STUDY ON CONSTRUCTION OF LARGE CAPACITY CLOSED SYSTEM DISPOSAL FACILITIES IN JAPAN

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SUMMARY :
This is a report of results of study on construction of large capacity closed system disposal facilities (landfills) in Japan conducted by the Working group for study of construction of large capacity Closed System(CS) disposal facilities , Planning and Design Study Group, Research Committee for Closed System Disposal Facilities. This report introduces the results of study on the construction of two types of large capacity closed system disposal facilities, including construction in urban locations; wide and large planar type landfills with waste capacity of 200,000 m^3 and deep and large sterical landfills with waste capacity of 500,000 m^3.It also describes the method of relocation of the covering and some examples of construction cases.

1.INTRODUCTION

The closed system (CS) disposal facilities have been adopted in approximately 50 projects including full-scale one constructed in municipal waste disposal facilities in Yamagata-mura, Nagano prefecture, Japan (completed in March, 1998), which is earlier case, and those constructed by March, 2005. Constructions of the large capacity CS disposal facilities were ordered in 2003 in Kita-Morokata-gun, Miyazaki prefecture (Miyakonojo Kita-Morokata Kouiki Shichouson-ken Jimu Kumiai) with waste capacity of approximately 77,000m^3, and in Kurose-cho, Hiroshima prefecture (Kamo-Koiki-Gyosei-Kumiai) with waste capacity of 195,000m^3. Twelve of these disposal facilities have capacity ranging from 10,000 to 50,000m^3 (32%), and five of them have capacity over 50,000m^3 (13%). In recent construction of CS disposal facilities, large scale ones are increasing as well as regular scale ones, and thus, it may be important to make planning of disposal facilities and selection of urban locations bring the large capacity disposal facilities into the view of the projects.

2.EXAMPLES OF CONSTRUCTION OF LARGE CS DISPOSAL FACILITIES IN JAPAN

2.1 Kamo Environmental Center
-Location:Higasihiroshima City, Hiroshima
-Landfill area: Approximately 12,000 m^2
-Landfill capacity: Approximately 195,000 m^3
-Landfill structure: Reinforced concrete 4pits with a covering using membrane

2.2 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

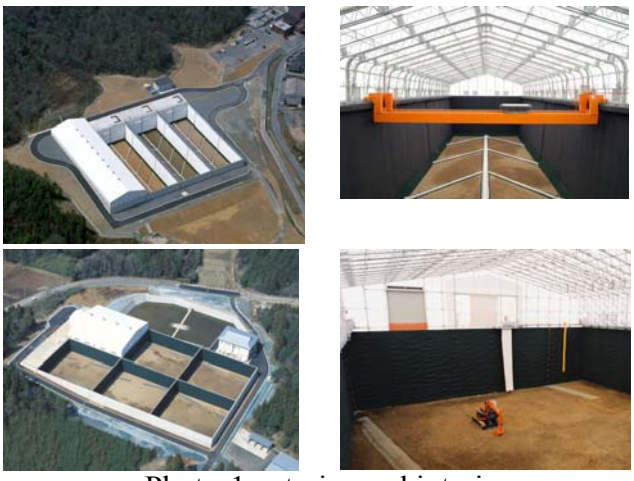


Photo-1 exterior and interior

3.LARGE PLANAR DISPOSAL FACILITIESS (CAPACITY OF 200,000 M^3)

When examining large planar disposal facilitiess, we assumed locations in local urban areas or suburbs with population of about 300,000. Principal features of the plan are described below.

Shape of leveled land: For flat lands, excavated earth is carried out from the site and used to make the land level with peripheral land, or excavated earth is used to level the site. In that case, the excavated soil is used to fill peripheral reclaimed ground to make the disposal facilities semi-underground, but the ground becomes a little higher that peripheral land. This makes the covering higher, resulting in spoiling the landscape.

Waste reservoir structure: The depth of the structure may be approximately 15 m or less. This was resulted because the waste passage way is linear and it is necessary to prevent the earth retaining structure from becoming extremely large. When underground water level is high, dewatering method is used to lower the water level temporarily to make the water-tightness of the disposal facilities higher or lower the underground water level continuously. RC pit can be adopted if uplift is not a problem. If the underground water level is low, structure of the wall and that of the bottom can be separated. In such case, it is possible to use water shielding by making the wall using reinforced soil or by using retaining wall and by making the bottom using double geomembrane or mixed soil.

