CAPPING OPTIONS FOR A LOW-LEVEL RADIOACTIVE MATERIAL STORAGE PILE

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ABSTRACT

Capping is the most common method used to contain low-level radioactively contaminated soil and rubble (LLRSR) storage piles and to prevent release of fugitive dust emissions and water filtration. The failure of an existing cover at two LLRSR storage sites prompted an investigation to find a capping system that would be reliable, durable, resistant to wind damage, protective, and economical to construct.

The authors evaluated several options that used different types of synthetic materials (such as Hypalon™, HDPE, polypropylene) and natural clay. Based on results of material testing and design and cost analyses, it was concluded that the preferred capping option is a thermally welded polypropylene membrane reinforced with polypropylene rope and anchored to the soil using a unique helical anchor system.

INTRODUCTION AND OBJECTIVES

Low-level radioactively contaminated soil and rubble (LLRSR) collected during remediation of a contaminated site must sometimes be stored on the site until proper arrangements can be made for its final disposal. These interim storage piles require adequate cover systems to control water infiltration and subsequent contamination of groundwater caused by leachate from these piles. The type of cover system used for an LLRSR storage pile is often site-specific. For the sake of economy and keeping quantities of contaminated soil to a minimum, the interim storage piles of short life are usually covered with a geomembrane instead of topsoil. Because the life of a geomembrane is relatively short, it needs to be upgraded periodically. Failure or deterioration of a geomembrane cover can occur for several reasons.

This paper summarizes the deterioration and failure of pile covers at two LLRSR interim storage sites, the replacement geomembrane covers and anchor systems that were evaluated, and recommendations for upgrading pile covers at these two sites and at other sites under the Formerly Utilized Sites Remedial Action Program (FUSRAP) for the U.S. Department of Energy (DOE).

The objective in performing this study was to:

- Establish reasonably economical, feasible, and constructible solutions for each of the existing LLRSR interim storage piles
- Establish criteria and/or standards for construction of future LLRSR interim storage piles

BACKGROUND

On March 27, 1991, wind damaged one of the pile covers at a LLRSR storage site in St. Louis, Missouri. A section of cover measuring approximately 30.5 by 61 m (100 by 200-ft) was blown off of the pile. A short-term restoration of the pile cover was performed by repositioning the original cover to the extent possible, and covering it with a geotextile and geogrid. A perimeter anchoring system was used to hold down the geotextile and geogrid. A geogrid is a plastic mesh material with openings approximately 3.8 by 2.5 cm (1.5 by 1 in.); this material is available in continuous rolls.

On March 29, 1992, wind damaged the pile cover at a second LLRSR interim storage site in Maywood, New Jersey. A section measuring approximately 15 by 18 m (50 by 60 ft) was blown off of the pile. Short-term restoration of the pile cover was performed by repositioning the original cover and repairing the failed seams as required. In addition, a layer of gravel was placed along the perimeter using geotextile as a support material to prevent any future failures.

EVALUATION

As part of a continuing effort to determine and recommend long-term corrective action required to prevent accidental failure of membrane covers at other storage sites, the following comprehensive evaluation program was implemented:

- Visual inspection of covers to establish current conditions of the pile covers
- Laboratory testing of membrane cover samples taken from the existing piles to determine actual remaining strength
- Cost analysis to compare costs and merits of various options
- Design analysis to determine the effects of wind forces on the pile covers
- Recommendation of corrective actions, if any, based on results of the material testing and design analysis

Visual Observations

Based on visual inspections, the interim storage pile covers at two sites were found to be in fair to good condition, with the exception of the several small patches taken for analysis. However, the covers at two other sites were found to be in poor to very poor condition, with major seam repair work required along the base and at large patches on the piles. It was also noted that although all field seams were made using the manufacturer's recommended glue, the seams were becoming brittle and less effective from weather exposure. Furthermore, ethylene propylene diene monomer (EPDM) seams were very difficult to repair.

Laboratory Test Results

Results of laboratory tests (1) of key physical and mechanical characteristics (including multi-axial stress/strain response, tensile strength, tear resistance, and puncture resistance) indicated that the cover materials had experienced no significant degradation at any of the sites, except one. It was noted, however, that the peel strength of the factory seams of the Hypalon™ and EPDM material was significantly less than the tear strength.

Summary of Cost Analysis

For purposes of analyzing costs, the following options were considered for upgrading the existing pile covers.

A. Existing cover to be covered with new high-density polyethylene (HDPE) and steel cables

B. Existing cover to be covered with new Hypalon™ and cable

C. Existing cover to be covered with new geogrid and perimeter steel cables

D. Existing cover to be overlain with topsoil

E. Existing cover to be held down by steel cables only

F. Existing cover to be covered with scrimmed polypropylene membrane and steel cables

G. Existing cover to be covered with scrimmed polypropylene membrane, polypropylene rope, and helical anchor system

H. Existing cover to be strengthened by double seaming

Use of EPDM was not considered as an option because of frequent seam problems experienced with this material. Because of certain advantages that are summarized in Table I, use of Hypalon™ was considered as an option, although the seams are chemically bonded and are less durable than thermally bonded HDPE or polypropylene.

