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# An example on the construction of MSW landfill site with the leakage detection and restoring automatically

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ABSTRACT: The impermeable structure developed in this study adopts that the double liner system sandwiches excellent permeable material to detect leakage of leachate from the impermeable sheet. The site divided into some blocks made in the bag of a liner sheet with wideness of 300–500 $m^2$. Each block has a tube for detection of the leakage. When some water leaks, it flows to the detection pit through the tube quickly. The PH-sensor/EC-sensor installed in the site analyzed whether or not the fluid is contaminated. If the dew water is clean, it is just taken off. Otherwise, the restoration material will be pumped into the bag through the tube and defect part in the liner was recovered urgently. Administrators in the room controlling landfill can monitor the barrier performance of liners using the telephone line for 24 hours.

## 1 INTRODUCTION

The impermeable performance has much influence to the liner sheet in a landfill site. The system monitoring damage of liner sheets is required in order to improve the safety performance of the landfill.

This monitoring system needs to be applicable for any kind of landfill site. In ideal, the damage on the liner sheet is detected and then, it should be able to restore the performance quickly. Besides, detection system as for the leakage should be recovered smoothly. However, it has been difficult to detect the new damage again after restoring the damage.

Leak detection system should have the following properties of:

(1) Simple, less troubles and less labor,
(2) Availability of detecting leakage urgently and analyzing water quality,
(3) Availability of detecting a defect part before the pollution spreads out,
(4) Recovering impermeable performance quickly and the function after restoring the damage continuously and;
(5) Availability of restoring damage of liners without digging them up from the landfill site.

In this paper, a leakage detecting and a defect restoring system newly developed with very safe and reliable, are introduced on constructing of landfill with respect to municipal solid waste (MSW). Gravity flow method does not need special facilities for detecting the damage. It can also estimate the quantity of leakage and analyze the water quality. Moreover, the system developed can continue to detect the leakage for 24 hours and transfer the data to a distant place by the phone line. Bentonite colloid fluid makes the liner sheet into the bag structure fill with a defect part. After restoring, it can continue to detect the leakage with monitoring the quantity of solution decrease, continuously.

## 2 SUMMARY OF SYSTEM DEVELOPED

Figure 1 illustrates an entire system developed in this study. This system basically has the 5 layers with lower protective mat, lower impermeable liner sheet, inner good permeable mat, upper impermeable liner sheet and upper protective mat. The cross section of the bag structure is shown in Fig. 2. An area of cross section of the bag is approximately 300 $m^2$ to 500 $m^2$ (Kanou et al. 1995). If any damage is caused in the impermeable liner sheet, the water should be drained into the detection pit through the tube connected to every bag with gravity flow.

Schematic of the system of leakage detection is illustrated in Fig. 3. The leakage can be monitored for 24 hours.

It was confirmed that it could detect the leakage within 24 hours if the liner had even 0.5 mm diameter

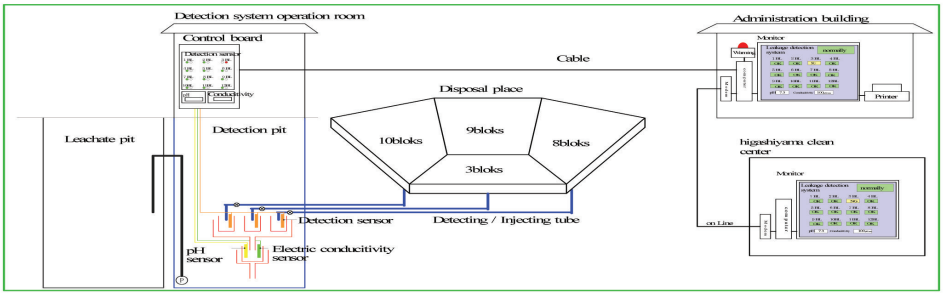


Figure 1. Schematic of entire system with the leakage detection and restoring automatically.