Filling with waste: Because it should be possible to ensure a structure that has a waste passage way down to bottom of the site, and to ensure an access for refueling and maintenance of the machines, we decided to make a rampway with slope of 10% for direct transportation of heavy machines and vehicles.

Covering: The span of the covering is determined so that it can be constructed economically. The use of center posts or use of the covering that can be disassembled when moving it can be considered. (This time, we examine to use lump type covering.)

Facility: The covering is provided with passage for inspection around the disposal facilities. Because the facility is planarly wide, it is necessary to consider the use of forced ventilation. Since some of hazardous gases are heavier that air, it is necessary to ventilate at the bottom of the facility. Especially, it is necessary to be careful of the ventilation because such gases can easily stay on the bottom as the earth retaining wall becomes vertical.

For the ventilation of disposal facilities, it is possible to use moving blowers. The water sprinkling made for preventing of dust and chemical stabilization of the waste during the disposal facilities works. Basically, water is sprayed from the wall, if watering from the wall is not sufficient, additional watering is made from the ceiling. It may be possible to use the working heavy machines for watering. Since the works are carried out by the workers, it is necessary to detect gas before beginning the work and during the work. For the gas detection, either manual or automatic type which ever more efficient can be used.

General layout of facilities: To minimize general occupied area, the necessary facilities such as water treatment equipment and control building are arranged properly in the site. It is necessary to consider what is to be shared for the local society when designing the facility, and utilization of the ground after closing operation of the disposal facilities.

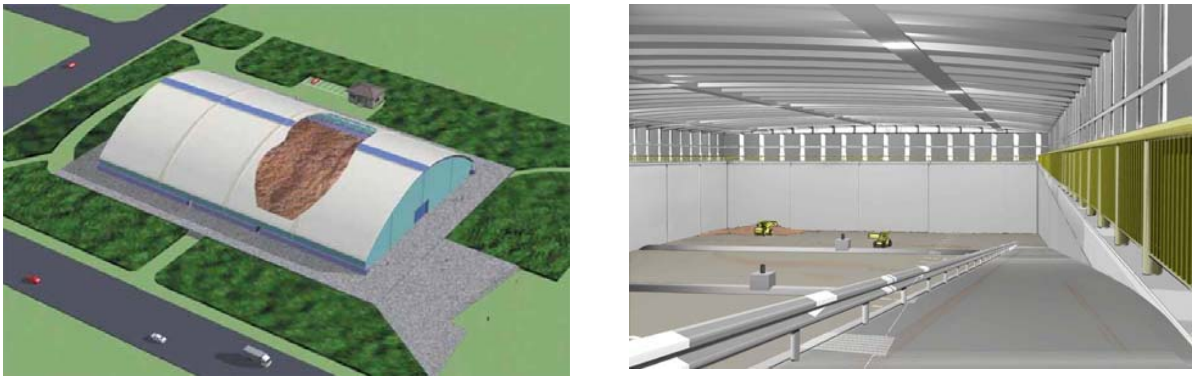


Figure.1 Image of a horizontally enlarged

● Case study:

Disposal facilities capacity: 200,000 m^3
Total ground area: 149m×306m＝45,600 square meters
Disposal facilities ground:
Case ① Reinforcing earth 240m×70m(×15.0m)＝16,800 square meters
(bentonite mixed soil + geomembrane)
Case ② Inverted T retaining wall 240m×70m(×12.5m)＝16,800 square meters
(double geomembrane)
Building:
Case ① Membrane roof 248m×78m＝19,344 m^2
Case ② Iron frame roof 245m X 80m＝19,600 m^2s
Leachate treatment facility: 25 cubic meters per day
Cost estimation:
Case ① Civil engineering cost (excluding leachate treatment): 25,000 yen / m^3
Case ② Civil engineering cost (excluding leachate treatment): 29,500 yen / m^3

4.Large sterical disposal facilities (capacity of 500,000 m^3)

When examining large sterical disposal facilities, we assumed the location with population of approximately 600,000. Principal features of the plan are described below.

Reliability of deep underground structure: Since the waste reservoir structure is constructed underground, the construction management for improvement of the construction quality (seepage function) is important. It is also important to use proper inner impervious wall construction method and impervious material installation method.

