STUDY ON METHODS FOR RENEWING AND PROLONGING THE LIFETIME OF EXISTING WASTE DISPOSAL LANDFILLS

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ABSTRACT

This paper proposes the five (5) methods to renew and prolong the lifetime of existing waste disposal landfills. These methods can increase the effective capacity of landfill by reducing the volume of damped disposal, and/or without any large-scaled renovation. This paper reports the outline, effectiveness and applicability of the five (5) methods, followed by the flow-chart to determine the proper method.

INTRODUCTION

Waste disposal landfills in Japan are nearly full, but new waste disposal landfills are increasingly difficult to construct due to the difficulty of acquiring land mainly because of the concern of local residents on safety and rises in land prices accompanying urbanization. Promising methods for renovating waste disposal landfills include reuse and reutilization of waste disposal landfills that have been closed and prolonging the lifetime of existing landfills by renewing the landfills and increasing landfill capacity. Therefore, development of methods is awaited for reutilizing and prolonging the lifetime of existing waste disposal landfills.

In this study, applicable technologies for reutilization and prolonging the lifetime of general waste disposal landfills were investigated. Methods for increasing the remaining capacities of landfills were classified into five groups, such as those that involve reducing waste volume and utilizing existing facilities; and characteristics, effects and applications were summarized for each group. A flow for selecting appropriate methods is also proposed, which considers the applicability of these technologies and the related laws and regulations of Japan.

ATTEMPTS TO REUTILIZE AND PROLONG THE LIFETIME OF DISPOSAL LANDFILLS

Brief history of reutilization and prolonging the lifetime of disposal landfills

Attempts to reutilize and prolong the lifetime of disposal landfills started in Japan in the 1980s. At that time, methods for prolonging the lifetime were discussed aiming to prepare for a then future issue (Hanajima,M.(1981),Oshiokata,T.(1991)). In the 1990s, the difficulty of constructing new landfills became apparent. In 1991, reduction in volume of wastes in landfills by excavating and treating wastes, such as incinerating, breaking, and selecting wastes, was proposed as a method for better utilizing existing waste disposal landfills (Ministry of Health and Welfare (1992)). In 1992, a reutilization method of waste disposal landfills and an actually reutilized landfills were reported (Higuchi, S. et al. (1992)). The government also started making policies to promote reutilization and prolonging the lifetime of waste disposal landfills, and in 2000, practical measures started, such as melting wastes to appropriately use an existing landfill (Isahaya City (2003)) and to prolong the lifetime of existing landfills (Kameyama City (2003)). Studies also started to investigate comprehensive technologies on reutilization of landfills.

Laws and regulations on reutilization and prolonging the lifetime of waste disposal landfills

In Japan, approval must be obtained to construct final disposal sites of wastes according to the Waste Disposal and Public Cleansing Law. The law also demands improvements of existing landfill sites to be reported following a procedure similar to that required for constructing a new landfill unless the improvement does not involve changes in major facilities and the changes in scale are equal to or less than 10%.

To reutilize and prolong the lifetime of a waste disposal landfill, the improvement must ensure remaining capacity of over 5 years. The landfills must be equipped with bottom liners and leachate treatment equipment that are in compliance with regulations and laws.

Environmental assessment should also be performed before construction except for cases that the construction of landfill would obviously cause no impacts on the peripheral environments. Wastes that are once filled in a final disposal site cannot be transported to outside the site in principle. When moving the wastes outside the site, detailed deliberation is necessary.

Application of measures for reutilizing and prolonging the lifetime of existing landfills should be decided based on these laws.

TECHNOLOGIES FOR REUTILIZING AND PROLONGING THE LIFETIME OF WASTE DISPOSAL LANDFILLS

Overview of technologies

Technologies for reutilizing and prolonging the lifetime of waste disposal landfills can be broadly classified into those that reduce the volume of already disposed wastes (volume-reducing methods) and those that expand the capacity of landfill sites (site-expansion methods). Proposed methods are summarized in Table 1.

