IMPLEMENTATION FEASIBILITY STUDY ON THE ENLARGEMENT OF CLOSED SYSTEM DISPOSAL FACILITIES IN JAPAN

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ABSTRACT

This paper describes the results of a research by the working group on facilities enlargement of the Research Committee for Closed System Disposal Facilities conducted concerning the plans to enlarge urban Closed System Disposal Facilities（CSDFs）.

Study themes concerning the enlargement of CSDF

-Plans to horizontally increase the size of CSDF to 200,000 m^3

-Plans to vertically increase the size of CSDF to 500,000 m^3

-Plans to built large CSDF in urban areas

Keywords: Closed system disposal facilities, enlargement, large CSDF in urban areas

INTRODUCTION

Closed system disposal facilities （CSDFs） are composed of a landfill and covering. Installing the disposal facility under covering enables the artificial control of the internal space, and helps reduce the environmental loads of the waste.

The first CSDF was completed at the municipal solid waste (MSW) landfill site in Yamagata Village in Nagano Prefecture in March 1998. Approximately 50CSDFs have been or are being constructed as of March 2008. The landfill capacity ranges from approximately 2,000 m^3 to 200,000 m^3.

Based on this 50CSDFs, the percentage of small landfills with the capacity of less than 10,000m3 accounts for the majority of 51% , while that of large facilities 10,000m^3 to 50,000m3 is 37%, more than 50,0000m^3 is 12%. The largest CSDF in capacity is 195,000m^3.

EXAMPLES OF CONSTRUCTION OF LARGE CS DISPOSAL FACILITIES

●Kamo Environmental Center

-Location:Higasihiroshima City, Hiroshima, Japan

-Landfill area: Approximately 12,000 m^2

-Landfill capacity: Approximately 195,000 m^3

-Landfill structure: Reinforced concrete 4pits with a covering using membrane

Photo.1 exterior and interior

●Dai2 Ichiyama MSW disposal facilitiy

-Location: Katori City, Chiba, Japan

-Landfill area: Approximately 9,120 m^2

-Landfill capacity: Approximately 90,100 m^3

-Landfill structure: Reinforced concrete 6pits with a covering using membrane

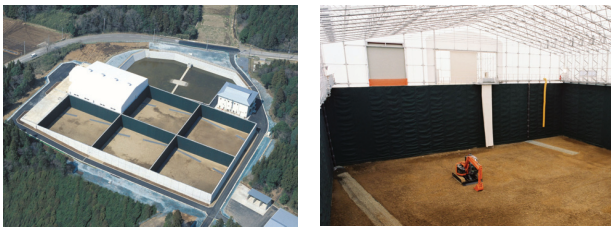

Photo.2 exterior and interior

INCREASING HORIZONTAL SIZE

Defining the structural dimensions

Studies were made on 200,000 m^3-class CSDFs under the following conditions.

-The depth of the landfill yard was set at 15 m because preventing the earth retaining structures from becoming excessively large was necessary and because landfill operators were expected to work at the bottom.

-A straight and sloping (gradient: 12%) waste transport route was selected to enable waste transport by heavy vehicles direct to the bottom of the landfill and to provide paths for oiling and maintaining the machinery.

-A retaining wall with a slope gradient of 1:0.5 was adopted for the landfill.

-The covering span was set at 80 m to enable efficient construction. The area of the landfill was determined based on the volume of waste. The top and bottom surfaces of the landfill were both rectangular with dimensions 240 m x 70 m and 219 m x 49 m, respectively.

Figure.1 Image of a horizontally enlarged CSDF

Requirements for horizontal increase size of CSDFs

1)Requirements related to storage

-Prevention of surface stormwater infiltration through the geomembrane of the storage facility, and quick drainage of groundwater and leachate

-Uplift control measures in the case where excavation is involved

-Structural stability where the covering is founded on

the crest of the storage

-Selection of earth retaining systems

Earth retaining structures are frequently constructed at CSDFs to secure required landfill capacity. Figure 2 shows typical types of earth retaining structures. Other earth retaining systems include structures on a slope, reinforced concrete sidewalls, steel plate liners and lightweight fills.

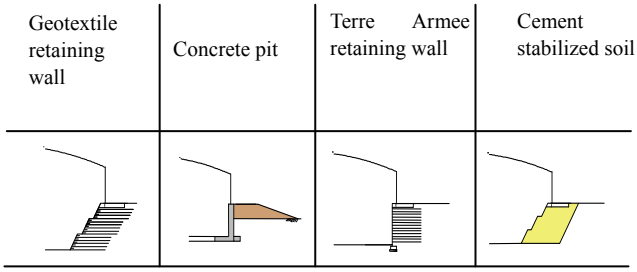

Figure.2 Typical earth retaining systems

2)Requirements related to covering

Decision should be needed on whether or not to install intermediate supports for large-span covering.