Underground water exclusion measures: It is necessary to use a facility that pumps underground water after completing the disposal facilities facility. Since it is necessary to install the facility deep underground, the structure of the facility should be designed taking into consideration the maintenance. Placement of auxiliary facilities should also be considered.

Leachate exclusion measures: Maintenance and management method for the facility should be examined in the same way as the underground water. Especially, for the leachate exclusion facility, it is desirable to design a structure that needs little maintenance and management directly by the workers.

Construction of seepage control on the structure with vertical walls: Since the seepage control works on the side wall are made on the vertical surface, the materials that make the work easier should be adopted. Especially, the stationary structure should be designed so that it is capable of ensuring easiness of construction on the vertical walls and structural stability against concentrated load applied to the structure, and prevents damage to the impervious materials as much as possible.

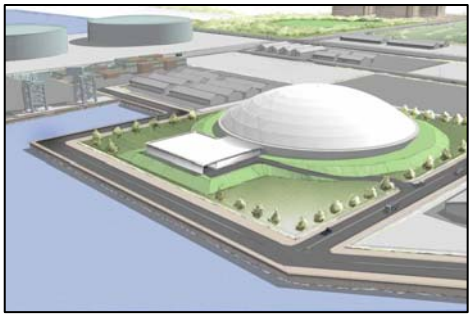
Effective and efficient ventilation system: As the structure extends deeper, the system that is capable of ventilating uniformly and efficiently down to the bottom of the disposal facilities facility is needed.

Water spraying facility and stabilization of wastes: For the deep underground disposal facilities, stabilization of wastes disposed in earlier operation may be impaired depending on the amount of supply of water into the waste layers. Therefore, it is necessary to take measures for promotion of the stability of wastes (control of wastes) such as sectioning of waste disposal space in vertical direction and placement of a facility that allows supply of water in the middle of the disposal space and exclusion of the gases.

Management of waste disposal and unattended disposal facilities facility: For the large sterical disposal facilities, it is difficult to drive the vehicles directly onto the surface of wastes disposed. Therefore, the wastes are stored temporarily above the ground and then carried into the waste reservoir later by using machines. The compaction works in the site are performed by using radio-controlled heavy machines, and delicate works that need hand working by the workers cannot be done because of unattended operation of the facility.

Especially for compaction of the waste disposed, it may be necessary to do the works near the walls without heavy machines and to place protective material on the geomembrane, which may be beyond the limit of the unattended operations of the facility. Therefore, it is necessary to establish unattended operation system that is capable of performing such delicate works.

Safety facilities: We consider that it is necessary to set up emergency exhaust system or fire extinguishing system that is capable of coping with hazardous gases that are produced during decomposition process of the waste and occurrence of fire. For the emergency evacuation system assuming works inside of the disposal facilities facility, we have to make some more examination on the features such as specific structures
It is necessary to implement planning and design of the disposal facilities facilities with multiple safety system that is capable of coping with problems comprehensively.



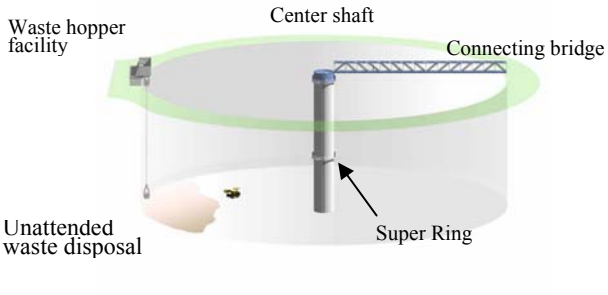


Figure 2. Visual image and Perspective view of sterical large closed system disposal facilities

● Case study:

Disposal facilities capacity: 500,000 m^3
Total ground area: 212m×152m＝32,200 m^2
Disposal facilities ground: Continuous wall 2m＋ side wall 3m, inner diameter 120m(×45m) ＝11,300 m^2
Building: aluminum roof, inner diameter 117m＝10,800 m^2
Leachate treatment facility: 25 cubic meters per day (16 cubic meters × 1.5)
Additional facilities: center shaft with connecting bridge, gondola type waste input equipment, remote controlled heavy waste disposing machines
Cost estimation:Civil engineering cost (excluding leachate treatment): 38,500 yen / m^3.