Volume-reducing methods include those that involve compression of wastes and those that reduce volume by re-treating wastes. Site-expansion methods include those that rise the height of banks and those that involve renovation of leachate treatment equipment and site bottom liners. There is a method that involves transfer of wastes from a point to another in a landfill site to maximize the capacity. This method is a combination of the re-treatment and renovation methods, but is included in the site-expansion methods in this study.

The following sections describe construction flows, effects, applicability, problems, construction methods and examples of the volume-reducing and site-expansion methods.

Volume-reducing methods

As described above, volume-reducing methods include compression methods and re-treatment methods. Legal restrictions, construction flows, effects, applicability and problems of these two methods are summarized in Table 2. Their construction methods and examples are described below.

Compression methods:

1) Methods: Methods for compressing and consolidating filled wastes include:
Loading method: Wastes are compressed by filling soil.
Turning rolling compaction method: Wastes are rolling compacted.
Static compression method: Wastes are compressed by statically introducing casings and applying pressure.
Vibratory tamper method: Wastes are roll compacted by vibrating tamper.
Dynamic consolidation method: Wastes are compressed by dropping hammers of 5 to 40t from a height.

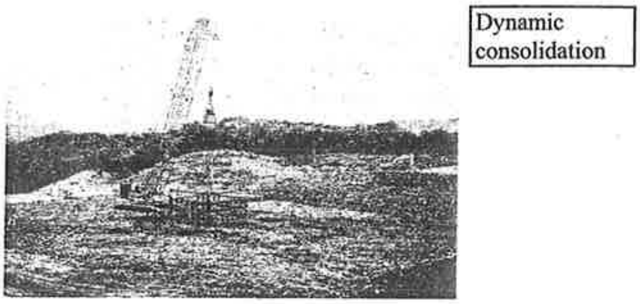
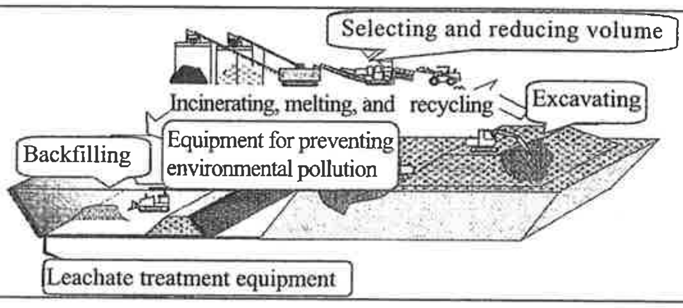
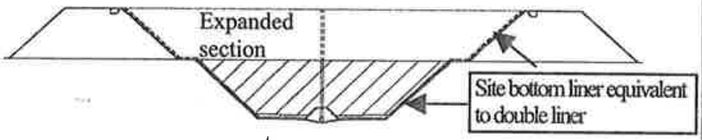
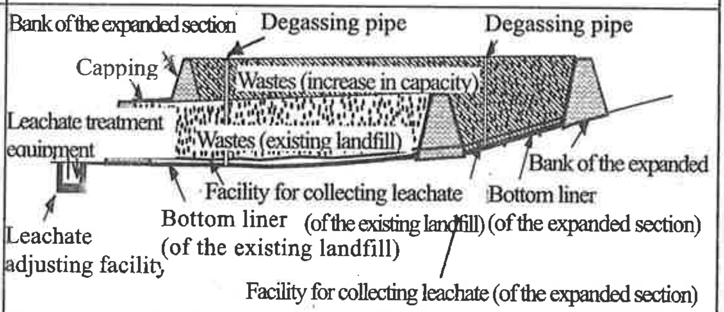
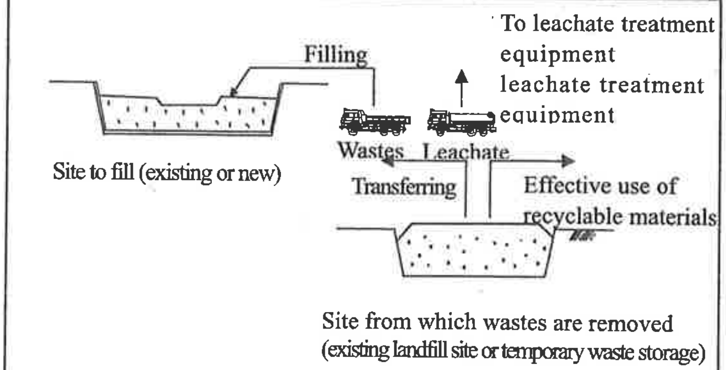
Technology control to be performed while applying these compression methods should include confirmation of effects and assessment of impacts on peripheral environments and facilities in the landfill sites. Assessment items include settlement of the landfill surface before and during construction and measurements and tests, such as standard penetration tests. Impacts of peripheral environment should be assessed for vibration, noise, gas generation, hoisting and scattering of wastes, water level of leachate, and effects to equipment.