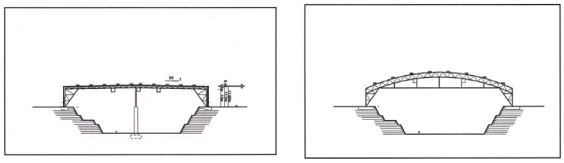

Figure.3 Case with/ without inter mediate supports

(i) With intermediate supports

-Installing intermediate supports enables substantial reduction of cross section of steel constituting the covering. High supports, however, need measures to prevent buckling. The design of the support should be structured to guarantee safe and efficient landfill operation, and to take into account the relation to liners.

-A continuous wall composed of intermediate supports provides space for storing sorted waste on both sides of the wall.

(ii) Without intermediate supports

-Without intermediate supports, the covering is made of string beams composed of trusses and tie beams.

-The covering is arched with its center projecting.

Without intermediate supports, the weight of beam material increases considerably, but the option is beneficial with respect to the connection with liners and the efficiency of landfill operation.

3) Requirements related to landfill liners

The structure of landfill liners varies according to the structure of the landfill. Double liners are used according to official standards in Japan. Reinforced concrete liner layers require crack control measures. For upright walls, the material of geomembrane and fixing methods need to be assessed.

4) Requirements related to facilities

The requirements of facilities at large CSDFs are listed below.

-Securing paths for inspection for maintaining the inside of the covering and the landfill

-Securing sufficient illumination for a wide and deep landfill

-Installing lighting equipment on the covering at a great height

-Attaching spotlights to heavy landfill machinery or other equipment

-Controlling the reduction of lighting efficiency due to intermediate supports

-Applying artificial ventilation that is required in a wide area

-Applying ventilation at the bottom that is required because certain types of toxic gas are heavier than air

-Applying auxiliary ventilation to the landfill surface using mobile air blowers or other equipment

-Installing facilities for detecting gases before landfill operation starts

-Installing exhaust air outlets to minimize impact on the surrounding environment (determining the positions of outlets and selecting the deodorizing method)

-Sprinkling water from the ceiling or walls to cover wide space

-Installing mobile sprinkling systems including sprinkler vehicles

-Placing fire extinguishers

-Providing escape routes

5) Requirements related to landfill operation

-Checking the site before manned landfill operation starts (checking the existence of toxic gases or lack of oxygen)

-Securing the safe width of sloping waste transport routes, and installing fences for preventing vehicles from falling

-Installing ventilation systems and escape routes for manned operation

-Preventing damage to landfill liners or structures by the crash of heavy machinery where there are columns or partition walls in the landfill

-Securing sufficient illumination and controlling the spread of dust particles during landfill operation.

INCREASING VERTICAL SIZE

Defining the structural dimensions

The facility is selected based on the experience of construction of large LNG (liquefied natural gas) underground storage tanks, and to secure a landfill capacity of 500, 000 m^3. In landfill sites of vertically increased size, long waste transport routes could deteriorate the efficiency of landfill operation and reduce the capacity of the landfill site. Waste is delivered to the landfill using machinery and unmanned landfill operation is selected rather than dumping the waste direct from the transport vehicles.

-Radius of construction site: 45 to 70 m

-Depth of the landfill site: 30 to 80 m

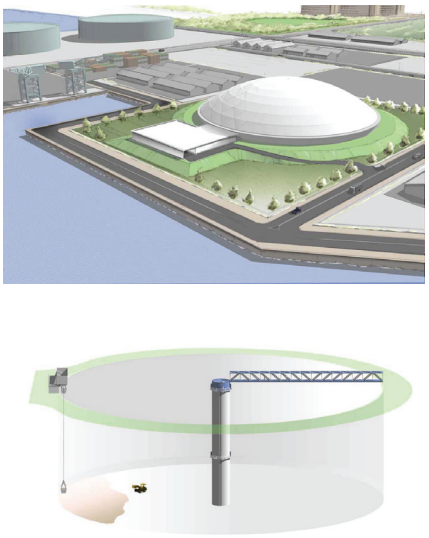

Figure.4 Image of a vertically enlarged CSDF

Requirements for vertical increase size CSDFs

General requirements for increasing the vertical size of landfill sites are listed below.

