Proceeding of the Korean Radioactive Waste Society
Vol. 1, No. 2, November, 2003

Artificial Rainfall Test of the Engineered Cover Barriers for Near Surface Disposal of LILW

Jin Beak Park, Se Moon Park and Chang Lak Kim
Nuclear Environmental Technology Institute
Korea Hydro & Nuclear Power Co., LTD.

ABSTRACT

Engineered barrier test facility is specially designed to demonstrate the performance of engineered barrier system for the near-surface disposal facility under the domestic environmental conditions. Comprehensive measurement systems for the water content, temperature, matric potential are installed within each test cell. In this study, short-term monitoring of the behavior of multi-layered cover system is implemented with artificial rainfall system. The periodic measurement data are collected and analyzed by a dedicated database management system, and provide a basis for performance verification of the disposal cover design.

1. Introduction

Former simple trench type of near surface disposal facility showed many problems regard to radiological safety aspect. To overcome these safety problems, multiple layered landfill cover systems which can limit surface water infiltration into the radioactive waste package were suggested and included in regulatory requirement from 1980's [1] .

Specifically designed landfill cover systems are adjusted for near surface radioactive disposal facility at several nations such as England, France and Spain. These cover systems are designed focused on the domestic environmental conditions of each nation.

In Korea, conceptual design of the engineered barrier cover system for the near surface disposal facility was implemented [2]. As an experimental validation purpose of our previous conceptual design works [2], construction of the engineered barrier test facility is recently completed and performance tests of the disposal cover system are being actively conducted.

The work scope of this engineered barrier test facility can be summarized as: (1) detailed engineering design and construction of facility, (2) analysis of the cover system performance by preliminary computer simulation and (3) long- and short-term validation experiments of the cover system and data analysis.

Artificial rainfall test was started from Oct. 21 2003 to the end of Nov. 2003. In this paper, procedures of short-term artificial rainfall test will be described and the test result will be discussed.

2. Conceptual Design of Near Surface Disposal Facility

The conceptual design of vault type disposal facility was conducted at NETEC from 1998 to 2000 along with a preliminary safety assessment of the near surface disposal facility. Fig. 1 shows the conceptual design of multi-layer disposal cover for the LILW disposal facility.

The cover material type and functions of each layer in the conceptual repository design are as follows:

(1) The function of top soil layer is to support the growth of vegetation and thereby promote evapotranspiration, to prevent soil erosion, and to temporarily intercept and store moisture for later removal by evapotranspiration.

(2) Protective layer 1 is gravelly sand layer designed to function as top soil layer, except that this layer acts as a filter to prevent migration of top soil into underlying gravel.

(3) Protective layer 2 is the protective layer made of a pea gravel. Its function is to protect underlying layers from degradation through repeated freeze/thaw cycle, repeated excessive wetting/drying, and plant roots or animal intrusion.

(4) Drainage layer 1 and 2 are designed to facilitate the lateral drainage and prevent head build up over the underlying asphalt and geosynthetic membrane.

(5) Asphalt and geosynthetic membrane layers, respectively, are designed to act as an artificial barrier to minimize water infiltration into the underlying materials. High density polyethylene was assumed as geomembrane material.

(6) Finally, barrier layer is consisted of clay of mixture of 20%-bentonite and 80%-sand to limit the water infiltration flux to be very low.