2) Examples of application: Fig.1 shows the relationship between impact energy E and the mean settlement S of the ground surface monitored during major applications.Table 3 shows the composition of wastes for the cases shown in Fig.1. The figure and the table show that the application of the methods resulted in mean settlement of 1 to 3 m although they varied in improvement depth and waste composition. The settlement was equivalent to 15% to 30% in compression ratio, and the methods were found to be effective for reducing the volume of filled wastes.

Re-treatment methods:

1) Methods: Methods for classifying wastes are shown in Table 2. Machines used to classify wastes include trommel screens, vibration screens, air and vibration classifiers, and shaking separators. The separated solid wastes are further separated into metals using magnetic selectors and into combustibles and non-combustibles by hand.Selection of wastes is schematically shown in Fig. 2.

Table 1 OVERVIEW OF REUTILIZATION AND LIFETIME PROLONGING TECHNOLOGIES

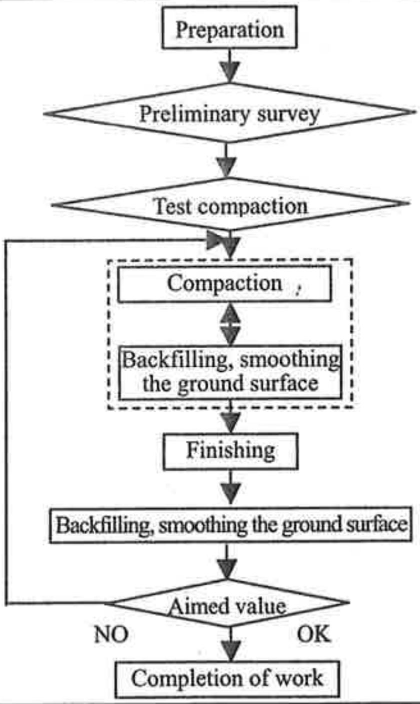
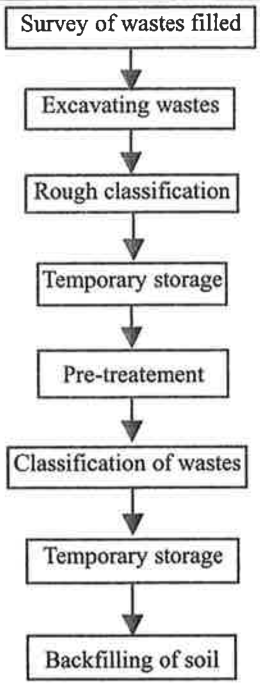
Classification		Brief explanation	Photograph of construction and schematic diagram
Broad class	Subclass		
Volume-reducing methods	Com-pression method	The volume of wastes is reduced by physically applying external force to reduce the spaces among wastes.	
	Re-treat-ment method	Wastes that have been filled are excavated and classified into those that can be cannot be recycled. Those that can be recycled are removed and other measures are taken to reduce the volume of wastes.	
Site-expansion methods	Raising banks	The capacity of landfill site is increased by constructing banks above already existing banks or constructing a landfill site above already existing landfill site.	Schematic diagram of landfill expansion plan
	Reno-vation method	When the landfill site can be expanded, waste disposal site bottom liners and leachate treatment equipment are renovated to increase the capacity.	Example of expansion and renovation that require no auxiliary works
	Waste-Reinter-ment method	Wastes filled in a landfill site is transferred to another place within the site, and the capacity of the landfill site as a whole is increased.	