6. Relocation of covering of closed system disposal facilities

In recent years, planning of municipal disposal facilities projects that are designed to accept large amount of waste has become more and more common in Japan because of conditions of the times that make construction of the disposal facilities difficult and expansion of administrative district.

On the other hand, there is a growing need for CS disposal facilities due to raising of environmental awareness of the residents, and thus, there is a trend that CS disposal facilities with large waste capacity are demanded because preparation of such disposal facilities makes it easy to obtain the residents understanding.

Since the large capacity CS disposal facilities needs wide disposal area, and the type that covers whole disposal area with one roof makes the span larger, they provides many issues with regard to their economic efficiency and easiness of construction. Therefore, in recent years, many CS disposal facilities projects plan sectioning of disposal area that assumes relocation of the covering roof.

At present, 50 CS disposal facilities are in operation or under construction (as of January, 2008, data published by Research Committee for Closed System Disposal Facilities), and over 20% of them or ten cases have implemented or are planning relocation the covering. Based on the present situation that the relocation of the covering is becoming a practical means for continuous operation of disposal facilities, we investigated achievements of existing CS disposal facilities to understand their structural features, and examined the results by positioning that the final target is to propose design and principles for relocation of the covering “rapidly, and safely at lower cost”.

7. Achievements of relocation of CS disposal facilities coverings

Table 1 shows achievements of relocation of CS disposal facilities coverings.

Table 1. CS disposal facilitiess planning relocation of covering

No.	Name of disposal facilities facility	Scale	Structure of covering
1	Minami Uonuma-gun Kouiki Jimu Kumiai	Disposal facilities area: 952m^2 Waste capacity: 7,100 m^3	Covering with framework & membrane structure
2	Kougo Kita Kouiki Chouson Jimu Kumiai	Disposal facilities area: 2,400 m^2 Waste capacity: 19,000 m^3	Covering with aluminum framework & membrane
3	Kimobetsu-cho Municipal disposal facilities	Disposal facilities area: 1,770m^2 Waste capacity: 5,982 m^3	Coveringwith iron framework, single story building
4	Higashi-Hiroshima-shi Kamo-Kankyo-center Municipal disposal facilities	Disposal facilities area:12,000 m^2 Waste capacity: 192,000m^3	Framework & membrane structure (mobile)
5	Yatsushiro-gun Seikatsu Kankyou Jimu Kumiai	Disposal facilities area:5,499 m^2 Waste capacity: 19,032 m^3	Framework & membrane, long folded plate roof
6	Naie-cho, Omoiyari-ka	Disposal facilities area: 2,940 m^2 Waste capacity: 15,500 m^3	Framework & membrane structure
7	Katori Kouiki Shi-chou-son-ken Jimu Kumiai	Disposal facilities area: 9,120 m^2 Waste capacity: 90,100 m^3	Framework & membrane structure
8	Kuriyama-cho	Disposal facilities area: 4,060 m^2 Waste capacity: 25,000 m^3	Steel lattice structure + vinyl chloride membrane
9	Wakkanai-shi	Disposal facilities area: 27,000 m^2 Waste capacity: 189,000 m^3	Aluminum framework & membrane structure
10	Nimi-shi Municipal disposal facilities	Disposal facilities area: 4,107 s m^2 Waste capacity: 27,200 m^3	Steel rigid frame membrane structure

8. Study on relocation of covering

8.1 Method of relocation

When planning relocation of the covering facility, it is important to design the covering facility that is light, easy to construct, and economical in operation. And thus, it is necessary to adopt a method that helps minimizing the movement period.

The following figures describe a model of the relocation of the covering.

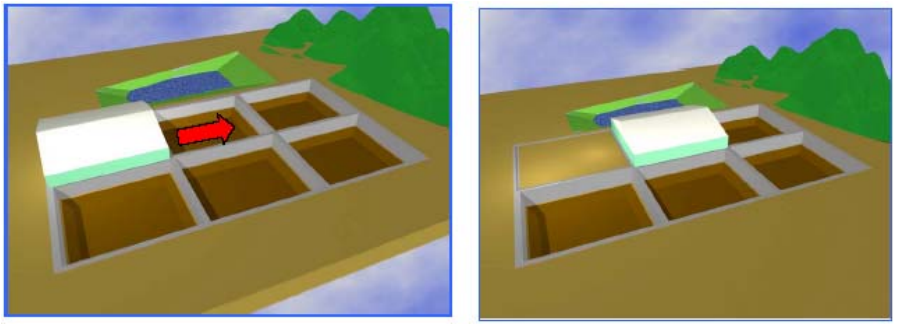


Figure 3. Covering movement model (in travel direction, sliding system) 1)