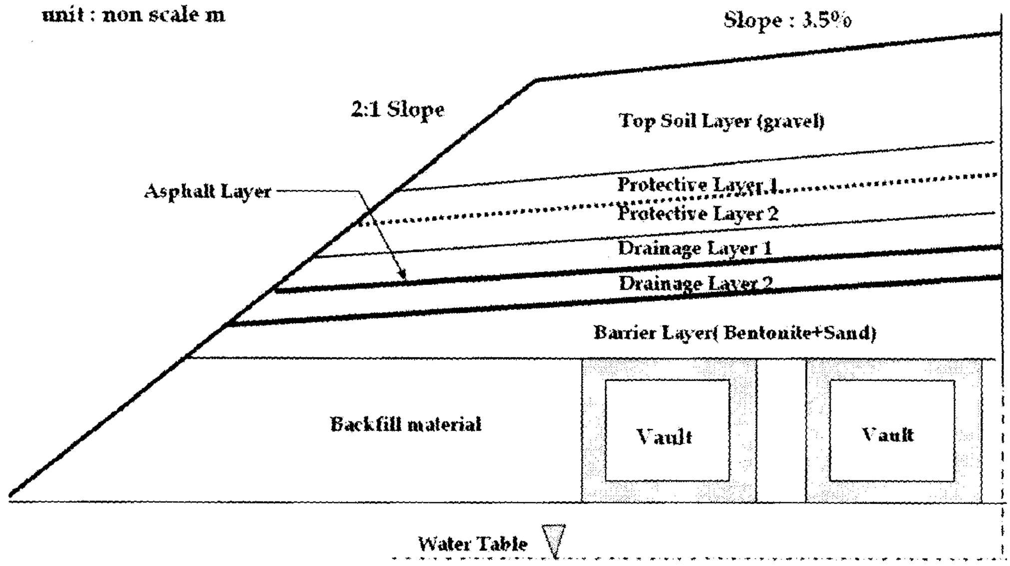


Figure 1 Conceptual design of multi-layered disposal cover for the LILW disposal facility

3. Engineered Barrier Test Facility

A. Disposal Test Cell

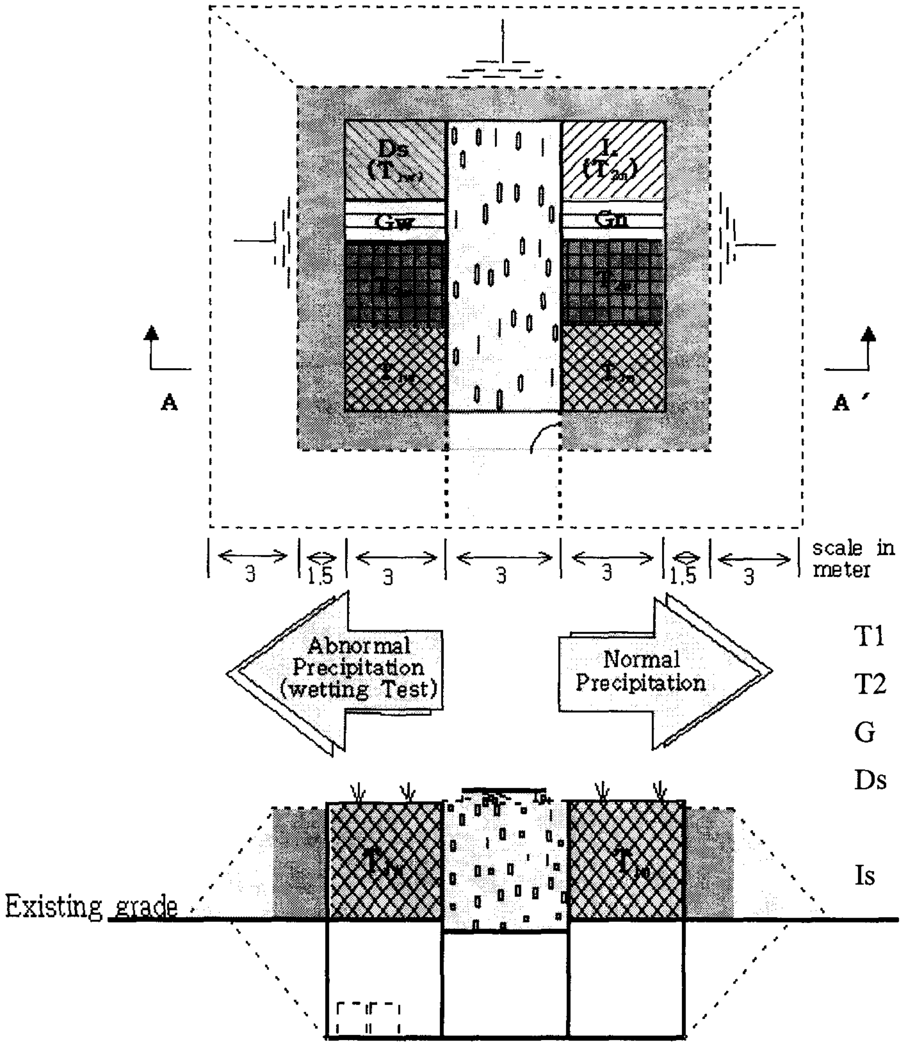
Disposal test facility has two floors. Facility has six test cells in which multipurpose working space and a corridor are in the upper floor and disposal information space for PR center assuring the safety of LILW disposal in the lower floor. Layout of this test facility is depicted in Fig. 2.