The mesh sizes and types of sieves should be determined so as to be most appropriate for reusing the soil fraction. Machines should be selected by considering amount of waste to be excavated and places to install the machines (either at the site of excavation or at a separate classification yard).

In re-treatment methods, impacts on peripheral environments must be controlled, such as vibration, noise, dust, smell, and gas, as well as the quality of waste water, safety and hygiene of workers, effects on related facilities during excavation, and the types and quantity of wastes.

2) Examples of application: A type 3 landfill site for industrial wastes was re-treated by excavating wastes, separating soil from the wastes using trommel screens, and removing plastic wastes using air classifiers. Separation of soil alone resulted in a volume reduction of about 40% (Nikkei Construction(2002)).

Table 2 PRINCIPAL CHARACTERISTICS OF COMPRESSION METHODS AND RE-TREATMENT METHODS

Method	Compression method	Re-treatment method
Legal restrictions	There is no need to obtain permission for alteration.	Wastes cannot be transported outside the landfill site. There is no need to obtain permission for alteration.
Construction methods		The following treatments are to be taken: Recyclable wastes --> Recycling Combustible wastes --> Incinerating 
Effects	Reduces volume by 15 to 30%	Reduces volume by 30 to 50%
Applicability	• Applicable conditions: Thickness of waste-filled layer: thick Groundwater level: low Possibility of broken bottom liner: small Nearby structure: none • Applicable to large-size wastes and muck.Difficult to apply to highly elastic wastes and wastes of high water contents	• Appropriate for landfill sites where the wastes are uniform and contain much recyclable and combustible wastes rather than sites that contain wastes of various kinds and various properties. (The method is more effective for industrial wastes than for general wastes.)
Problems	• Assessment of effects of compression on the stabilization of filled wastes • Methods that consider the properties and configurations of wastes and arrangement of facilities • Durability of facilities in landfill sites of	• Measures to prevent scattering of wastes and generation of dust and gases • Stabilization of slopes during excavation • Measures for treating leachate • Prevention of bottom liner from breaking

	prolonged lifetime	

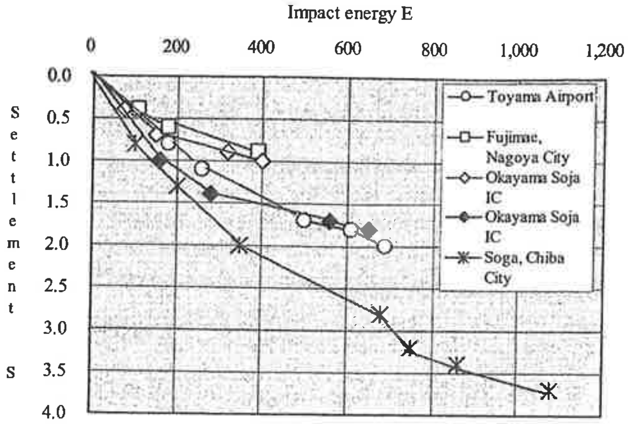


Fig. 1 IMPACT ENERGY E AND MEAN SETTLEMENT S OF THE GROUND SURFACE (added to Higuchi,S.(2002))

Table 3 PROPERTIES OF WASTE-FILLED GROUND (parts of data are cited from Narumi N.et.al(1996))

