# RENOVATION METHOD OF LANDFILL FACILITIES FOR THE CLOSURE/ RE-USE OF THE INADEQUATE SITES AGAINST THE RECENT REGULATION OF JAPAN

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## ABSTRACT

Japan has been improving improper old landfill sites against the latest regulations into the proper closures or the renewals based on the large amendment of the related regulations in 1997 for the structural standards of the landfill disposal facilities with announcing the list of unsuitable sites. On account of the suitable improvement of the unsuitable landfill site without watertight surroundings and water treatment plants, we summarized the concepts from the investigation to the designing and a sires of methods, ideas and the way of improvement by countermeasures such as waterproofing, sub-drainage, gas releasing and water treatment for leached water, quality control and monitoring method as a reference of the technical offers in this research. We introduce the out-lines of the investigation technique, the construction methods of vertical underground waterproofing wall, capping, drainage, gas releasing and leached water treatment methods from this results.

## INTRODUCTION

In March 1998, the Ministry of Health and Welfare of Japan announced to the public 538 Landfill sites as inadequate sites under the current regulations. And the government prepared the subsidizing plan for the concerned local government to renovate those sites from fiscal year 2000 to 2005.

However, the actual technical guidance for the renovation method was not well prepared for such projects except for "Technical Reference on account of the Renovation Method for Inadequate Final Disposal Site" issued by the Ministry in Nov.27$^{th}$, 1998.

Under such circumstances, LSA's research working group for Execution Method commenced to study to summarize the acceptable designing method based on the conventional execution methods.

This is to introduce those methods and basic concept, which would be acceptable to carry out such projects in Japan under the recent regulations.

## 1. REGULATIONS' REQUIREMENT

Summarized technical requirements in the latest regulations are shown in FIG.1 for the control type of final disposal site. Final disposed waste should be separated from the outside of the site with water proofing membrane or liners, and leachate should not be released without treatment which ensure the treated water lower than the Waste Water Discharge Standard or the values determined by each site which may be much lower than the regulation's values. The fences should enclose the site with notice boards for the access control. Slope protection or settlement measurement might be required in case necessary for the physical stability of the site.

Ventilation pipes to release bleeding gases from the waste and drainage to collect leachates should be provided.

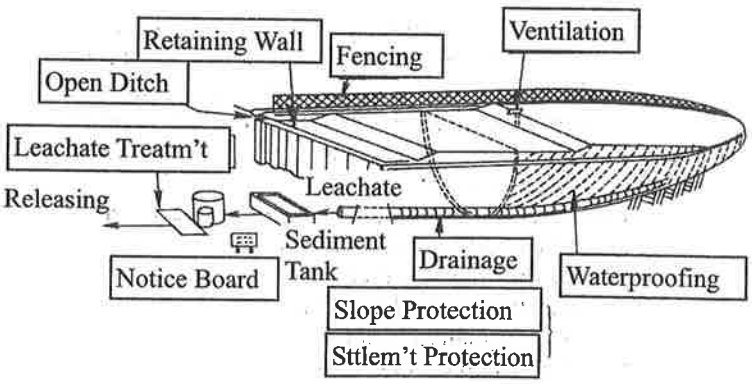


FIG.1 REQUIRED FACILITIES FOR CONTROL TYPE FINAL DISPOSAL SITE

## 2. CONDITIONS & INVESTIGATIONS

Following key investigations should be carried out for planning of the appropriate renovation.

### 2.1 Natural Environment

Natural environment is the external condition to the waste effecting on the leachates and the changes of the nature of waste.

a. Weather Condition

Information of precipitation, temperature, humidity, wind, hours of sunlight are essential for the prediction of the permeation to the waste layer, which cause the leachate from the site.

b. Topographical & Geological Condition

Land shape provides the surface and the underground with the tendency of water flows towards the lower part. Geological information provides with the stability of the ground and also water flows under ground by the combination of permeable and impermeable layers. Especially for the existing site, impermeable layers concern with the isolation of the waste together with the ground wall as mentioned in the conceptual designing.

c. Groundwater Condition

Actual groundwater flows may be measured by the bored hole. Ingredients of the groundwater in and outside of the site show the chemical background or future reference of the contaminations.

d. Surface Drainage Condition

Immediate drainage may be required for the improvement.