Two types of test cells are installed to simulate the degradation of the asphalt and geomembrane and denoted, respectively, as T1 (Type 1-with asphalt and geomembrane) and T2 (Type 2-without asphalt and geomembrane). Detailed configurations of T1 and T2 cells are shown in Fig. 3.

Fig. 2 shows that symmetrical allocation of T1 (T1w and T1n) with destructive sampling cell (denoted as Ds) in left hand side and T2 (T2w and T2n) cell with In-situ test cell (denoted as Is) in right hand side. This division is to test abnormal and normal rainfall (precipitation) situation for each test cell. Abnormal wetting test can be simulated in short-term experiment with artificial rainfall system which is installed with motor driven pump and water storage tanks.

B. Detection system

Soil water contents and temperature of each cover layer are measured with Time Domain Reflectometry (TDR). Total 108 numbers of TDR sensors are installed and 72 tensiometers measure the matric potential of each cover layer. All TDRs and tensiometers are connected to the multiplexer for collecting the detected data. Datalogger system of CR10X (measurement and control system) is installed in wiring panel and is connected to personal computer, at which management software (i.e. PC208W) is installed and control the result data processing.



T1 : Type 1 cell
T2 : Type 2 cell
G : Test Gallery
Ds : Destructive sampling cell
Is : In-situ test cell

Figure 2 Layout of disposal test facility

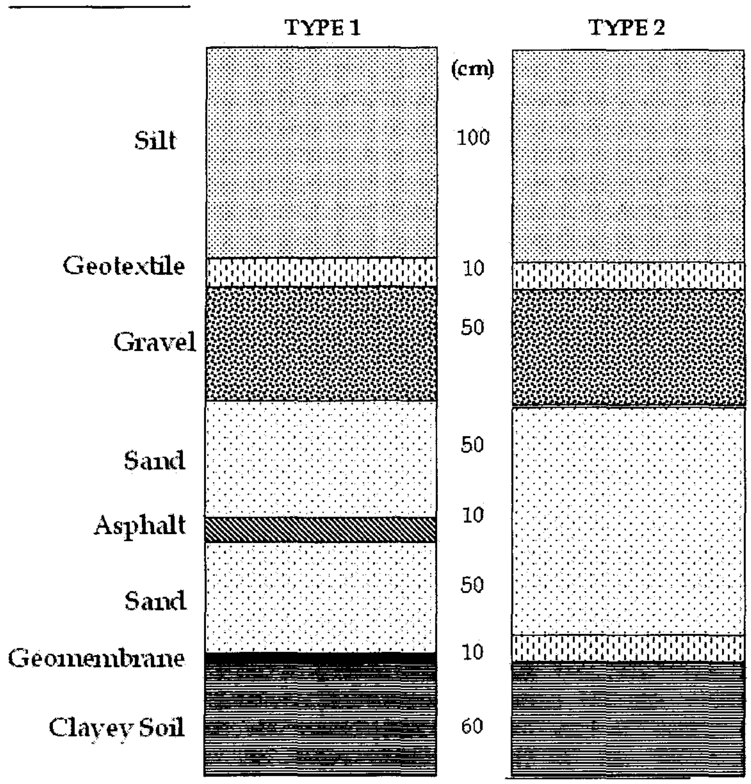


Figure 3 Cross section of Type 1 and Type 2 test cell

4. Artificial rainfall test of Type 2 Cell

Short-term artificial rainfall test of the disposal cover is implemented from 21 Oct. 2003 to the end of November. Total 1800 liters of water that is stored in water storage tank is poured out through the artificial rainfall nozzles into T2w cell during 5 hours. Fig. 4 shows the variation of measured water content of this short-term rainfall test.