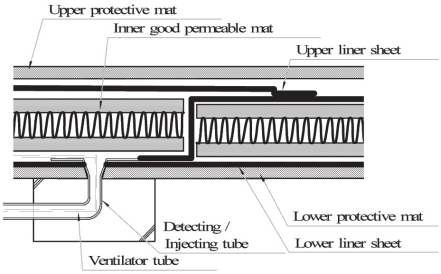


Figure 2. Cross section of the bag structure.

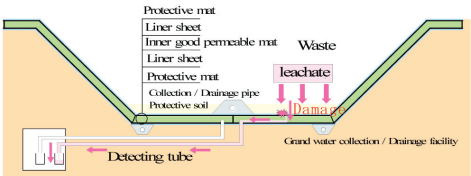


Figure 3. Schematic of the leakage detection.

hole. PH-sensor/Electric Conductivity (EC) sensor analyze whether or not the fluids detected is polluted. If leachate is detected with a sensor, the bentonite colloid solution is injected into the bag through the detecting/injecting tube. When the solution comes out from the ventilator tube, the injection is completed. The colloid solution restores the damage by making the mud cake in the bag with keeping the water pressure. Schematics of the basic concept and restoration model are illustrated in Figs. 4 and 5 (Hongou et al. 1997 and Hongou et al. 1997), respectively. It was confirmed that it could detect the leakage within 24 hours even if the defect was only 0.5 mm diameter hole in the liner.

## 3 LANDFILL CONSTRUCTION

The features of construction are drawn as follows:

- Site of construction: A certain city in Nagano
- Capacity of landfill: 38,000 $m^3$

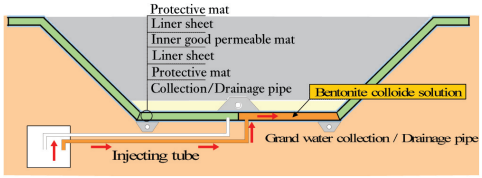


Figure 4. Schematic of the repairing idea.

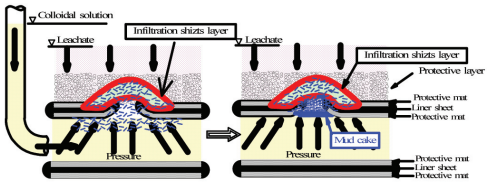


Figure 5. Model of the repairing.

- Structure of Liner system:
  The base part and the first slope; 5 layers (damage detection system) and
  The second slope and upper; Shotcrete and 3 layers.
- Liner facilities area; 5 layers; 3274.8 $m^2$
  3 layers; 4045.6 $m^2$
- Construction period: From 2004/06 to 2004/08

The pictures of construction site are shown in Figs. 6–7 and the plane view of this site is shown in Fig. 8. The barrier system in this site can detect the leakage up to the first level of the slope with much possibility of the damage to the impermeable liner. The impermeable liner with 5 layers was installed in the division. In more than 5 m depth; it has 3 layers on the shotcrete because it has little risk, which the sheet is defected. Based on this concept, it is recognized that the MSW landfill will be into stable period.

Impermeable liner is composed of a polyurethane sheet with 1.5 mm thick. Lower protective mat is non-woven fabric made of short fiber. Upper protective mat is non-woven fabric with laminating made of long fiber. The reason using the mat with laminating is to avoid the damage with snow load. The site is divided into 12 blocks which are the bag structure and have the detecting/injecting tube each.

Figure 6. Picture of situation in the construction.

Figure 7. Picture of constructing liner facilities.

Figure 8. Picture of after completion liner sheets.

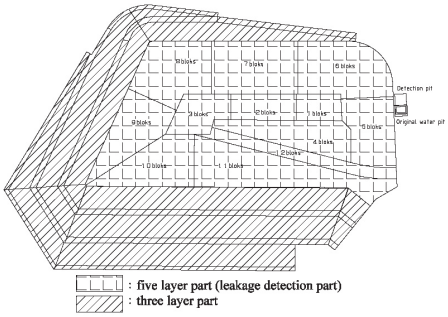


Figure 9. The plane view of the site.