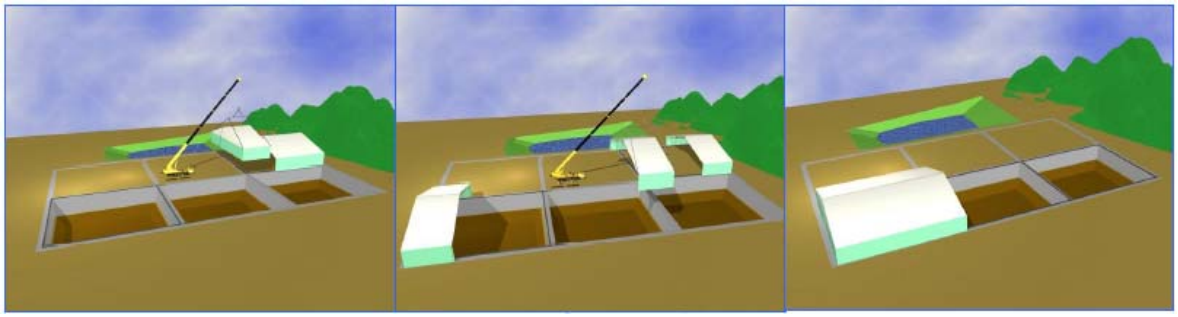


Figure 4. Covering movement model (in span direction, hoisting system)

8.2 Idea of relocation of covering

When designing a covering facility, the dimensions and shape is determined according to the disposal area, and the structure the covering is determined according to the basic structure of the waste reservoir. Therefore, when examining relocation of a covering, it is necessary to include the covering relocation plan in the design stage of the CS disposal facilities on which the covering is installed. The basic design should include achievement of the facility by saving the weight, dividing the facility into blocks, and minimizing the facility with the motto "rapidly, and safely at lower cost".

When adopting the covering facility that is divided into sections according to the number of divisions of the waste retaining area, relocation of the facility after a division of the area is filled with waste provides the following advantages.

① By using the covering facility of which covering area is equal to the area of a division, the covering area can be made smaller, resulting in reducing the construction cost, however, the relocation cost is needed additionally.

② In case the covering facility or seepage control layer is damaged, it can be repaired efficiently because the repair is needed only for the damaged division.

③ In case the indoor environment is spoiled by produced gas, power dust, indoor air temperature, humidity, or other factor, the improvement action for the divided space becomes more effective as the volume of the space is smaller.

④ Since the scale of indoor facility is proportional to the volume of a division, the facility functions more effective as the volume of the space becomes smaller. At the same time, the facility becomes economical because it can be made smaller as the number of divisions of the disposal facilities area becomes larger.

⑤ Although the maintenance and management items do not depend on the number of divisions, the covering area becomes smaller as the volume of a division becomes smaller.

⑥ When planning utilization of the divisions after finishing their operation in earlier stage, the possibility of the utilization becomes higher as the number of divisions increases.

Since the span length of the covering facility in the range from 35 to 40 m makes the division the most suitable, relocation of the covering facility should be planned so that the dimensions of a division by the waste retaining structure is equal to such span length.

8.3 Methods of relocation of covering

The methods of relocation of the covering includes "sliding system", "hoisting system" and "disassembling-assembling system" that are described in this section individually by Table 2.

Table 2 Covering relocation systems

Method of relocation of covering	Description
Sliding system	The covering structure is slid in the relocating direction to a predetermined destination with the structure maintained firmly. Similar to building drawing methods, this method allows relocation of the covering with its form maintained, and does not need the uses of wide working yard and large sized heavy machines. This method requires continuity of locations of the facilities in the site. It is necessary to prevent deformation of and application of strain to the structural members.
Hoisting system	This method uses a hoisting equipment such as a crane to move the covering to another location. Since the hoisting equipment has a specified capacity, it may be necessary to divide the covering. The heavy machines such as cranes require a firm work yard, and the yard have to be clear of obstacles within their operating range. It is necessary to prevent deformation of and application of strain to the divided structure while hoisting it.
Disassembling-assembling system	The covering facility is disassembled before the movement, and then, assembled at the destination. The working process is the same as that of the construction. This method requires mature construction capabilities that protect the seepage system from being damaged if the machines are operated on the waste. Although the advantage of this method is that the component members can be checked after disassembling the covering, the method requires longer working period as compared with other method, which is the biggest issue.