Properties	Place / Classification		Kuramae Ryutsu Industrial	Toyama Airport	Oakayama Soja IC	Soga final disposal site of Chiba City
Waste composition (percentage in weight)	Combustibles	Paper and cloth	2.3	3.5	5.9	2.9
		Synthetic resin, rubber,	5.7	4.8	8.7	7.1
		Wood, bamboo, straw	10.6	2.8	2.3	9.4
		Kitchen waste	0.1	0	0	0
	Non-combustibles, etc.		81.3	88.9	83.1	80.6

Site-expansion methods

Site-expansion methods include raising-bank method, renovation method, and waste-reinterment method. Legal restrictions, construction flows, effects, applicability and problems of the former two methods are summarized in Table 4. Those for the waste-reinterment method are summarized in Table 5. Their construction methods and examples are described below.

Raising banks:

1) Methods: As shown in Table 1, banks are raised either by raising the height of existing banks or by constructing new banks on existing landfill.

Raising the height of existing banks: Landfill sites should be first confirmed that they are in compliance with the regulations and laws now in effect.When the expansion would result in prolonged use of the landfill site, the period prolongs for the entire landfill site to stabilize, and facilities and equipment should be examined for the durability during the lifetime of the site.

Constructing new banks on existing landfill sites: Fast stabilization should be attempted by promoting the stabilization of the lower existing landfill site. The upper landfill site to be newly constructed must comply with regulations in effect.

2) Examples of application:

In Japan, banks for general waste landfill (control-type landfill) are planned to be constructed on a closed landfill site for industrial wastes (stable-type landfill). In France and Korea, banks have been continuously raised to fill wastes. In Korea, there are banks that have been raised to 100 m (LSA,Ed.Handbook (1999)).

Renovation method:

1) Methods: As shown in Table 4, the renovation method consists of either involving supplementary measures or no supplementary measures. When the bottom liners of existing landfill are in compliance with the regulations in effect, supplementary measures are not necessary. When the bottom liners of existing landfill are not in compliance, supplementary measures must be taken.

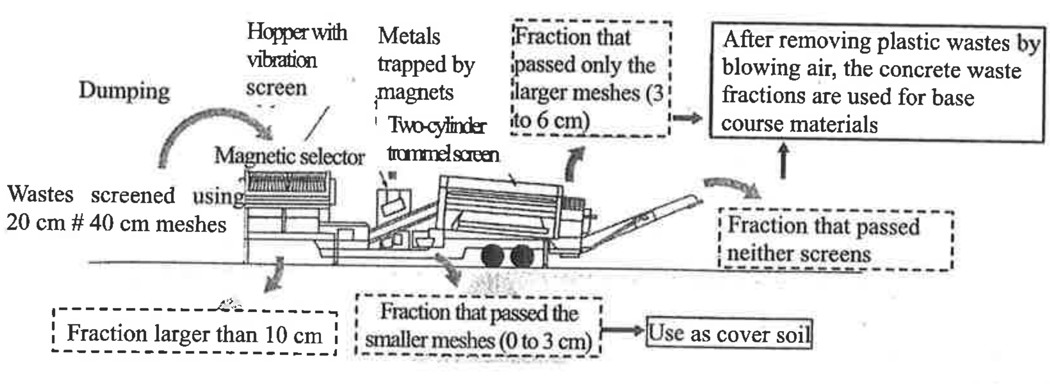
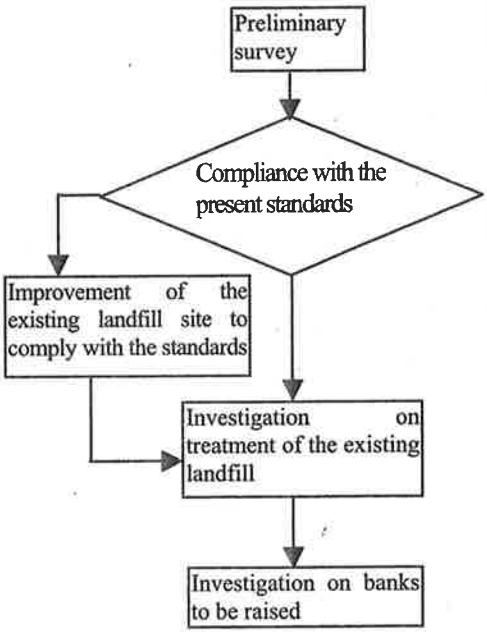
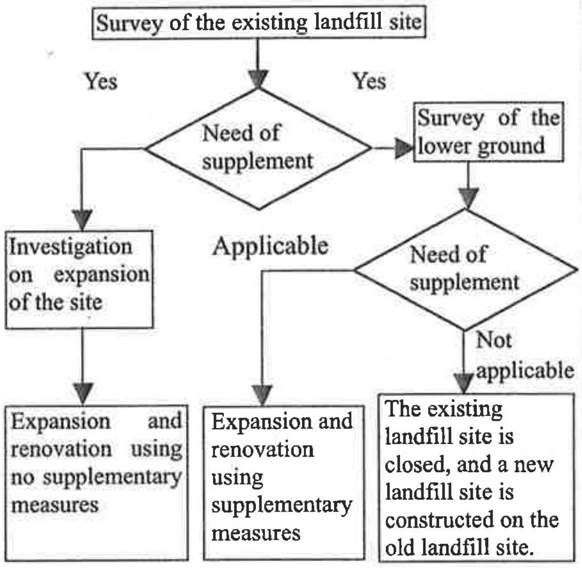


