Geosynthetics, J. Kuwano & J. Koseki (eds)

Improvement of waste landfills using geosynthetics in Japan

Imaizumi, S.
Graduate School of Engineering, Utsunomiya University, Japan

Nakamura, K.
Geo-design Co., Ltd, Japan

Matsuyama, S.
Takiron Co., Ltd, Japan

Konishi, Y.
Taiyo-Kogyo Corporation(Sun), Japan

Kanou, H.
Neo-Roofing Limited, Japan

Keywords: waste landfill, geomembranes, geotextiles, regulation, history

ABSTRACT: In waste landfills, many kinds of geosynthetics such as geomembrane, GCLs, geotextile, geocomposite, geodrain and geogrid have been commonly used. The regulations for barrier systems in Japan were dramatically revised in 1998. These regulations require the use of double geomembrane barriers, or single geomembrane with an impervious soil layer. In the paper, history of the regulations of liner system is reviewed, and types of geomembrane for the barrier sheets and the total amounts of geomembranes used in 1998 are shown. There are many landfill sites which were constructed before 1998, and those do not conform to the new-regulations. In the paper, since those sites need to be urgently improved, methods and some ideas to improve the landfill sites are described.

1 INTRODUCTION

The regulation for barrier systems in Japan was dramatically revised in 1998. This regulation requires to use double geomembranes as barrier sheets or single geomembrane with impervious soil layer. It also requires to use geotextiles as protection mat on the top geomembrane and between the geomembranes. In waste landfills, other kinds of geosynthetics such as GCLs, geocomposite, geodrains and geogrids are also used.

There are many waste landfills which were constructed before 1998, and those sites do not conform to the new-regulations. Therefore it is urgent to improve those old sites, and many types of method to improve the land fills have been used so far. For some methods, geosynthetics do important function.

In Japan, it is very often to encounter many opponents when a new landfill site is planned. The number of operational landfills has been decreasing year by year. Therefore, the ideas that the existing landfill site should be enlarged are very important.

In this paper, recent situations and technologies for the landfill improvement in Japan are described.

2 HISTORY OF WASTE LANDFIILS IN JAPAN

Open dumping into valleys or old excavations without any barrier has been done before enforcement of the landfill regulation in 1977. However in some landfills, attempts was carried out to prevent the leachate of waste from infiltrating the ground.

The Nakata landfill in Chiba city constructed in 1977 was the first sanitary landfill with a geosynthetic liner. The EPDM (Ethylene Propylene Diene Monomer) with a thickness of 1.5 mm was used for barrier sheets. After 1980, a lot of landfills has been constructed using single geosynthetic liner made of EPDM or EPDM blended with Butyl Rubber.

The first regulation concerning landfills was notified in 1977. In this regulation, landfills with industrial waste were divided into three types, that is, (1) stable waste landfill, (2) controlled type landfill and (3) hazardous landfill. As the landfill where municipal waste was disposed in was the same as the controlled one, the controlled type landfill was the most popular type in Japan. It was required to have barrier system; leachate collecting and a ventilation system for aerobic-biological decomposition. The barrier system requirement was either a thick compacted clay with a coefficient of permeability of lower than 10^{-5}cm/sec or single geomembrane sheet. EPDM with a thickness of 1.5mm was commonly used.

In 1990, TV program reported the contamination of a well near the controlled type landfill at Hinode town in Tama area, where the source of drinking water for Tokyo is partially located. The TV program also said that EPDM liner was very easy to be punctured and there were many holes to be repaired

on the EPDM liner placed on a bench of the landfill.

After this report, protest meetings against construction of a new landfill by the people who lived near the planned landfill site have occurred at many cities and towns. Unfortunately, the landfill has been thought to be the most hated facility in most towns in Japan. On the contrary, an amount of wastes including municipal and industrial had been increased until 1990, because Japanese economy had been highly growing. In consequence, the active capacity of the landfill became very small level at that time.

To give confidence to the people in the landfill-planned town, and to gain the approval of the construction of a new landfill, it has become necessary to develop new materials and techniques, for example, a self healing material such as GCL (Geosynthetic Clay Liner) or a leachate point detection system. More importantly, HDPE (High Density Polyethylene) geomembrane was mainly selected as a liner-component because of its good physical properties such as tensile strength and puncture resistance.

In December 1995, the Ministry of Health and Welfare notified the revised regulations. The concept of the revised design for barrier system was based on double liners, that is, composition of two geomembranes or single geomembrane placed on the low permeable clay. Unfortunately, as the natural clay is not available easily in most part of Japan, the composition system using two geomembranes was commonly employed. A geotextile sheet was also spread between geomembranes for the protection.