### 2.2 Condition for Execution

On account of the execution, following condition should be examined for the selection of the method.

a. Access Condition

Large machinery and transportation equipment may require sufficient access to the site for a certain construction method.

b. Working Yard

Area for preparation of plants, equipment, preparation of machinery, stock of the material, treatment of surface or ground water should be required by each construction method to be studied.

Restriction of noises by the construction may affect on the habitants around the site.

c. Water Rights

Execution may affect on the rights of the water by the stakeholders around the site. Water supply for construction might be required.

d. Regulation for the Land Use

A certain regulation of the land use might affect on the construction or restoration method.

### 2.3 Composition of Waste & Landfill Method

Composition of waste and landfill method shall effect on the contents and volume of the leachates and gas production from the waste layers.

a. Condition of Landfill

- Landfill Method

  2 methods for landfill, both Cell Method and Sandwich Method effect on the stabilization and the gas-generation. Location, thickness, areas, quantities of the intermediate covers and history of landfill should be studied from the record.

- Waste Condition

  Kinds of waste such as ash, incombustible residue, combustible waste, mass waste etc. and their locations, thickness and range should be examined.

b. Ingredients and Composition of Waste

Landfill waste should be characterized because it the effect on the designing of the leachate treatment method through the process.

- Incombustible or Combustible Waste

  Ingredients, distinction of resins, metals, perishable wastes, papers, rubbles etc. should be characterized as incombustible or combustible.

- Ash

  Content or existence of ash should be recognized.

- Fire Fighting Record

  Record or history of fire should be investigated.

- Debris and Residue from Incidental Fire

  Residual waste from incidental fire contains mixed waste which were not incinerated well should be recognized.

- Angle of Shearing Resistance and Cohesion

  Physical character of filled waste should be known.

c. State of Stabilization

Character of filled waste tends to change into stable stages in the due course of time. Condition of the existing stabilization stage should be recognized from the items as shown below.

- ig.loss, BOD, COD, T-N, pH etc.
- Unit Weight, Temperature of Waste, Achievable Void Reduction Ratio
- Leachate Analysis
- Bearing Gas Content
- Volume of Groundwater and its Ingredients
- Temperature of Ground

## 3. DESIGNING CONCEPT

"Guidance for the Performance of Final Waste Disposal Site" described final disposal site as it "is able to stabilize the wastes biologically, physically and chemically keeping in the facility adequately without any harmful occurrences for the maintenance of the living environment・・・".

That requires functions as;

① Safety storage with the disaster prevention
② Prevention from contamination by washing out
③ Stabilization of the filled waste