To determine relative economic merits and cost comparisons of various available options, a cost analysis was performed. The cost for covering the pile with topsoil (option D) was found to be the highest, and the cost for double seaming (option H) was found to be the lowest.

Design Analysis

Results of laboratory tests (1) indicated that a failure, if any, would be from material seams, especially when wind is allowed to enter beneath the cover. This mode of failure could be substantially minimized by using thermally welded seams. It was learned, however, that thermal welding was difficult and impractical for field seams on Hypalon™ and EPDM-type materials.

The geomembrane pile cover alone could be more easily damaged and destroyed under wind-induced uplift pressure and, therefore, needed an additional support system. The general practice is to use concrete blocks, sandbags, truck tires, or soil cover to reduce unsupported lengths and widths of the geomembrane cover. Use of these objects was found undesirable because:

- Concrete blocks, sandbags, and tires tend to slide off of the slopes
- Concrete blocks can tear the membrane
- Soil cover can increase the volume of wastes because it can become contaminated

To avoid these problems, the use of several support systems was explored. Along with the original concept, several design variations were developed for one of the sites where the pile was covered by a geogrid. Some variations included a cable ballast system and a helical anchor system to further limit deflections and movement of the cover. Also, a polypropylene membrane variation was considered instead of a geogrid because of the polypropylene membrane's significantly greater strength.

Results of the design analysis indicated that the tensile force and the deflection in the existing Hypalon™ membrane would be very large unless an additional cable ballast system was introduced. In a similar analysis, it was found that the deflection in the polypropylene membrane would also be very high, although the tensile force would be below the yield strength of the membrane. Manufacturers of polypropylene material, however, do not recommend using polypropylene alone without ballast. Ballast is required to reduce the amount of deflection in the membrane. Because steel cables stretched across the pile in both directions could abrade or cut into the geomembrane-type pile cover, a helical anchor system placed under the membrane was evaluated.

Advantages and disadvantages of the various options evaluated and discussed above are summarized in Table I.

SUMMARY AND RECOMMENDATIONS

Based on the above analyses and inherent problems associated with the chemically bonded seams of Hypalon™ and EPDM, it was apparent that the existing pile membranes should be entirely covered with a high-strength membrane material that has superior and durable thermally jointed seams. Although HDPE is superior to Hypalon™ and EPDM, it does not readily conform to pile configuration in cases of pile settlement. HDPE has a higher thermal expansion coefficient, which would cause it to be more sensitive to changes in ambient temperature, and which would ultimately lead to failure of the geomembrane. Further, HDPE becomes brittle at low temperatures and has a high environmental stress crack risk.

A geogrid with a perimeter cable system would provide continuous support to the existing Hypalon™ materials; however, seam construction of geogrid can be achieved only by mechanical fasteners, which will not be as durable as thermally welded seams.

Hence, thermally welded polyprophylene membrane reinforced with polypropylene rope and anchored to the soil using a unique helical anchor system (see Fig. 1) would be the preferred option (option G). This option would eliminate inherent problems associated with all other options discussed here.