In October 1998, the final regulation was notified. Figure 1 shows the barrier systems indicated in the regulation in 1998. The types of double liner system include four methods, that is,

(1) Low permeable cohesive soil; a coefficient of permeability is less than 10^{-5}cm/sec and a thickness is more than 5 m. In this case, we don't need to use any geomembrane as a liner.
(2) Composite barrier of geomembrane; thicknesses of geomembrane and cohesive soil are 1.5 mm and more than 50 cm respectively. A coefficient of permeability of cohesive soil is less than 10^{-6} cm/sec.
(3) Composite barrier of geomembrane; a thickness of 1.5 mm for geomembrane. A thickness of asphaltic concrete is 5 cm, and a coefficient of permeability is less than 10^{-7}cm/sec.
(4) Double geomembranes liner; The thickness of geomembrane is 1.5 mm.

The concept of the barrier system in 1998 made a little progress comparing to that of 1995. The basic concept of the final regulation has two important points to prevent leachate from infiltrating into the surrounding ground. The first point is to use the secondary liner, and the second is to place many protective layers for preventing the sheet from mechanical damages. Therefore, in the case of double geomembrane liners, two geomembranes should be placed separately and also the protective layer should be placed between them.

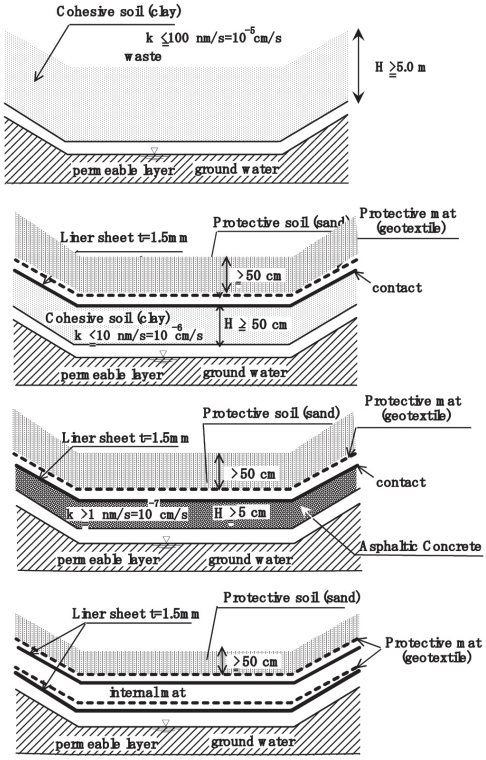

Figure 1. Double liner system regulated in 1998.

3 TYPES OF GEOSYNTHETICS FOR LANDFILLS

3.1 *Geomembranes*

Table 1 shows the types and total amounts of geomembranes used in waste landfills in Japan, investigated in 1998 by the Japanese Association of Barrier Sheet. From the table, it is understood that HDPE geomembrane was the most popular one and took about 50% of barrier sheets in 1998. However, the use of geomembranes with medium rigidity, such as TPO-PP, TPO-PE and LLDPE has been increased recently. Because most of landfills in Japan are constructed to bury the valley with surrounding embankment in mountainous areas, and also typical disposed area is between 20,000 m^2 and 50,000 m^2, the barrier sheet is required to keep better workability.

Table 1. Types and total amount of Geomembranes used in landfill in 1998.

Type	Amount (m^2)
HDPE	888,557
MDPE	9,154
LLDPE	17,374
TPO-PE	654,556
TPO = PP	79,000
EPDM	75,803
TPU	28,000
PVC	0
Asphaltic sheet	26,300
Others	13,500
Total	1,792,244

3.2 *Geotextiles*

Geotextiles are used as the protective mats for barrier sheet. They are placed above and bottom of the barrier sheet, or between the sheets when double sheets system is employed. The use of stapled nonwoven geotextiles reinforced by fabric has been increased recently. The mass per unit area is between 500 g/m^2 and 1500 g/m^2.

When the protective mat is used over the barrier sheet on side slope, it functions shielding the sun light, especially the ultraviolet ray. It results in decreasing the temperature of barrier sheets.

Green geotextiles are often used as the protective mats for the harmony with surrounding landscape as mountains or green hills.

4 IMPROVEMENT OF IREGULATED LANDFILL

As mentioned before, there are many landfill sites which were constructed before 1998, and those do not conform to the current regulation. It has been urgent to improve those situations. Many kinds of method to improve the landfill have been used so far.

Where the ground water level is below the bottom of the existing landfill and there is impermeable layer at a shallow depth beneath, typical method is to build a vertical barrier wall surrounding the landfill. Figure 2 shows the schema. A vertical cut off wall is excavated into the impermeable layer, and bentonite slurry trench, geomembrane or steel sheet is used for a protection of the wall. Usually leachate treatment facility is also built as shown in Figure 2(a). The leachate is withdrawn by pump and sent to the facility. Recently, however, the number of vertical cut off wall method with over-capping as shown in Figure 2(b) has been increasing gradually. Geomembranes, GCLs, geogrids and geotextiles are used in the over capping system.

The other popular method is shown in Figure 3. In this method, the existing waste is first removed and placed temporary. The old landfill is improved by constructing the double sheets liner system on the bottom and side-slope. Then the removed waste is again disposed into the new site after it is pre-treated, such as separation and removal of recycleable materials in order to decrease volume of the waste.