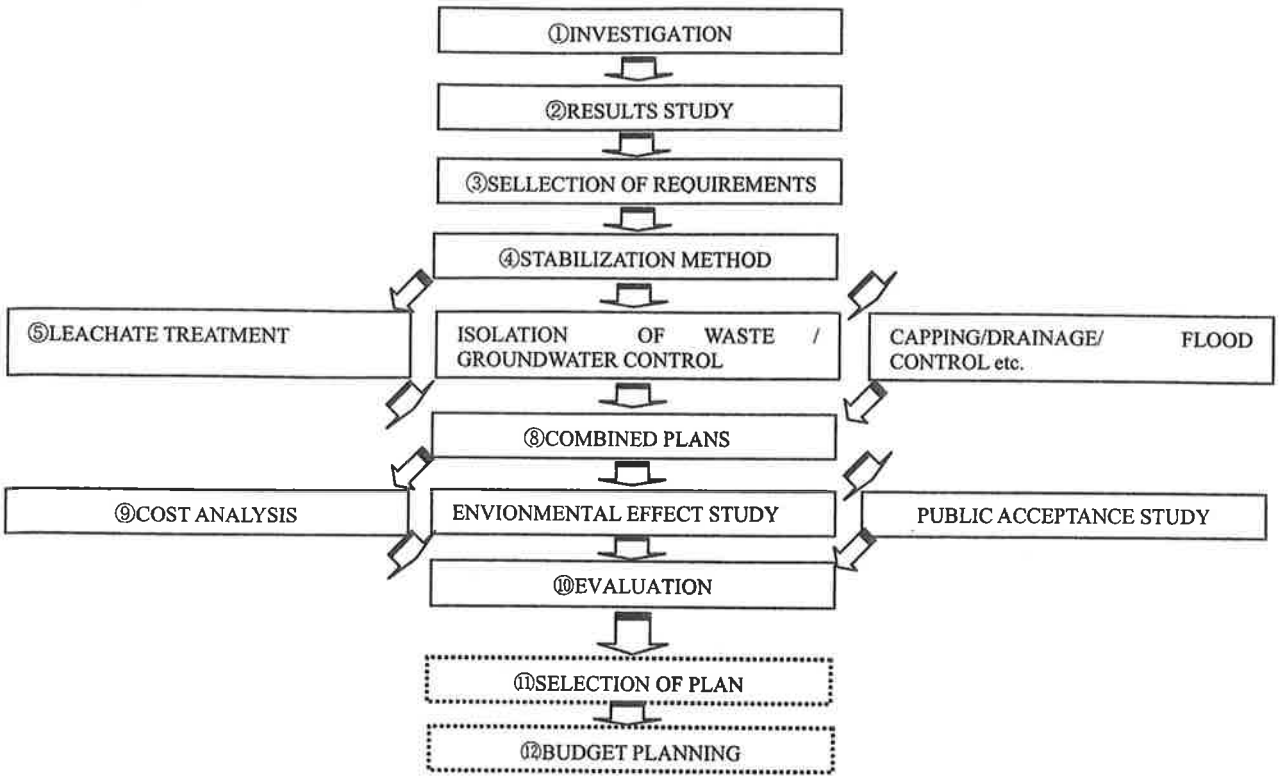


FIG.2 RENOVATION DESIGN PROCEDURE FOR INADEQUITE SITES

The design concept described in this report mainly concerns with the item② to isolate the filled waste due to the improper facilities that was not regulated in the previous stage of Japanese low or illegal dumping of waste.

As the item①is in the conventional civil work category, it is not described in this report.

Although the item③ should be very important for the designing, the recent studies have not established the effective stabilization method of waste or site so far. This topic shall be handled by the other report of LSA.

Designing flow for the renovation is shown in FIG.2. Based on the results of the INVESTIGATION①, REQUIREMENTS③ for the site shall be extracted by the RESULTS STUDY ②. And based on the REQUIREMENTS③, STABILIZATION METHOD ④ for the future termination of landfill site's care shall be selected. Together with the STABILIZATION METHOD④ and other requirements, LEACHATE TREATMENT, ISOLATION OF WASTE / GROUNDWATER CONTROL, CAPPING / DRAINAGE / FLOOD CONTROL etc. ⑤ shall be selected to combine to form a few proposals. Those COMBINED PLANS⑧ shall be evaluated from viewpoints of construction cost, the public acceptance, environmental effect studies, and the other requirements affected.

a. Requirement of Design

Requirements should be extracted or arranged from the results of the investigations and from the requirement by the owner such as local government, cooperative of the local government etc. running or maintaining final disposal site.

The requirements might be consists of the local releasing criteria of the treated leachates, the future use of the site, any contamination to the outside of the site or else. Such requirement also might cause variety of the improvement plans.

b. Concept for Improvement

Basic concept is the Isolation of the waste from the surrounding environment by way of the water migration control.

"Technical Reference Concerning Improvement Method for Inadequate Final Disposal Sites" indicates 6 cases of the counter-measure concept such as the following figures.

The key methods to achieve these concepts are ground-walls for the isolation of the groundwater, groundwater / surface water controlling methods, an over-capping and water treatment methods from such viewpoint.

