Asphalt Barriers for Containment

John J. Bowders[1], J. Erik Loehr[2], Deepak Neupane[3] and Malek Bouazza[4]

Abstract: An alternative barrier system has been designed that incorporates 100 to 150 mm of asphalt concrete overlain by a 2 to 3 mm thick fluid-applied asphalt/geotextile (FAA/GT). Hydraulic conductivity tests were performed separately on laboratory prepared FAA/GT and asphalt concrete specimens. The FAA/GT specimens exhibited hydraulic conductivities less than 1×10^{-11}cm/s. Conductivity tests on asphalt concrete specimens revealed that specimens having 7 % or more asphalt cement and unit weight of 22 kN/m^3 or greater have conductivity less than 1×10^{-9} cm/s. A full-scale test pad (60 m x 18 m) was constructed and tested. FAA/GT and asphalt concrete samples were retrieved from the test pad. Laboratory conductivity measurements on field samples demonstrated conductivities comparable to that of the lab-prepared specimens. *In situ* hydraulic conductivity measurements were performed on the test pad using sealed-double ring infiltrometers. The average conductivity was 1×10^{-10} cm/s. Compatibility tests with construction and demolition debris leachate on the field-constructed specimens did not show any appreciable change in the barrier property of the asphalt specimens. Tests are underway to monitor the deformation characteristics of the asphalt liner and the resulting hydraulic conductivity.

Asphalt barriers have been used in containment applications for more than 70 years. Prior to the mid 1960s, asphalt barriers were primarily used to control water seepage from facilities such as impoundments and earth dams (Sherard et. al 1963, Monismith and Creegan 1996). Asphalt was applied as hot-sprayed asphalt membranes and as asphalt concrete for the barrier layer. In the late 1960s and early 1970s asphalt was on the way to becoming the state-of-the-practice landfill liner (Asphalt Institute 1976). Several US facilities were constructed using asphalt concrete (hot-mix asphalt) liners, which in some cases were combined with sprayed-on fluid applied asphalt layer. The petrol shortage of the 1970s along with the establishment of rules for hazardous and solid waste landfill designs that focused the industry toward composite liners consisting of geomembranes and compacted soil contributed to the decline of the use of asphalt for containment. However, in the mid-1980s, resurgence into the use of asphalt for waste isolation was initiated by the US Department of Energy (DOE) in their quest for very-long-term hydraulic barriers (1000+ years) for radioactive and mixed waste sites (Wing and Gee 1994a).

---

[1] Associate Professor, Civil & Environmental Engineering, University of Missouri-Columbia, Columbia, MO, 65211-2200, USA, Ph 573.882.8351, Fx 573.882.4784, bowders@missouri.edu (corresponding author)
[2] Assistant Professor, Civil & Environmental Engineering, University of Missouri-Columbia, Columbia, MO, 65211-2200, USA, Ph 573.882.6380, Fx 573.882.4784, eloehr@missouri.edu
[3] Graduate Research Assistant, Civil & Environmental Engineering, University of Missouri-Columbia, Columbia, MO, 65211-2200, USA
[4] Senior Lecturer, Civil Engineering, Monash University, Melbourne, Australia

Historical analog information collected by the DOE indicated that asphalt can have lifetimes of greater than 1000 years. DOE developed performance criteria for a cover system which included an asphalt barrier for mixed waste sites (Wing and Gee 1994b). A test cover including a fluid applied asphalt (FAA) layer above the asphalt concrete was constructed and evaluated. The initial results indicated conductivity of cores from the asphalt concrete layer to range from $1.3x10^{-9}$ to $1.2x10^{-10}$ cm/s and field measured conductivities to range from $1.1x10^{-7}$ to$1.9x10^{-9}$ cm/s. The higher values in the field are likely attributed to measuring techniques and may not be representative of the asphalt conductivity. The conductivity of the FAA was measured and reported to be $1.8x10^{-11}$ cm/s. The asphalt barrier looked very promising but DOE efforts have diminished on this program and little follow up information is available.

Results of laboratory and field efforts with asphalt concrete and fluid applied asphalt have illustrated that low hydraulic conductivities can be achieved with these barriers given proper design and high level construction quality control (Bowders et al 2000). Several lessons learned from the existing data include: the percentage of air voids must be below 4% (vol. basis) to achieve low hydraulic conductivity, asphalt cement content must be above 6% (wt basis) to achieve low hydraulic conductivity, fines content (fraction less than 0.02 mm) must be increased to 8% - 15% to ensure a dense graded mixture, at least two layers of asphalt concrete should be used with a minimum thickness of 5 cm/layer to minimize continuity of potential defects and lateral spreading of any seepage, apply an asphalt cement tack coat between layers, stagger and slope the joints for good compaction, the fluid asphalt applied layer should be between 1 and 3 mm thick, and the subgrade must be stable and adequately drained.