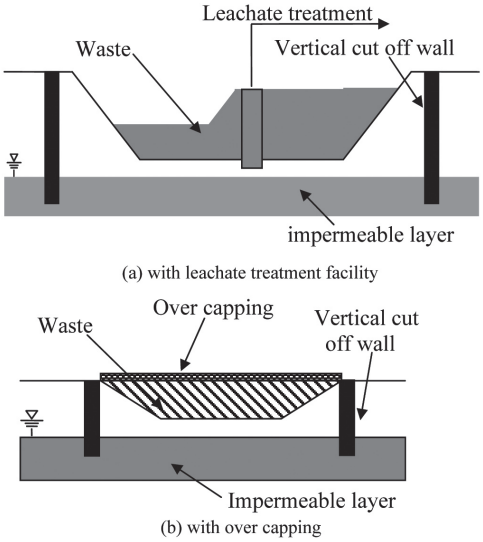

Figure 2. Vertical cut wall method.

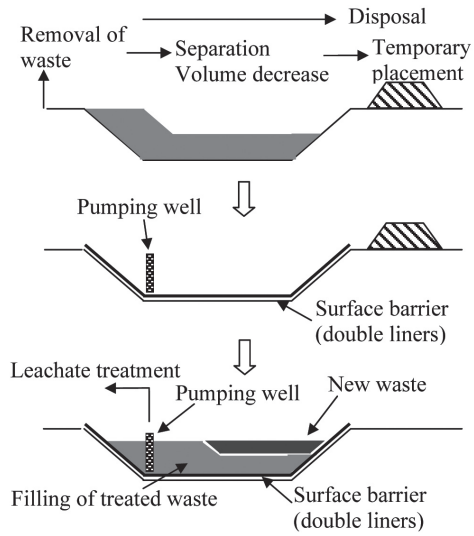

Figure 3. Removal (temporary) of existing waste and construction of double liner system.

The water treatment facility is also constructed at the same time. This method sometimes produces open space for the further waste disposal because the volume of old waste can be decreased as mentioned above.

Figure 4 shows the other stabilization method to improve the unregulated landfill. Solidification using cement or sodium silicate has been popular method

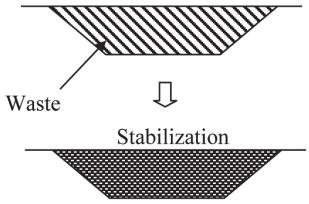

Figure 4. Chemical stabilizing of the existing waste.

to stabilize the hazardous materials which are included in the waste. In this method, it is seldom to use geosynthetics.

5 EXTENDING THE LIFE OF EXISING LANDFILL

It is very often to encounter many opponents when a new landfill site is planned. For this reason, the number of landfills which is operational and designed to be constructed has been decreasing year by year. Table 2 shows the remaining capacity and years of landfills in 2002. Remaining life of landfill for industrial waste is only 4.5 years. Therefore, it is very urgent to extend the life of existing waste landfill.

Table 2. Volume, remaining capacity and life of waste landfill.

		Municipal waste	Industrial waste
Generation Volume (10^3 ton)		51,610	393,000
Disposal Volume (10^3 ton)		9,030	40,000
Landfill	Remaining Capacity (ha)	14,477	18,178
	Remaining Life (year)	13.1	4.5
	Number of sites	2,048	2,655

There are two types of rising method which are commonly used. One is such that the soil bank is first constructed on the existing landfill of which surface has covering soil. Slope surface of the new bank is lined by the double sheets as shown in Figure 5. Then the new waste is disposed into the space.

Figure 6 shows the other rising method. In this method, concrete wall is constructed on the existing landfill, and inside of the concrete is lined by the double sheets. The end of barrier sheet is fixed by steel clamps.

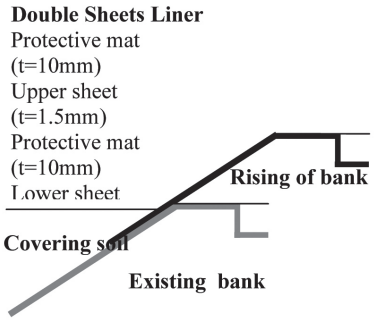

Figure 5. Rising of bank to make open space for the future waste.

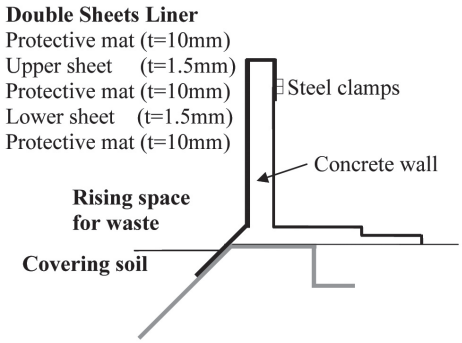

Figure 6. Construction of Concrete wall with liner.

6 CONCLUSIONS

In this paper, history of regulations for barrier system of waste landfill is described. In Japan, liner system with double geomembranes is most popular, and HDPE, TPO-PE and TPO-PP are typically used. Non-woven geotextiles reinforced by fabric plays important part to prevent the barrier sheet from mechanical and chemical damages.