(i) Operation environment for deep landfill

-Lighting systems for deep landfill

-Air convection and ventilation in the facility

-Dumping of waste and control of dust (water sprinklers to control or prevent dust)

-Fire protection facilities

-Pumping of leachate and groundwater

-Safety of landfill operation and efficiency of landfill operation control (solutions to problems involved in unmanned operation)

(ii) Impact of large facilities on surrounding environment

-Change in traffic condition in the vicinity of the site due to waste transport vehicles

-Impact of deep facilities on surrounding ground

-Impact of large covering on urban environment, and aesthetic measures for the landfill site

(iii) Prevention of the spread of pollution to surrounding environment

-Control of the spread of groundwater pollution

-Structure of monitoring facilities

(iv) Thickening of landfill and stabilization of waste

-Aeration devices and gas removal facilities

-Landfill using cleansed waste, or underwater waste disposal

-Promotion of waste stabilization and auxiliary facilities

(1) Liner requirements for the storage at the landfill site

Deep landfill sites are made of either reinforced concrete or prestressed concrete. Concrete structures are generally subjected to the deterioration of impermeability due to cracking or other causes.

The following measures should therefore be considered.

-Modifying the storage so as to enhance impermeability

Placing structural joints or designing joints to induce cracking

-Enhancing impermeability by using more effective material for the storage

Increasing the performance of concrete using admixtures or additives, and mixing fibers

-Taking auxiliary measures to enhance the impermeability of the storage

Preventing cracking by surface coating

The liners that are required according to technical standards should be assessed as an integral part of the storage. In order to provide required impermeability, double and single liners are selected at the bottom and in the parts of the sidewall that are in contact with water, and for the parts of the sidewall not in contact with water, respectively. The requirements for liners are listed below.

a. Liners on the sidewall

-Single liners for the parts not in contact with water

-Double liners in the parts in contact with water that are similar to the works at the bottom

-Making the sidewall of the storage impermeable

-Methods for applying and fixing liner material

b. Liners at the bottom

-Double liners composed of highly watertight concrete and liner material in the case where the storage is made impermeable

-Double liners composed of watertight asphalt and liner geomembrane in the case where the storage is not impermeable.

(2) Requirements for facilities

-Passageways: Passageways are required for covering the landfill, applying impermeability and inspecting machinery. Elevators or other lifting equipment should be installed for long-distance travel down to the bottom.

-Lighting facilities to illuminate deep areas: General or local lighting should be selected to provide sufficient illumination to ensure safety and lighting efficiency.

-Ventilation systems: Mechanical rather than natural ventilation is adopted for the landfill site of vertically increased size. Air blowers and exhaust fans are used. Efficient methods including the combination of local and general ventilation systems are selected according to the phase of landfill operation and work environment.

-Water sprinklers: Sprinkling water from walls or using heavy equipment is considered more effective than sprinkling from the covering (roofing) because the vertically enlarged landfill site has a great depth. Water sprinklers are installed mainly for promoting the biodegradation of waste and preventing the spread of dust particles.

-Fire extinguishing systems: Fire alarms, fire hydrants

and fire extinguishers should be placed to control on-site fire expected to be induced by inflammable gases emitted from the waste, by machinery or by fire for heating. In large space in particular, deluge guns are considered more effective than sprinklers. Appropriate automatic fire control systems should be selected.

-Escape routes: Escape staircase is not effective for quick escape because the vertical escape distance is expected to exceed 100 m. Safe and reliable escape routes should be provided by installing elevators or other devices while minimizing impact on the liners.

-Gas detectors (facilities for monitoring indoor environment): The health and safety of workers should be ensured because they work in a closed space at the covered landfill site. Equipment is selected for monitoring the internal environment according to the measurement items and frequency. Automatic monitoring systems should preferably be adopted for the wide space at a great depth. Use of a centralized monitoring system using various sensors should be considered.

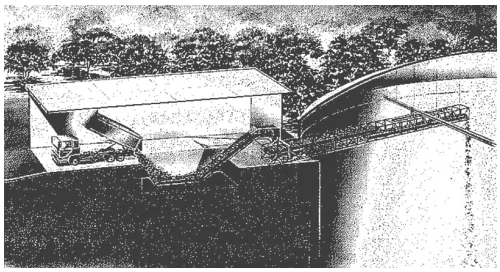

Figure.5 Delivering waste on a belt conveyor

(3) Landfill operation

(i) Waste delivery system

Belt conveyors are considered effective for delivering waste to large landfill sites in view of the efficiency of delivery, and operation and maintenance. Dumping waste from above the facility is likely to damage the liners at the bottom or on the sidewall, or cause dust problems or odors because the waste drifts in the air for a long time. It is therefore necessary to sprinkle water before dumping the waste.