In the United States several containment barriers incorporating asphalt have been constructed primarily for cover systems for existing landfills and contaminated sites (Bowders et al 2000). The designs follow closely with the lessons learned cited above. The authors have used a systematic methodology to develop an asphalt mix design and quality control-assurance measures followed by in situ testing to document the field performance of an asphalt barrier. The program is described below.

An alternative barrier system was designed that incorporates 100 to 150 mm of asphalt concrete overlain by a 2 to 3 mm thick fluid applied asphalt/geotextile (FAA/GT) (Figure 1). Hydraulic conductivity tests were performed separately on laboratory prepared FAA/GT and asphalt concrete specimens. The FAA/GT specimens had measured

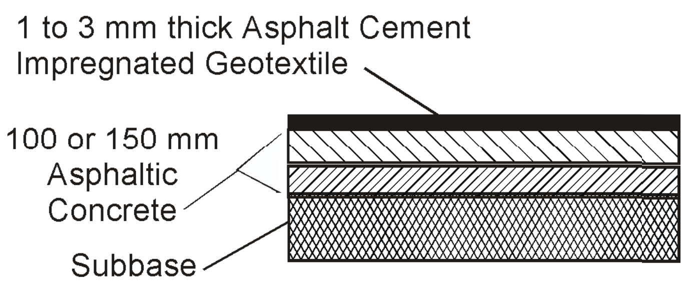

Figure 1 – Cross-section of asphalt concrete and fluid applied asphalt-geotextile barrier.

hydraulic conductivities of less than $1x10^{-11}$cm/s. Conductivity tests on asphalt concrete specimens indicated that specimens having 7% or more asphalt cement and unit weights of 22 kN/m^3 or more have conductivity of less than $1x10^{-9}$ cm/s.

A full-scale test pad (60 m x 18 m) was constructed and tested for barrier performance. FAA/GT and asphalt concrete samples were retrieved from the test pad to measure the hydraulic conductivity. Measurements on field installed FAA/GT and asphalt concrete specimens revealed conductivities comparable to that of the lab prepared specimens. In-situ hydraulic conductivity measurements were also conducted. Sealed-double ring infiltrometers (Figure 2) were used to measure the conductivity. The average measured conductivity was $1x10^{-10}$ cm/s. Given the longevity of buried asphalt and the high level of barrier performance shown by lab and field testing, asphalt-based liner materials are equivalent and in some regards superior to the present prescriptive subtitle-D liner.

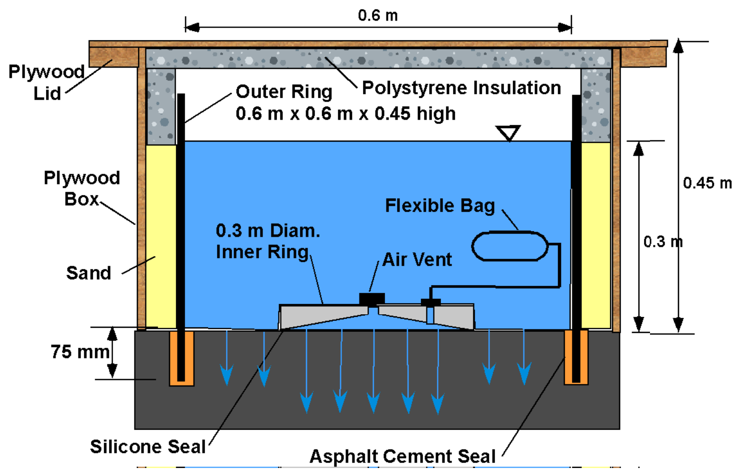

Figure 2 – Elevation view of sealed double-ring infiltrometer for measuring vertical infiltration into asphalt concrete barrier layer.

References

Asphalt Institute (1976) *Asphalt In Hydraulics*, College Park, MD, 68p

Bowders JJ, Loehr, JE, Mooney DT and Bouazza A (2000) "Asphalt Barriers for Waste Containment, *Proceedings* of the GeoEng 2000, Melbourne, Australia, p243.

Monismith CL and Creegan PJ (1996*) Asphalt Concrete Water Barriers for Embankment Dams*, ASCE Press, 196p.

Sherard JL, Woodward RJ, Gizienski SF and Clevenger WA (1963) *Earth and Erath-Rock Dams*, John Wiley & Sons, New York, 725p.

Wing NR and Gee GW (1994b) " The Development of Surface Barriers at the Hanford Site," *Proccedings* of the 33rd Hanford Symposium on Health and the Environment, In Situ Remediation: Scientific Basis for Current and Future Technologies, Part 1 Eds GW Gee and NR Wing, pp 427-440.

Wing NR and Gee GW (1994b) "Quest for the Perfect Cap," *Civil Engineering*, 64(10):38-41.