Fig. 2 CLASSIFICATION OF WASTES (Nikkei Construction(2002))

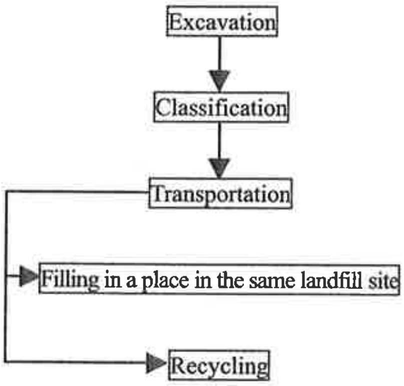
Table 4 PRINCIPAL CHARACTERISTICS OF BANK-RAISING METHOD

<table>
<tr><th>Method</th><th>Bank-raising method</th><th>Renovation method</th></tr>
<tr><td>Legal restrictions</td><td>•Since the method requires intensive changes, permission of alteration must be obtained, the process of which is similar to the process of obtaining permission for constructing new landfill site.</td><td>•When the bottom liner of the existing landfill site are not in compliance with the regulations that are presently in effect, the liners must be renovated.</td></tr>
<tr><td>Construc-tion method</td><td>There are two construction methods:
(1) Raise the height of the existing banks, and
(2) Construct new banks on existing landfill site.

</td><td>There are two construction methods:
(1) Expansion and renovation using supplementary measures --> When the bottom liner are not in compliance with the present standards
(2) Expansion and renovation using no supplementary measures

</td></tr>
<tr><td>Effects</td><td>•The capacity can be increased without acquiring extra land.</td><td>•Large capacity can be obtained by expanding the land and renovating facilities.</td></tr>
<tr><td>Applica-bility</td><td>• The existing landfill must comply with the standards and regulations in effect to raise the height of existing banks.
• Stabilization should be promoted to construct new banks.</td><td>•The method cannot be applied for landfill sites with no bottom liners.</td></tr>
<tr><td>Problems</td><td>• Consensus of residents must be obtained again.
• Settlement of the ground and impacts on facilities due to increases in load must be assessed.
• Appropriate stabilization control of existing landfill and stabilization promotion measures are needed to construct new dams on existing landfills.</td><td>• Leachate treatment equipment should be renovated since the amount of rain water that seeps through the waste layer increases as the landfill area increases. Capping measures are also needed.
• The period of maintaining and controlling bottom liners and related facilities should be prolonged and their performances should be ensured for the period since the service life of the landfill site is prolonged.</td></tr>
</table>

For landfill requiring no supplementary measures: New banks are constructed around the expanded land section. Bottom liners that are in compliance with the standards and regulations in effects shall be spread on the waste filling section, and leachate treatment equipment is constructed.