In this experiment, initial water content in % of top soil layer is measured about 43% (at 290 cm) and 48% (at 310 cm). After the artificial rainfall system start to rain at 3.0 day in Fig. 4, peak value of water contents reaches rapidly to 68 % (at 310 cm) and 55% (at 290 cm) within a day and then water content profile decreases slowly.

Upper drainage layer (sand) at 150 cm and low drainage layer(sand) at 90 shows relatively small peak. Initial water content of upper layer is initially very low indicating at 37%. After the artificial rainfall, profile of upper sand, 150 cm, starts to increase to reach at maximum value, 43%, and then decreases more slowly. By contrary to upper drainage layer, low drainage layer shows initially high water content. This is due to the clay barrier layer just beneath the low drainage layer. Clay layer shows its water content to be close to full-saturation value. Lower drainage profile shows small peak of water content and then return to previous value within several hours.

Drainage layer shows the satisfactory performance as intended in the design stage. It is investigated in Fig. 4 that no more increase of water content in barrier layer and prompt return to previous value in low drainage layer.

Table 1 shows the accumulation of lateral drainage from upper and lower part of drainage layer. Table 1 shows the prompt increase of water volume initially and then reaches to its plateau. This means that a half of artificial rainfall water (about 900 l) flows to lateral drainage system and another half of rainfall water is used to increase the water content of top soil material mainly. Volume of top soil is more than 1400 liters (1.2m x 1.2m x 1.0m(H)). Small portion of rainfall water is supposed to stay in sand drainage layer.

Fig. 5 indicates that there is no relation between the rainfall and temperature of layers. From Fig. 6, higher variations of matric potential within top soil layer are observed than within the drainage layer. This is due to 1) water infiltration of top soil is dominant during the test and 2) lateral drain within lateral drainage layer is dominant than the downward infiltration.