Each method shall be introduced in the following section.

c. Ground wall for the Isolation from Groundwater

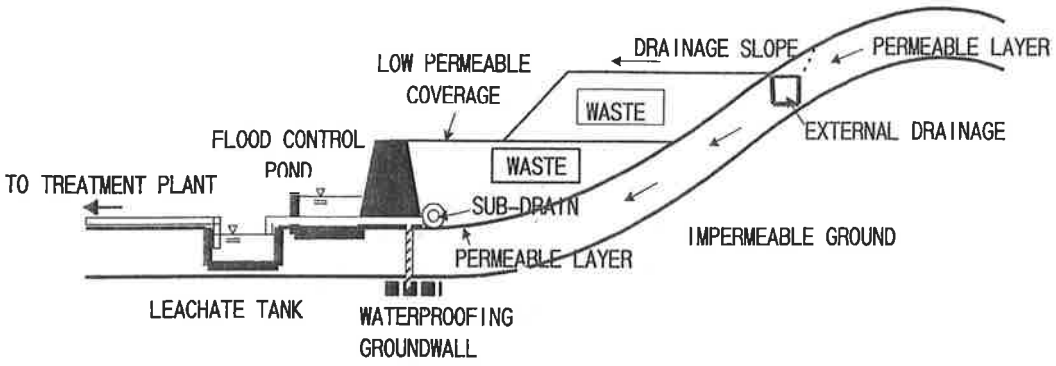


Fig.3 HILL AREA TYPE IN CASE OF NACHURAL FLOW LEACHATE

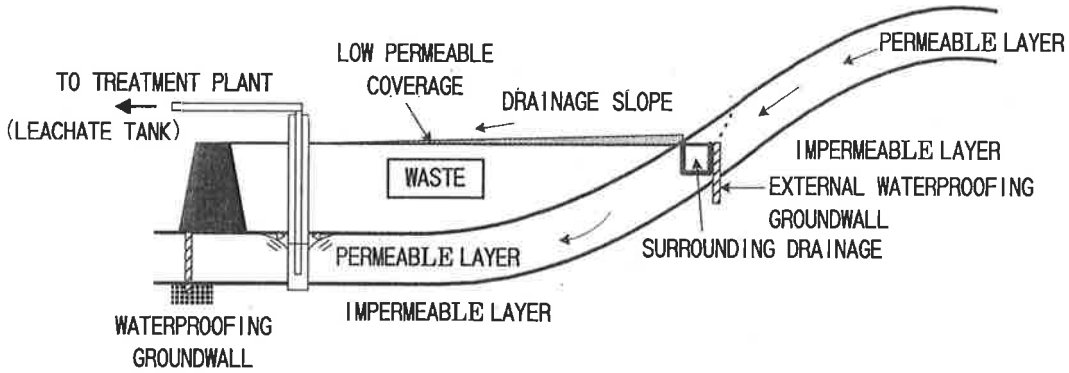


Fig.4 HILL AREA TYPE IN CASE OF PUMPING-UP FLOW LEACHATE

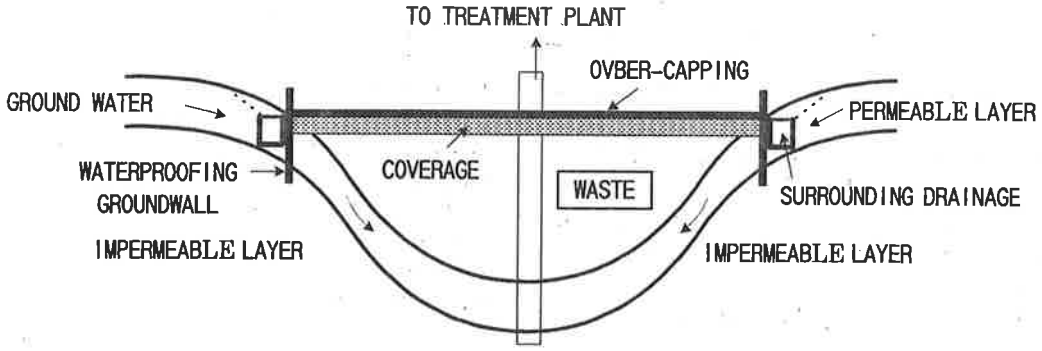


Fig.5 HILL AREA TYPE IN CASE OF ENCLOSED LEACHATE

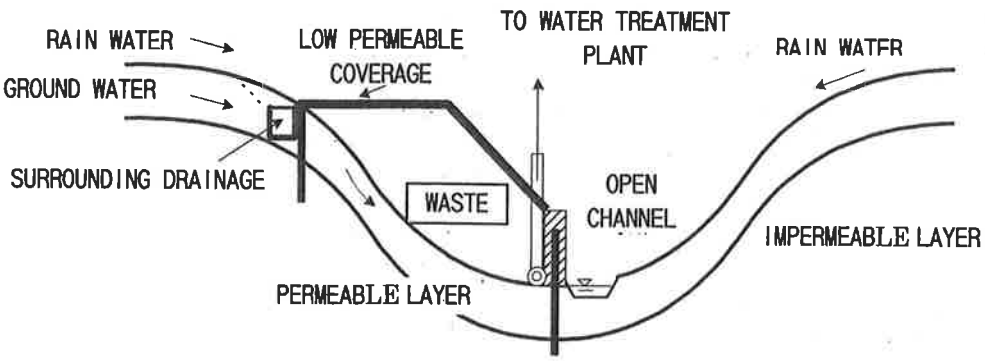


Fig.6 FLATLAND TYPE SURROUNDED BY SHORING

landfill waste in the ground shall be isolated by both impermeable layers below $10^{-5}$cm/sec required by the regulation below the bottom of waste and the ground wall. Therefore the end of the ground-wall shall be inserted into the impermeable layer enough to ensure the proper watertight performance.

Ground-wall should be designed for each site based on the groundwater condition and its control as the watertight requirement might be varied by the factors. The process as shown in below will select proper method.

1) Suitability for the ground condition
2) Depth of the wall
3) Suitability to the ground shape
4) Watertight performance
5) Corrosion resistance/Durability
6) Thickness of the wall/Structure of the wall
7) Constructional condition as yard, electricity etc.
8) Cost

Methods could be combined as the case may be to perform for the necessary requirement.

Methods to be considered shall be mainly classified as below.

1) Sheet Method

Sheet Method consists of vertical waterproofing membrane such as High Density Polyethylene Sheet(HDPS), Flexible Polyvinyl Chloride Sheet(FPCS), Rubber Asphalt Sheet(RAS) etc.

It shall be classified as the method of direct piling and setting in slurry stabilized trench.

① Vertical Sheet Method

This method provides HDPS in ground by either direct piling or setting in trench. HDPS is known as durable and chemical resistance material with flexibility to allow deformation of ground or movement by earthquake. This method may be executed with cement-hardened earth or triple sheeting depending on requirements or condition to ensure the stability.

② Continuous Sheet Waterproofing Wall Method

This method provides FPCS fixed in a trench with hardened backfilled soil or slurry. Sheet joint shall be welded on ground properly before installation in the ground.

③ Earth-cut Method

This method provides a mechanical wire saw to make 13-30mm wide trench between guide-holes