For landfill requiring supplementary measures: The bottom liners of existing landfill are renovated into those that comply with the standards and regulations in effect. After that, the procedures in no supplementary measures are taken.

Table 6 PRINCIPAL CHARACTERISTICS OF THE WASTE-REINTERMENT METHOD

Method	Waste-reinterment method
Legal restrictions	This method is applicable only when there is space for temporarily storing excavated wastes and filling the wastes within a landfill site from which the wastes are to be removed. When the spaces are not in a single site, permission must be obtained to change the border of the site. Wastes that had been filled inappropriately before 1977 can be transported outside the site.
Construction method	There are cases in which: (1) there is one filling space for one waste-removing space, and (2) there are more than one filling space for one waste-removing space, or there are more than one waste-removing space for one filling space. 
Effects	· The method can reduce the volume of wastes and renovate the space from which wastes are to be removed, enabling capacity of the entire landfill site to increase and its lifetime to be prolonged. · The method enables landfill sites to be integrated and renovated. It is effective for improving peripheral environments and facilitates effective utilization of nearby land.
Applicability	· The method is effective when applied to landfill sites whose waste volume decreases greatly by the application.
Problems	· The same problems as in the re-treatment method would be encountered at waste-excavating site during excavation and classification of wastes. There are also technical issues and legal restrictions involved in transportation methods and temporary storage facilities. · The same problems as in the renovation method would be encountered to renovate the space to fill in wastes.

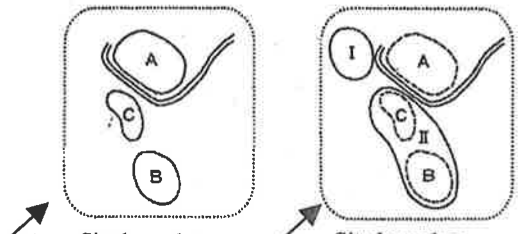
2) Examples of application: There is a plan to close a landfill and build a new landfill next to this existing landfill. There have been no landfills renovated using this method.

Waste-reinterment method:

1) Methods : As shown in Table 6, the waste-reinterment method, there are cases in which (1) there is one filling space for one waste-removing space, and (2) there are more than one filling space for one waste-removing space, or there are more than one waste-removing space for one filling space. In all cases, the method involves the following process.

The site where the wastes are to be removed is treated as in the re-treatment method. Where there are more than one space to which the wastes are to filled in, the wastes are divided after surveying the wastes.At the site where the wastes are filled, the wastes are consolidated and compacted, although this process depends on the composition of the wastes.

2) Examples of application : A landfill was renewed using the waste-reinterment method to treat inappropriately filled wastes of 60,000 m^3, secure an extra capacity of 20,000 m^3 (equivalent to 10 years) and create a space for new landfill for approximately 15 years as shown in Fig. 3 (Sasai,H.(2001)).