(ii) Waste spreading and roller compaction methods

To achieve unmanned automatic spreading and roller compaction of waste, heavy machinery needs to be remote-controlled using on-site radioactive communications, and the liners at the bottom and on the sidewall should be protected from damage by installing television cameras and sensors of the vehicular gap.

LARGE COVERING

Requirements for covering

Large sheds are required to have the following quality and functions. These requirements should be satisfied.

(1) Covering: The span should be determined according to the landfill capacity. The cover should be of a shape suitable at the site. An effective size of the shed should be determined by specifying optimal depth and horizontal size of the storage.

(2) Safety against natural forces: Strength specified in the building standard law of Japan, standards of the Architectural Institute of Japan and other standards should be provided against earthquakes, snow and wind.

(3) Consideration of surrounding environment: The release of gases, odors and vapor from the landfill site should be controlled. Treatment of stormwater should be ensured. Noise during operation should be insulated.

(4) Consideration of internal working environment: Ventilation, daylight and internal temperature should be controlled to provide effective working environment.

(5) Fire safety: It should be noted that fire safety and fire resistance requirements for the shed specified in standards vary according to the type of waste accepted

(e.g. incombustible, inflammable or slow-burning material).

(6) Durability: Resistance to chemicals, weather, heat and water or moisture should be provided. Chemical durability is especially important. The service life should be determined according to the duration of landfill operation (the period in which the landfill site is in service).

(7) Ease of construction: Methods should be selected providing for simple erection and dismantling of the shed. The erection method in particular should be selected according to the size and shape of the shed.

(8) Use at the same site: The possibility of removal or repetitive use of the shed should be considered. If the shed is to be used for other purposes after the closure of the landfill site, the size and specifications should be determined according to the expected use.

(9) Economy: Both initial and running costs should be reduced. Repetitive use of a mobile shed is likely to require high initial cost and low running cost. Decision should be made based on the total balance of cost.

(10) Design: The shape, material and color of the shed should match the surrounding environment.

Structure of covering

When selecting the structure of the shed at a CSDF, the span, shape, strength, ease of construction and economy should be taken into account.

URBAN SITE

Location

Urban areas with numerous residents and a large daytime population inevitably produce large quantities of waste to be disposed of. MSW landfill sites are therefore likely to be large.

MSW landfill sites have frequently been located in remote mountainous or waterfront areas in Japan. Such sites have been installed and maintained nearly unnoticed. Concern about the waste, structure of MSW landfill sites and landfill control methods has induced protest campaigns in many cases and finally resulted in the failure to obtain residents' consensus.

In studying the enlargement of CSDFs, the conditions and requirements for locating the facilities in urban areas using the benefits of closed systems, were identified to assess the possibility of construction. Urban areas here refer to big cities of a population of 300,000 to 800,000.

Conditions for locating a CSDF in an urban area

(i) Acquisition of land with required horizontal and vertical dimensions where a large-capacity MSW landfill site can be built

(ii) Transportation convenience

(iii) Conservation of surrounding environment and harmony with the life of local community

Requirements for urban facilities

(1) Structure

Large-capacity urban MSW landfill sites should be constructed where construction is allowable and designed to have an appropriate structure. Table 1 lists the types of land where MSW landfill sites can be constructed.

(2) Traffic condition

Constructing a MSW landfill site results in the increase of vehicles for transporting waste. Problems occur in the vicinity of the site such as traffic congestion, noise and auto emissions. A large facility in an urban area is likely to attract vehicles. Control measures are therefore required.

Most of the waste is delivered to the landfill site after it is subjected to intermediate processing. Constructing

MSW landfill sites as close to intermediate processing plants as possible is considered beneficial with all respects.

(3) Environmental conservation and relation with local community

Obtaining the consensus of local residents on the construction of the landfill site is important. Selection of the location as well as of the functions and structure of the site is the key.

The landfill site needs to improve the living environment. Measures should be taken to have the site make social contributions at the minimum.

(4) Structural type

Closed system disposal facilities consist of a landfill equipped with covering. They come in three types: underground type with an underground landfill covered with a man-made slab, semi-underground type of an underground landfill covered with roofing or an underground landfill with a man-made slab, and ground type with a building on the surface. Figure 6 shows different structural types.