Figure 10 shows the control panel and, Fig. 11 shows the distribution of the injecting pipe in the detection pit. The screen of monitoring on a personal computer is displayed in Fig. 11. The detecting tube has the sensor, which detects the leakage with measuring and recoding every one hour. If the sensor detects the leakage, light emitting diode (LED) in control panel warns emergency by turning red from green. The data is transferred to the administration building at the same time.

This system works for 24 hours, any emergency is informed speedily to administrative room in landfill.

Figure 10. Picture of control panel.

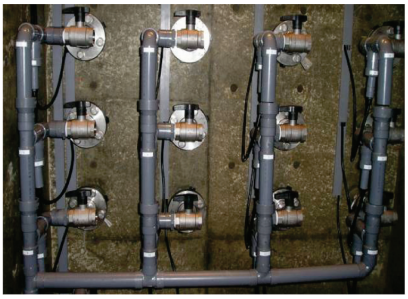

Figure 11. Picture of detecting/injecting tube in the detection pit.

Figure 12. Screen of monitoring on PC.

## 4 ASSESSMENT OF DEVELOPED SYSTEM

It was experimented whether or not the system practicality works by gravity flow in the actual site. The sheet tested in field experiment is shown in Fig. 13. The pictures with respect to detecting/injecting tube entrance, the damaged sheet artificially, keeping the water pressure at the damage, and the leakage are shown in Figs. 13–18, respectively. The model bag was prepared with width of 2 m, length of 3 m, and slope of 5%. There is a difference with the damage level of the impermeable liner, however; it was confirmed that the system detects the leakage within 24 hours after the outbreak even if it had the damage about even 0.5 mm diameter damage. The result is shown in Table 1. Hence, the system developed detects

Figure 13 Picture of bag structure of experiment layer.

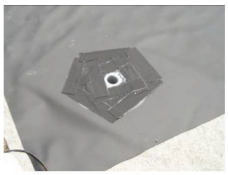

Figure 14 Picture of detecting/ injecting tube entrance.

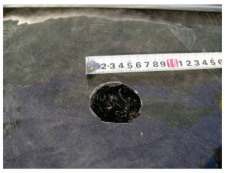

Figure 15 Picture of damaged sheet (hole).

Figure 16 Picture of cylinder for water pressure.

Figure 17 Picture of water leak situation from detecting tube entrance.

Figure 18 Picture of the situation filling colloid solution to the defect part.

the leakage from the damage without polluting neighboring environment. Besides, it can switch from detecting to restoring quickly.

It was confirmed that it can almost remove the fluids collected in the bag by vacuuming. The colloid solution was able to be filled up with pushing up the remaining water as pumping the colloid solution into the bag. Therefore, it was evaluated that it could replace the leachate with the colloid solution in the bag by vacuuming the leachate and circulating the colloid solution well.

## 5 CONCLUSIONS

This system of detecting leakage and restoring its part automatically is performed well one in real site.

The gravity flow method can resolve various problems in the system which detects the leakage and restoring the damage. We confirmed that using bentonite colloid solution enables to continue to detect the leakage after restoring the damage.


## ACKNOWLEDGEMENT

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Table 1. Table of the confirmation result.

| | Arrival time (sec) | | Leachate volume of water (Kg) | | | |
|---|---|---|---|---|---|---|
| Damaged hole (mmφ) | Detection entrace | Detection tube entrance | Volume of supply water | Gravity flow | Vacuumed water | Remain water |
| 50 | 60 | 100 | 57.3 | 54.3 | 1.9 | 1.2 |
| 10 | 120 | 210 | 59.2 | 48.6 | 10.0 | 0.6 |
| 05 | It will exhaust it in 18 hours. | | 3.2 | 1.9 | 0.6 | 0.7 |