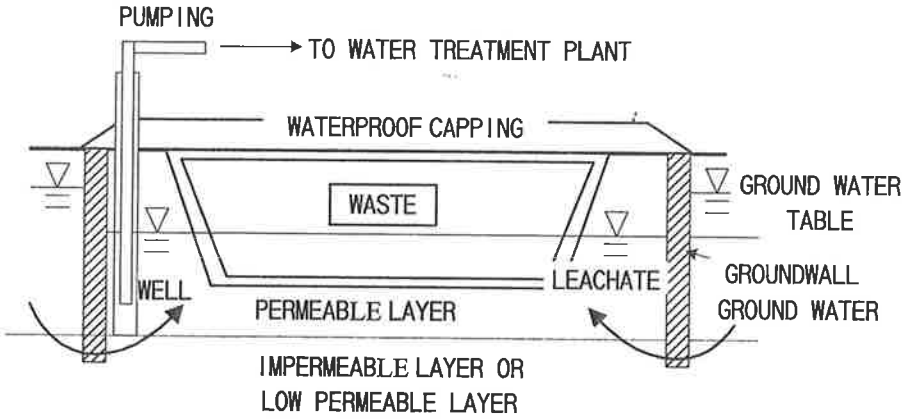


Fig7 FLATLAND TYPE WITH GROUND WALL & GROUND WATER CONTROL

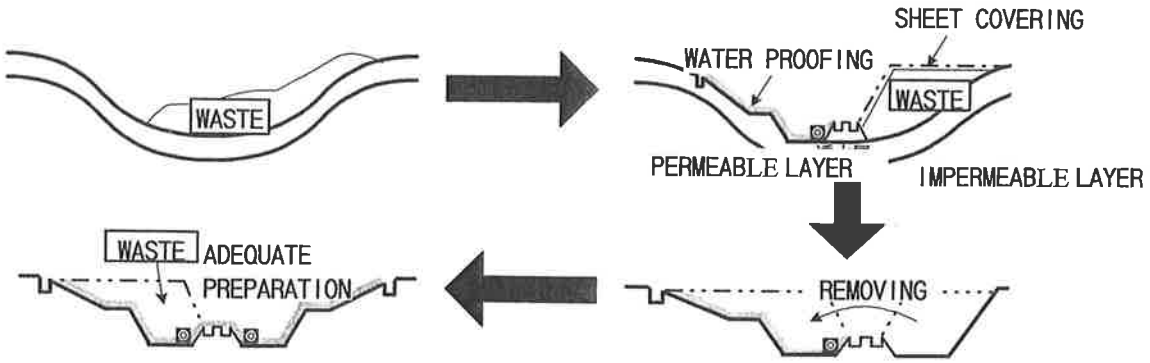


Fig.8 FLATLAND TYPE IN CASE OF REMOVAL FOR RENOVATI0N

bored before the work. Geo-membrane shall be installed in the thin trench after the removal of excavation devices.

It will be able to make 25mm thick watertight wall in the ground with less excavation and less slurry with small equipment. It can avoid obvious vibration and noise to secure the work in urban area.

④ Thinner Type Ground-wall with Watertight Membrane Method

Disk-cutter running between 400mm in diameter guide holes construct 100mm thick wall with watertight sheet in between after the joint treatment in the steel device filled with non-shrink mortar for the sheet joint.

It saves excavation about 50% from the conventional ground-wall.

⑤ Ground Waterproofing Membrane Continuous Wall Method

Chine-saw running between guide holes forms 15mm thick wall with RAS surrounded by mortar.

Thin excavator can excavate without a question of water level. Wall flexibility shall be adjusted by the cement content according as the ground condition.

2) Sheet Piling Method

① Sheet Piling

Conventional method should be executed stipulated by the regulation for the joint treatment as;

- To apply waterproofing material to joints, or
- To grout in front of sheet piles

The grouting range from the sheet pile for the latter is 500mm for $k=10^{-6}$cm/s, 50mm for $K=10^{-7}$cm/s.

And the required insert of piles to the impermeable layer should be more than 2.5m according to the manual.

② Sheet Wall Method

Sheet Wall is 1m in effective width steel pile jointed with watertight material at the joint device.

3) Continuous Ground Wall Method

As the conventional method, such a 100t giant excavating machine is required to construct concrete wall in ground. However smaller size machine such as a 50t gross weight machine has been developed for the limited conditioned site. Construction method 1)② to ⑤ mentioned previously also a part of this method to reduce the wall thickness.

Water tightness should be adjusted by the cement or bentonite content in case it would involve membrane.

4) Soil-cement Solidified Ground Wall Method

This method is to mix cement with soil in ground to form a wall after the execution. This method has Column connection type and wall type. The column connection types are, for instance, SMW, TMW etc. to connect holes filled with cement slurry after boring from the surface.

The wall types are TMW, PTR, Excavation Re-use Ground-wall etc. to connect sections of ground wall by the equipments.

In each method, joint between the column or wall section is quite important for water tightness.

5) Deep layer Mixing Treatment Method

This method categorized in Mechanical Mixing Method and High Pressurized Grouting Method. As the mechanical mixing method causes fluctuations of water permeability, it should be planed to be couple with other method.

6) Grouting Method

Grouting method is to grout cement or hardening chemicals into ground to solidify the ground. This method has Low Pressurized and High Pressurized Methods that includes the former item.

Low pressurized method is said that it achieves usually $1 \times 10^{-4\sim5}$ cm/sec nearly $10^{-5}$cm/sec required by the regulation, however, it should carefully executed because it could be influenced by the soil in the permeability.