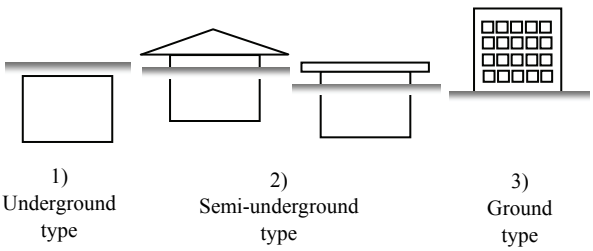

Fig.6 Structural types of CSDFs

(5) Image of facility

Figures 7 and 8 show images of large urban CSDFs of varying structures built on varying types of land.

Fig.7 At an interchange[1)]

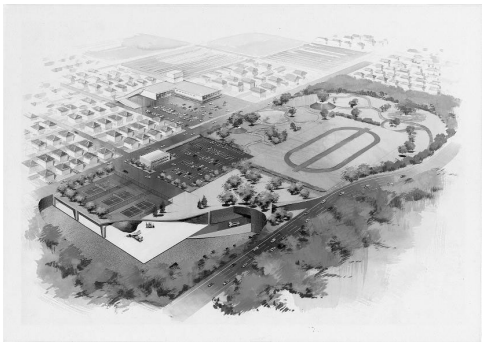

Fig.8 Landfill site doubling as a park or green space[1)]

CLOSING REMARK AND FUTURE TASKS

As a result of the study on horizontally enlarged 200,000m^3-classCSDFs and vertically enlarged deep and large 500,000m^3class CSDFs, issues involved in enlarging disposal facilities and locating them in urban area were discussed. The challenges facing typical horizontally enlarged CSDFs include the design of economical covering, guarantee of safe landfill operation and provision of appropriate working environment based on manned operation (e.g. ventilation and availability of escape routes). For vertically enlarged CSDFs, storage and liner structures, and unmanned landfill equipment and methods suitable for deep facilities are required. When locating a CSDF in an urban area, complying with the laws concerning the construction at the location is a great challenge.

Table 1 Types of land where MSW landfill site can be built

<table>
<tr><th>Type of land</th><th>(i)
Land acquisition</th><th>(ii)
Transportation convenience</th><th>(iii)
Conservation of surrounding environment</th><th>Comment</th></tr>
<tr><td>Interchange</td><td>Need to confirm urban planning regulations. Complicated sharing of management responsibility.</td><td rowspan="3">Easy access is provided. Care should be exercised to prevent traffic congestion.</td><td>Care should be exercised to prevent the deterioration of driver visibility and adverse impact on aesthetics.</td><td>Complicated sharing of management responsibility makes thorough consultation necessary.</td></tr>
<tr><td>Industrial complex</td><td>Need to confirm urban planning regulations.</td><td>No problem.</td><td>The land is suitable for a landfill although the scale may be limited depending on the plan and operation of the industrial complex.</td></tr>
<tr><td>Cargo terminal</td><td>Need to confirm urban planning regulations. Space under the existing facility is developed.</td><td>Need to verify the impact of underground development.</td><td>Not feasible in view of the structure and construction method required. (Large amount of cost is required.)</td></tr>
<tr><td>Former factory site</td><td>Land acquisition is easy.
Need to confirm urban planning regulations.</td><td rowspan="2">Generally, easy access is provided.</td><td rowspan="4">No problem.
Harmony with surrounding areas is especially important because of the closeness of the site to residential areas.
Harmony with surrounding areas is especially important because the general public visit the site, which is relatively close to residential areas.</td><td>Suitable.</td></tr>
<tr><td>Park or playing field
Afforestation, environmental conservation or disaster prevention areas</td><td rowspan="2">Land is acquired on condition of advance use of the landfill site.
Need to confirm urban planning regulations.</td><td>Suitable only when the existing facilities are renovated or new facilities are constructed.</td></tr>
<tr><td>Former site of governmental office</td><td>Land is acquired on condition of advance use of the landfill site.
Land acquisition is easy (or unnecessary).</td><td>Easy access is provided. Care should be exercised to prevent traffic congestion.</td><td rowspan="2">Suitable only when the existing facilities are renovated or new facilities are constructed.</td></tr>
<tr><td>Intermediate waste processing site</td><td>Need to confirm urban planning regulations.</td><td>Easy access is provided.</td><td>Environmental loads can be reduced by delivering the waste on belt conveyors instead of dumping the waste direct from transport vehicles.</td></tr>
<tr><td>Waterfront landfill</td><td>Land acquisition is easy.</td><td>Easy access is provided. Care should be exercised to prevent traffic congestion.</td><td>No problem.</td><td>Suitable.</td></tr>
</table>

ACKNOWLEDGMENT

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REFERENCE

１）: Research Committee for Closed System Disposal Facilities: *Introduction to closed system disposal facilities - plan and case studies for covered MSW landfill sites*