGINEERING: BACKGROUND

In general, the geo-environmental engineering topics can be divided into the following six areas:

1.0 Types of Wastes and Waste Characterization
- 1.1 Solid Waste (Municipal and Hazardous Wastes)
- 1.2 Semi-solid Waste (Semi-SW)
- 1.3 Liquid Waste

2.0 Waste Disposal
- 2.1 Landfills (SW)
  - 2.1.1 Base Liner (Low Permeability and Geosynthetic Materials)
  - 2.1.2 Leachate Collection Removal and Detection Systems (LCRS/LCDS)
  - 2.1.3 Cover Systems
- 2.2 Surface Ponds (Semi-SW and Liquid Waste)
  - 2.2.1 Pond Liners
  - 2.2.2 LCRS/LCDS

3.0 Remediation
- 3.1 Site Investigations (Sampling and Characterization)
- 3.2 Excavation, Transport, and Handling (Surface Sediment Removal, Dewatering, and Site Preparation)
- 3.3 Restoration/Remedial MethodS (Solidification/Stabilization, Bioremediation, Vapor Extraction, Chemical Fixation, and Incineration)
- 3.4 Containment and Isolation Technologies (Slurry Walls, Base Liner and Caps for Landfill Disposal)

4.0 Analyses
- 4.1 Infiltration and Leachate Generation
- 4.2 Contaminant Migration
- 4.3 Static and Seismic Slope Stability

5.0 Site Development
- 5.1 Structures (Shallow and Deep Foundations)
- 5.2 Recreation Areas (Parks and Golf Courses)

6.0 Regulations

## PAPERS PRESENTED

The following papers have been received in the general area of geo-environmental engineering:

1. <u>Soil Remediation</u> via Environmentally Processed Asphalt <u>by</u> Testa and Patton

2. Performance Evaluation of a Hydraulic Asphalt Concrete Pavement <u>Capping a Hazardous Waste Site</u> <u>by</u> Anthony, Sterrett, and Shepperd

3. <u>Remediation</u> of Contaminated Sites - Case Histories <u>by</u> Genseke, Klapperich, and Noll

4. Modified <u>Cover</u> System for <u>Hazardous Waste Landfill</u> in Semi-arid Areas <u>by</u> Dutta

5. Use of Low Plasticity Silt for <u>Soil Liners and Covers</u> by Knitter, Haskell, and Peterson

These papers generally discuss the following geo-environmental topics:

- Base Liner - 1 Paper
- Cover Systems - 3 Papers
- Soil Remediation - 2 Papers
- Infiltration and Leachate Generation - 2 Papers
- Regulation - 2 Papers

Testa and Patton present a soil remediation method via "Environmentally Processed Asphalt (EPA)." In this method, petroleum hydrocarbon and metal affected soil is mixed-in-place by portable asphalt batch plant with an asphalt emulsion and aggregate. This produces a range of cold-mix asphalt product. This end product can be used in landfill caps and liners, tank farm dikes and containment structures, parking lots, road construction, and other similar facilities. Based on the authors review of California Code of Regulations (CCR) Title 22 and Code of

Federal Regulations (CFR) Title 40, Testa and Patton conclude that the regulations do not classify recyclable materials or "waste." Therefore, these materials are not regulated as "hazardous waste" and their use, reuse and recycling are within the "letter spirit and intent of environmental legislation." The paper considers factors, such as, durability, chemical resistance and aging, biological resistance, permeability, and leachability to evaluate the long-term performance of cold-mix asphalt for affected soil remediation.

The authors evaluated durability, chemical resistance and aging and biological resistance based on literature survey. These factors should, however, be evaluated for specific end use. Permeability and leachability test results are presented in the paper. Test methods are not specified in the paper and may significantly affect the test results.

Anthony et al., describe the closure of a former pesticide facility near the center of the city of San Antonio, Texas. At this site, the pesticides were primarily located in the top two feet of the soil. The soil samples from five locations of the 1.3-acre site were collected and analyzed for a suite of pesticide compounds, including aldrin, BHC (lindane), chlordane, DDD, DDT, dieldrin, methoxychlor, PCP, silver, and toxaphene. The site investigation and analytical results indicated that the pesticide compound of primary environmental concern on the site was chlordane which will degrade with time and are relatively immobile.

The authors mention that the following remedial actions alternatives were considered:

- Excavation and off-site disposal
- Excavation and on-site bioremediation
- Excavation and on-site incineration
- Grading and capping the site with 3 feet of compacted clay

The remedial action selected was to cap the site; it was the least expensive alternative. The 3-foot compacted clay cap and 1-foot vegetative top soil provision would meet Texas Administrative Code, §335.3 et seq. for closure of a landfill containing Class I waste. However, a less costly alternative to clay was to use a high-bitumen-content hydraulic asphalt concrete (HAC) pavement.