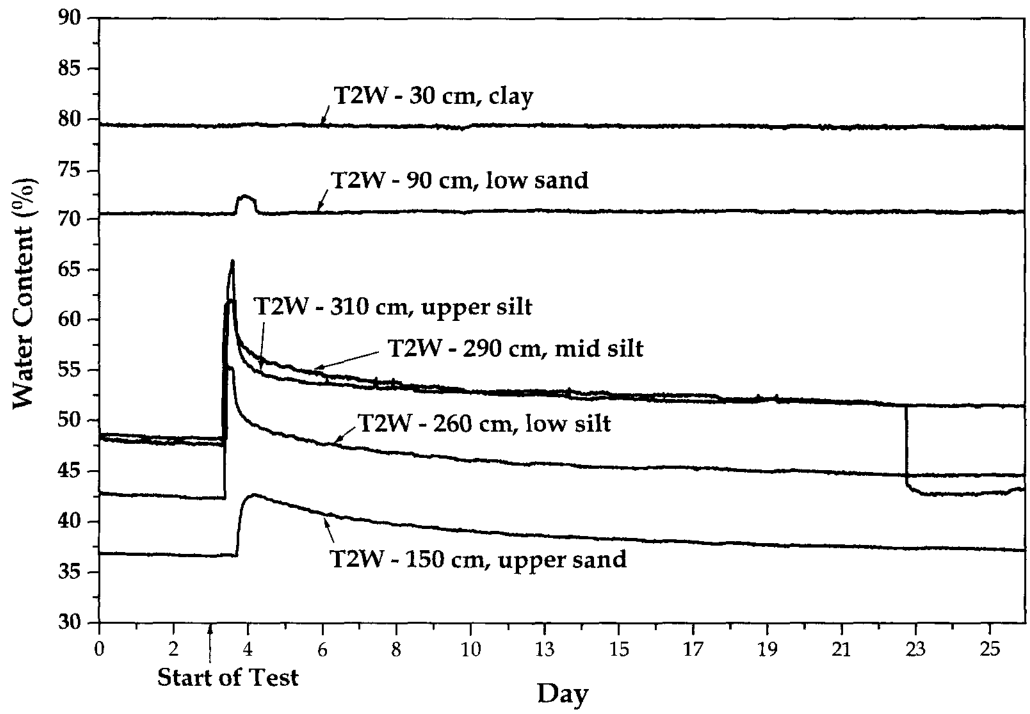


Figure 4 Variations of water content within engineered barriers

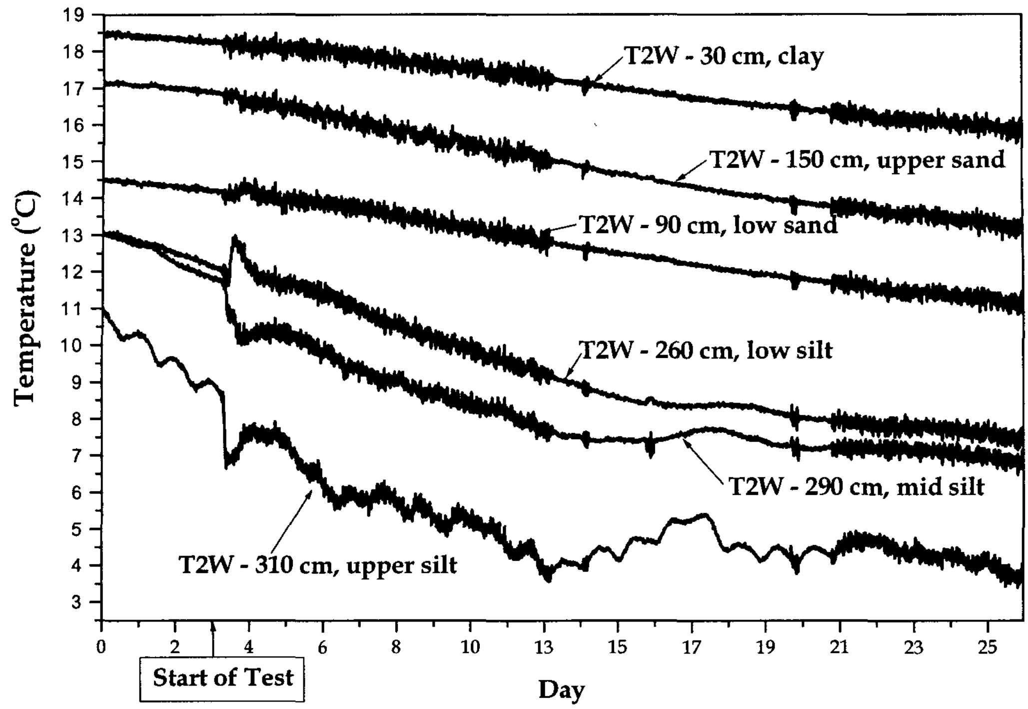


Figure 5 Variations of temperature within engineered barriers

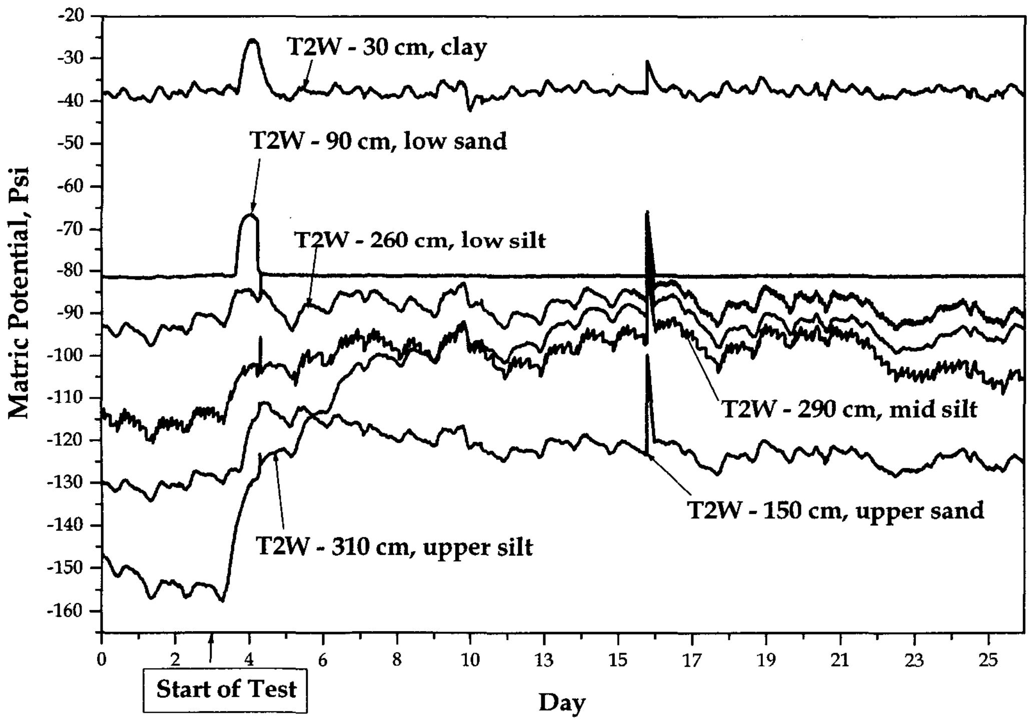


Figure 6 Variations of matric potential within engineered barriers

Table 1 Results of accumulated lateral drainage water volume

Measurement Time	Accumulated drainage water volume (liter)
2003-10-22 (11:30)	237.6
2003-10-23 (16:00)	511.2
2003-10-25 (10:00)	648.0
2003-10-25 (15:00)	662.4
2003-10-26 (17:00)	720.0
2003-10-27 (09:00)	748.8

5. Conclusions and Further Study

Engineered barrier test facility is prepared for the validation purpose of the conceptual design of near surface disposal of LILW in KOREA. This facility is composed of 6 test cells which are to demonstrate the ability of each cover layer under the natural domestic rainfall and artificial rainfall. Comprehensive measurement systems for the water content, temperature, matric potential are installed within each test cell.

During the artificial rainfall test, it is found that 1) drainage layer shows the satisfactory performance as intended in the design stage, 2) there is no relation between the rainfall and temperature of cover layers, 3) a half of artificial rainfall water (about 900 l) flows to lateral drainage system and another half of rainfall water is used to increase the water content of top soil material mainly, 4) Higher variations of matric potential within top soil layer are observed than within the drainage layer.

Similar artificial rainfall tests with Type 1 cell are scheduled. Comparison of test results between type 1 and type 2 cells will be reported.

6. Acknowledgements

This work has been carried out as a part of National Research Laboratory (NRL) program financially supported by the Ministry of Science and Technology (MOST), Korea

7. References

[1] Hakonson, T.E., *Capping as an Alternative for Landfill Closure-Perspectives and Approaches in the United States.* 1998, IAEA: Advisory Group Meeting Report.

[2] Kim, C.L., *Conceptual Design of the Disposal Facility for Low and Intermediated*

Radioactive Waste. 2000, Nuclear Environment Technology Institute (NETEC).

[3] Schroeder, P.R., et al., *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*. 1994, U.S. EPA: Washington, DC.

[4] Kim, C.L., et al. *Research Plan for LILW Near Surface Disposal Test Facility*. in *1st Workshop on Safety and Performance Validation of LILW Near Surface Disposal Facility*. 2001. Nuclear Environment Technology Institute (NETEC).