On the other hand, it is possible for High Pressurized Grouting to achieve less than $10^{-6}$cm/sec with good care for the execution, however, construction cost is higher than the other methods. In case of the execution in peat, hard sand gravel layer, clay whose cohesion is higher than 50kNm$^2$should be carefully examined the planning.

d. Over-capping

Technical reference issued on 27$^{th}$ Nov.1998 by the government for the calculations of planning volume of leachate shows that the over-capping is quite effective for the reduction of the leachate, but that it may cause delay of the stabilization of the waste.

In case of the urgency such as the serious contamination around the site should be treated by the tight capping. Otherwise, the capping with the more 500mm th. earth layer with low permeability $k=10^{-5}$ cm/sec may be suitable for the capping.

Capping may be categorized in 3 groups, sheet type, earth type and bituminous type.

The manufactured sheets with covering/protecting earth mainly form sheet type. If the sheets are jointed properly, factory quality shall be achieved on site. Usually the 3 layers, gas releasing sheets under the impermeable membrane, and drainage sheets on the membrane compose it.

Earth type has 3types of the concept. One is

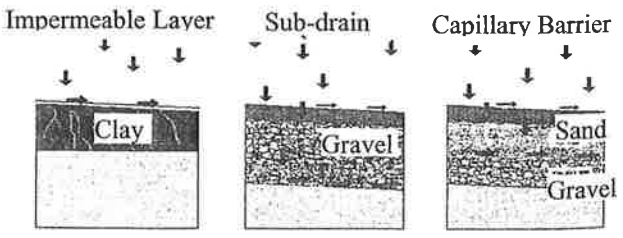


Fig. 9 Impermeable layer, Sub-drain, Capillary Barrier

ordinary impermeable layer consisted of clay or other impermeable layer. The 2nd is Sub-drain type, which has under-drain layer with gravel or other very permeable material to drain permeated water below the ordinary cover. The 3rd is the Capillary Barrier type, which has the sand drain layer on the gravel layer with covering earth.

Bituminous type might be included in the impermeable layer, 1st one of the earth type, but the material contains bitumen.

Except for the emergency case, a certain volume of permeation is expected for the capping on account of stabilization. On the other hand, reduction of the leachate is required for the economical operation of water treatment plant. Therefore instead of the impermeability, the latest capping is said to require an ability of water supply.

Capping should be designed by the permeability, stability and gas releasing measurement.

Leachate might not be determined only by the coefficient of permeability from the viewpoint of the recent data of experiments. However, the earth type capping may be analyzed for the permeation by the recent technology, and the sheet type capping shall be stand on the stage in the near future.

e. Groundwater Control

Groundwater control would be effective in case of the groundwater level was rather higher than the proper disposal. Sub-drains provided around the site might lower groundwater. But it is necessary for the ground water to maintain the ground water level in the landfill lower than the outside's not to leak out the leachate.

f. Water Treatment

Water treatment plant should be designed by the predicted quality of the leachates, by the criteria of the releasing treated water and by the estimated maximum volume of leachates for the selection of the plant type, and the determination of the plant capacity.

For stabilization of landfill, plant facilities might be utilized effectively to maintain the water table lower to accomplish the semi aerobic atmospheres in waste layer to accelerate the decomposition. Instead of the releasing treated water, it might be useful to circulate water in case leachate volume was lower than the plant capacity.

## 4. EXECUTION AND Q.C.

It is quite important to execute properly to achieve the expected quality. Even the well considered plans might not be effective in case certain defects were happened on the site. To say nothing of, proper planning of the Quality Control and its execution should be required.

## 5. CONCLUSION

This topic might be old and new at the same time in case it took as influences to the environment from a dumping place. Although such cases have been seen from the oldest age, remedial works have been seldom done. Only in the recent years, we came across with many cases due to the environmental movement. Therefore, we need to collect proper information on it, and make consensus for the designing to establish a certain standard. However, although waste stabilization should be essential for renovation as it shown in the designing flow, term of the stabilization could not predict on account of the estimation for the cost of the post-closure care until the termination due to the complexity of waste.

Water tightness of the ground-wall may be much ascertained. Sheet type capping may be applied to supply certain quantity of rainwater in the near future with established analysis such as the earth type capping have established.

Though LSA tried to issue reports in 2001and 2002 on the renovation method, those were insufficient so far. We still continue to research such problems after all, and we hope the results of our research could help engineers, stakeholders, and all of the person concerned with.

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