Evaluation of HAC for the cap system consisted of performing permeability (k) tests (in accordance with ASTM D-5084). The tests showed k values for HAC core samples less than $5 \times 10^{-11}$ cm/s. Following this, HELP model simulations were performed on compacted clay and HAC system caps; a Table in the text presents the characteristics of the materials and results of model simulations. The results indicated that a cover consisting of 4-inch thick HAC cap would perform better than 36-inch thick compacted clay. The other advantage is that the HAC cap can be visually inspected for integrity and easily repaired as required. Also, the HAC caped pavement can be used as a parking lot which other alternatives would not allow.

The paper also presents the performance specification for the project. The laboratory test results meet the design specifications. The results of permeability testing on cores from the pavement after 10-month curing have been tabulated in the text. These results met the design criteria.

Genske et al., cite two remediation project case histories for projects located in the German Ruhr District. The projects were located in an area where large numbers of coal mining activities started back in the 19th Century followed by secondary industries, such as, coal refinement plants, steel industries, and chemical plants. In the early 1980s, it was decided to develop the area into so called "Technology Parks." The problem was then to remedy the contamination left by earlier industries.

The first case study was for the Brauck Park which is located at the former mine and coking plant which was then followed by benzol and ammonia factories. Many other factories were built at the site during the 1920s through the 1950s. The subsurface conditions at the site were described as upper 2 to 9 meters as upper fillings, over quaternary sediments at about 10 meter depth underlain by fractured cretaceous marl bedrock. Groundwater was at about 5 meters below ground surface. Site investigation methods and laboratory and field testing methods have not been describe in the paper. Also, subsurface material characterization has not been presented in detail. The authors mention that the site has been contaminated with hydrocarbons which have migrated through the porous sediments into the fractured rock. At this site, regulatory EPA required that minimal excavation be conducted; therefore the remedial measure consisted of covering the site with a reinforced geotextile sandwich system. The system consisted of (a) a lower reinforced support layer, (b) a drain and seal system, and (c) an upper layer of reinforcement elements to account for vehicular loads. The system was placed in areas of heavy contamination; remaining part of the site was covered with $\geq 0.5$ meters of granular soil. A number of observation wells were installed. Some of these wells may in the future be used as recovery wells. Details of wells, spacing, and location criteria have not been presented in the paper.

The second case study was for Prosper Park Site which was utilized by coking plants and chemical factories. The subsurface conditions at this site were similar to the Brauck Park site. The upper strata consisted of about 1 to 3 meters of loose man-made fills (wasted soil and bricks), underlain by quaternary sediments (mainly silty sands) to a depth of about 16 to 20m where fractured cretaceous marl bedrock was encountered. Groundwater table was encountered at about 5m below the ground surface. Investigations indicated that all fills and upper quaternary sediments were contaminated. Bedrock has no significant levels of contamination. Remediation measures consisted of excavating the top 2m of contaminated soil and replacing it with coarse-grained cohesionless soil. The highly contaminated areas were covered with a drain and seal system to stop infiltration of precipitation. A series of observation wells were installed for monitoring purposes. The details of the drain and seal system are not provided in the paper. Performance of the remediation system by evaluating data from wells and infiltration analyses through the cover system also needs to be described.

The paper concludes that the following four factors should be considered for effective remediation of a site:

1. Environmental compatibility of the remediation measures, such as, effect on the groundwater flow direction and the emission of contaminated dust during remediation work.

2. Costs.

3. Time needed to complete the work.

4. No single industrial waste site resembles another one. Therefore, site-specific evaluations should be performed.

Dutta presents an alternate cover system to EPA recommended RCRA cover system for Tinker Air Force Base in Oklahoma. The site is located in a semi-arid area and consists of waste generated since the 1940s, from engine overhaul, maintenance, and other jet engine support services. The hazardous waste disposal sites within the boundary of the base include the following:

- Landfills
- Industrial Waste Piles (IWP)
- Underground Storage Tanks (UST)
- Sludge Pits
- Sludge Drying Beds
- Radioactive Waste Disposal Sites (RWDS)

The author has presented a good description of field investigation and waste characterization for the site. The RCRA cover system has the following main disadvantages:

1. It was difficult to suppress the development of surface cracks in clay layers even during installation of clay in 6-inch lifts.