Present state
A: Non-combustible and large-size garbage fill
B: Incinerator ash fill
C: Resource residual fill

After renewal
I: New landfill space I (Reinterment from C)
II: New landfill space II (Reinterment from A)
The treatment of incinerator ash is entrusted to a subcontractor

Fig. 3 EXAMPLE OF WASTE-REINTERMENT METHOD (added to Sasai,H.(2001))

SELECTING RENEWAL METHODS

Of these methods, the most appropriate method should be selected.Various flow charts have been proposed for selecting renewal methods from technological points of view (Higuchi,S.(2002)). In this study, a flow shown in Fig. 4 is proposed, which is based on the applicability and legal restrictions. First, it is judged whether it is necessary to obtain permission for alteration by the Waste Disposal and Public Cleansing Law. Then, the availability of acquiring land, the compliance of the existing structures with the standards and regulations in effects, and the necessity of renovating bottom liners are decided to select methods. This selection flow is a mere draft that has been drawn up based on the overview of the methods, construction procedures, applicability and problems involved. The flow should be further refined by conducting qualitative evaluations and feasibility studies.

SUMMARY

This paper described applicable technologies for renewing and prolonging the lifetime of existing waste disposal landfills for general wastes, and summarized them into five groups, including two that mainly involve reduction in waste volume, which are the compression and re-treatment methods, and three for increasing the capacities of the landfills, which were bank-raisin, renovation, and waste-reinterment methods. The applicability of these methods were investigated, and a flow was proposed for selecting appropriate method by considering related laws and regulations of Japan.

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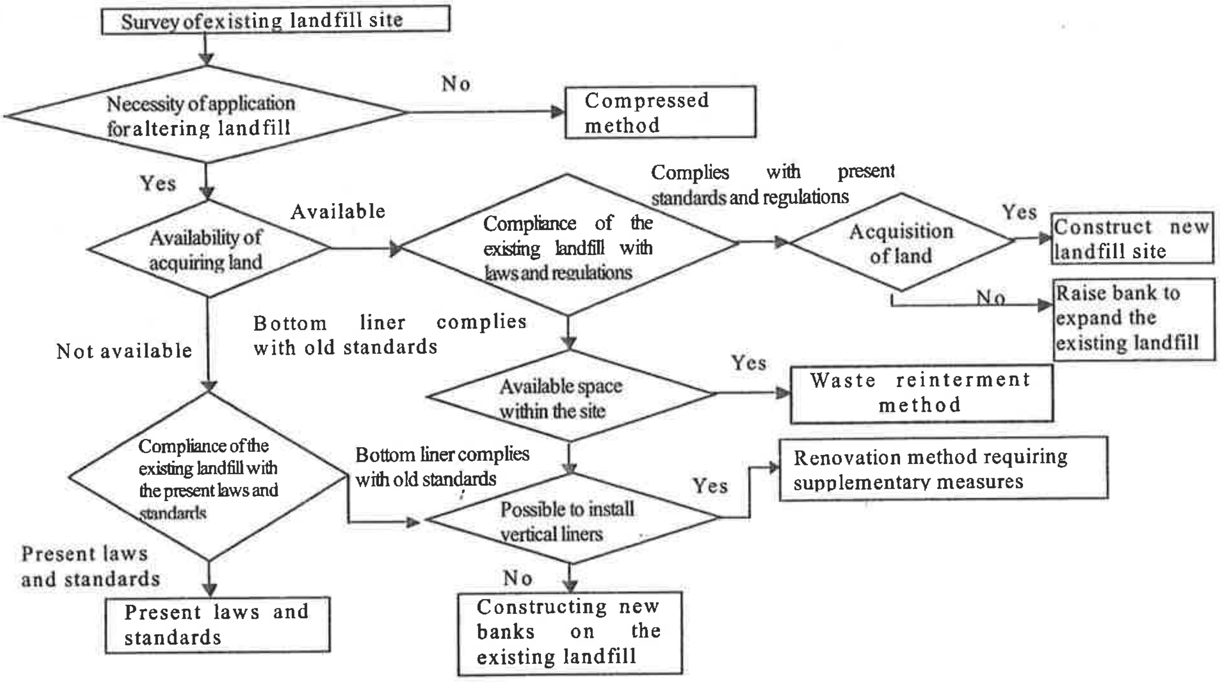

Fig. 4 FLOW FOR SELECTING RENEWAL METHOD

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