REFERENCES

1. PSI/Pittsburgh Testing Laboratory Division - Geosynthetic Material Testing report dated February 7, 1992.

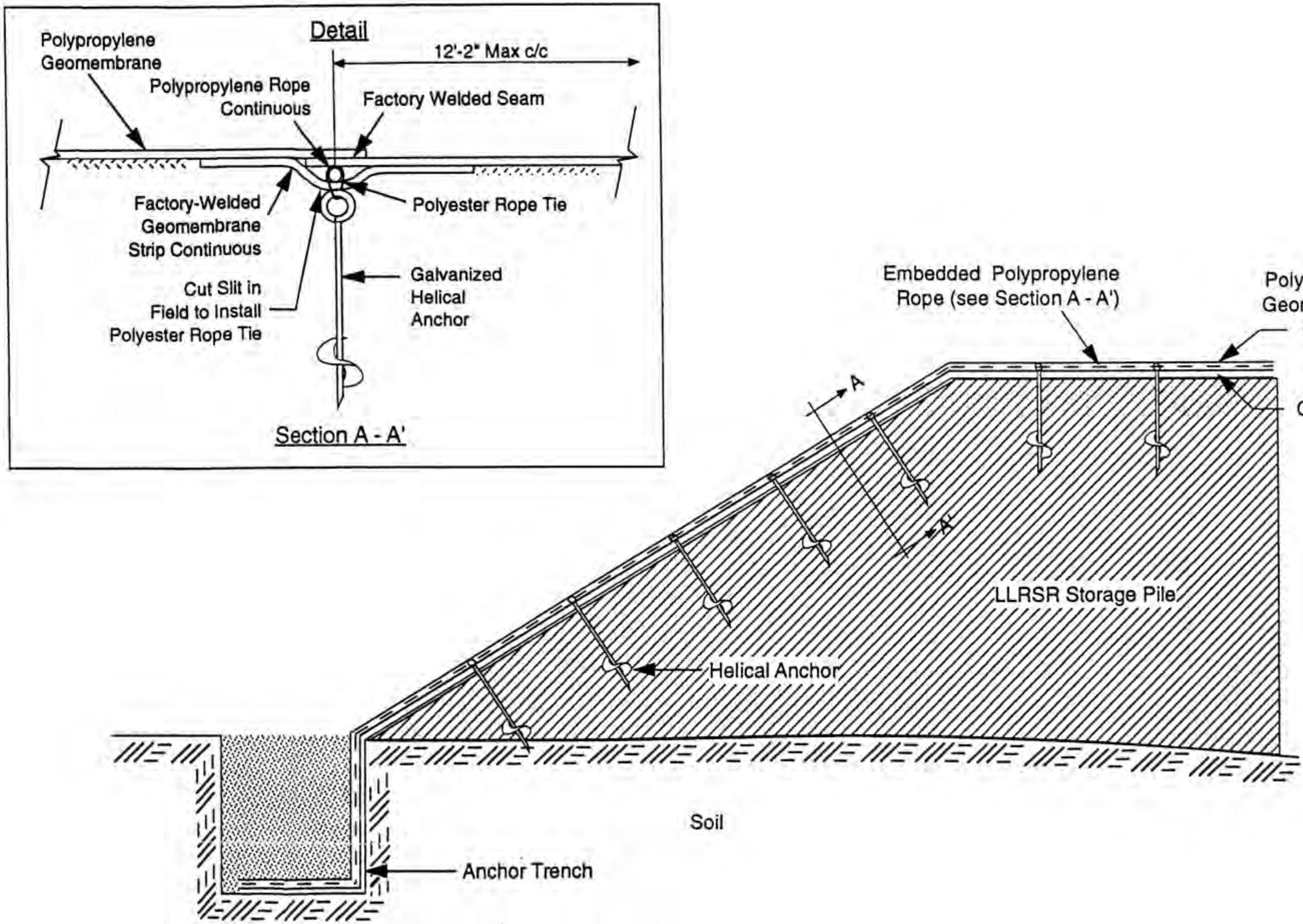

Fig. 1. Typical anchoring system for geomembrane-Option G.

TABLE I
Advantages and Disadvantages of Various Options for Upgrading Existing Pile Covers

Option/Description	Advantages	Disadvantages
A HDPE and cables	HDPE warranted 20 years; tear puncture, UV, and chemical resistant Eliminates possibility of existing pile cover tearing and being blown off, releasing pile material; easy to repair; swells least when exposed to water Very low vapor and gas transmissivity rates	Difficult to conform to pile configuration in case of settlement High thermal expansion coefficient High environmental stress crack risk
B Hypalon™ and cables	Warranted 20 years Seaming done chemically; can be used where electric power is not available Easily conforms to pile in cases of settlement Eliminates possibility of existing cover tearing and blowing off Low environmental stress crack risk; low thermal expansion coefficient Least combustible due to self-extinguishing properties	Low modulus of elasticity allows high deflection and increase in stresses Ages and cures with time, making field seam repairs difficult Cable may cut membrane Higher moisture and gas transmissivity rates than HDPE and polypropylene Chemically bonded seam inferior to thermally bonded HDPE or polypropylene; chemicals used may be subject to future regulations; chemically active-may react with pile constituents
C Geogrid and perimeter cables	Grid warranted 20 years Seams made using ties, permitting easy removal if pile is expanded Acts as extra reinforcemento existing pile cover	Difficult to patch holes in existing cover and do general maintenance Seam strength depends on tie strength Strength, integrity and effectiveness reduced at sharp bends
D Soil cover	Eliminates direct exposure and weathering of existing geomembrane No anchor trench required	Additional waste volume to deal with Gives public impression that interim pile may become a permanent pile Requires grass to be planted to reduce erosion; adds to maintenance costs
E Cables only	Economical Limits extent of wind-induced tears and fluttering	Does not protect existing aged covers from tears, punctures, weathering, and further deterioration of strength High probability of failure of existing cover on long-term storage

TABLE I, CONT'D

Option/Description	Advantages	Disadvantages
F Polypropylene and steel cables	Warranted 20 years; good resistance to tear, puncture, UV, and chemical exposure Easily conforms to pile configuration in pile settlement Low environmental stress crack risk; low thermal expansion coefficient and has low moisture and gas transmissivity rates Eliminates the possibility of existing cover being blown off, releasing pile material; easy to repair; less affected by water exposure than Hypalon™	Low modulus of elasticity allows high deflection under wind-induced uplift Steel cables may cut into membrane
G Polypropylene and helical anchors	Warranted 20 years; good resistance to tear, puncture, UV, and chemical exposure Easily conforms to pile configuration in case of pile settlement Eliminates the possibility of existing cover being blown off, releasing pile material; easy to repair; less affected by water exposure than Hypalon™ Low environmental stress crack risk; low thermal expansion coefficient; low moisture/gas transmissivity rate	Low modulus of elasticity allows high deflection under wind-induced uplift
H Double Seaming	Economical Strengthens seams and increases durability	Does not protect existing cover from tears, punctures, weathering, and deterioration of strength