2. The requirement of 2-5% surface slopes required extending landfill beyond the boundary; this deprived the base of about 2 acres of land.

3. The cost of RCRA cover system was high.

To overcome the above problems, a modified cover system consisting of a manufactured bentonite layer was designed. A HELP modeling was performed and infiltration rates for modified cover was found to be significantly lower than the conventional RCRA cover. Also, because of a lower overall cover thickness, the mounding effects were minimized. Finally, the cost of a modified cover system was cited to be significantly lower than the conventional RCRA cover system.

Knitter et al., present an interesting study (both laboratory and field testing) for the use of loess, a low plasticity silt, for soil liners and covers. The soil is proposed to be used for several municipal solid waste and one hazardous waste landfill liners in eastern Washington and north-central Oregon where clayey soil is not available.

The authors undertook an extensive laboratory testing program consisting of grain size, index properties, compaction and permeability tests. Results exhibit that permeabilities of less than $1 \times 1^{-6}$ cm/s can be obtained if percent fines are less than 15 micron, moisture contents are about 2 percent above OMC and percent saturation is over 85 percent.

Several Sealed Double Ring Infiltrometer (SDRI) tests were performed and the authors report a one-to-one relationship between laboratory and field tests. SDRI test data, however, are not presented in the paper. It was reported that wetting front could not be recorded by using tensiometers; the method of its measurement has not been reported. Use of bentonite admix (up to 5 percent) was found to result in permeabilities less than $1 \times 10^{-7}$ cm/s. Overall, it is a good documentation of laboratory and field tests for the use of loess in soil liners and covers.

## COMMENTARY ON GEO-ENVIRONMENTAL PAPERS

The major advantage of the EPA soil remediation method presented by Testa and Patton is that the contaminated soil can be incorporated into asphalt for use as landfill liner. It is important that the following additional information and issues be addressed for this remediation method:

- Chemical analyses of the contaminated soil before remediation should be provided
- Leachate compatibility tests should have been performed if the product is to be used as a base liner
- Comments regarding integrity of the cover for differential settlement of landfill is an important factor and should be addressed
- Interface strength tests may need to be performed between EPA/synthetic liners if the material is to be used as a composite liner (especially on steeper slopes).

The asphalt concrete pavement capping designed for a hazardous waste site by Anthony et al., has the main advantage that it is cost effective and the surface can visually be inspected for surface cracks and then easily repaired. The main problem with the system is that (36-inch + 12-inch =) 48-inch thick clay is being replaced with (4-inch + 6-inch =) 10-inch thick asphalt system. Any crack in 4-inch thick asphalt will cause major flow into the subgrade. Also, unlike clay, these cracks will not be self-healing. Impacts of these potential cracks should be evaluated by HELP modeling in a manner similar to synthetic liner.

Genske et al., present interesting case histories for sites contaminated for over 100 years. The authors need to discuss further issues, such as, detailed characteristics of sub-soil and type of hydrocarbon contaminants encountered, critical (cost and technical issues) evaluation of various alternative remedial methods before selecting the final remediation technique and finally some discussion on European regulatory requirements would be useful.

Dutta has presented an interesting modified cover system for hazardous waste landfills in semi-arid areas. The paper needs more details on the system, such as, specification on the type of FML designed, the reason for reducing the thickness of initial grading fill from (40-50 cm) to (0-30 cm) and the method of bentonite liner placement. It was mentioned in the paper that clay layers would crack during placement. The bentonite liner and underlying clay would also crack; this needs to be discussed. Finally, issues such as applicability of HELP model in semi-arid areas and considering leakage in FML should also be addressed.

Knitter et al., have presented the results of extensive laboratory and field tests on loess. The parametric study is well presented and will be useful in liner design in the Washington and Oregon areas. The authors should provide details of laboratory ASTM D-5084 permeability testing. The confinement/consolidation pressures and hydraulic gradients used may have significant impact on test results. Loess by itself is not suitable for hazardous waste landfill liner. Bentonite was suggested as admix material to reduce permeability. However, details of field mixing method can have important impact on permeability of the material and needs to be addressed. Wetting front measurement is an important factor in SDRI test calculations. The authors mention that tensiometer did not work for these soils. Therefore, the method of wetting front measurement should be mentioned. Finally, permeability is one factor for soil liners and covers. Other important factors are soil strength and the interface strength, if composite liner is used. These issues need to be addressed when selecting a material for landfill liners and covers.

Overall, the papers have been informative and of good quality. Geo-environmental engineering is a relatively young discipline. I am happy to report that we have started receiving quality case-histories in this field.