8.4 Covering system suited to relocation

There are following two types of the covering facility for CS disposal facilitiess, the covering with iron framework, single story building, folded plate roof, and the one with framework & membrane structure. The covering facility suited to the relocation needs to have basic members that are light and easy to handle, excellent covering function, and a structure that have long service life allowing repeated used.

Generally speaking, as compared with the covering with iron framework, single story building, folded plate roof, the one with framework & membrane structure allows to make the facility lighter, resulting in reducing the movement load and deformation and strain during the movement. Use of aluminum alloy frame members can make the facility lighter moreover and weather-resistant. The principal materials are selected based on the function of the facility required and the cost. As the structure of the covering, the one with framework & membrane structure is suitable for this purpose.

8.5 Points to consider when designing the covering

This section collects the points to consider when designing the covering system taking the relocation into consideration based on the considerations using actual cases.

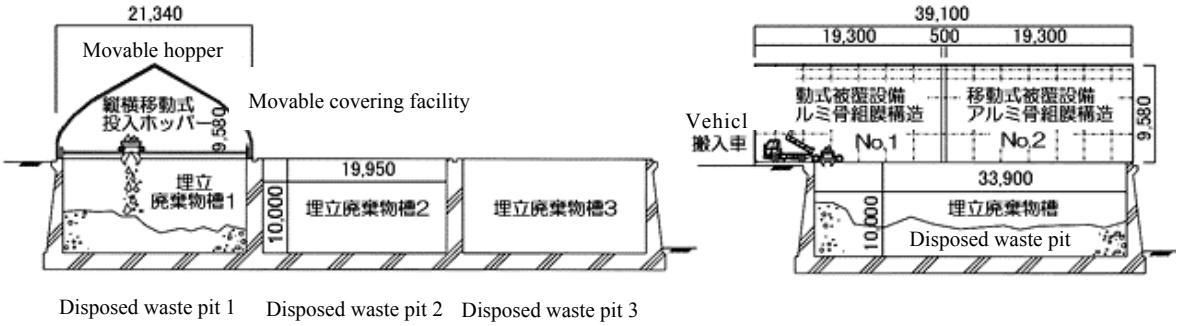
・Making structural members lighter and preventing deformation during movement.
・Ensuring high bearing capacity of waste ground on which the front chamber base of the facility is located
・Saving spaces in each waste reservoir pit for working vehicles such as crane vehicle.
・Planning arrangement of facility components so that they do not work against the relocation
・Obtaining building certification: Each relocation requires application for the certification because the movement is treated as redeployment that requires legal building certification
・Preparation of opening for works including removal and installation of base bolts and nuts (on the floor of inspection passage)

8.6 Introduction of actual implementation cases

8.6.1 Kougohoku Kouiki Chouson Jimu Kumiai, Kougohoku Waste Disposal Center

Operation from: April, 2002
Structure of roof: Dome, aluminum frame membrane structure (class C membrane)
Dimensions of roof: 21.3 m(W)×39.1 m (L)×9.6 m(H) (Gross weight 12.5 tons)
Time of relocation: March, 2006 (4 years after beginning of operation)
Relocation method: Hoisting system (2 divisions)

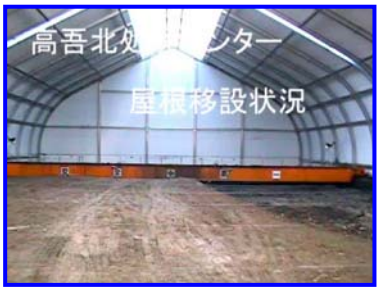
Figure 5 Kougohoku Waste Disposal Center, Municipal disposal facilities



1) Covering relocation process

Since the disposed waste reservoir pits are arranged in parallel with each other, the covering was divided into two and moved by using hoisting system. The covering relocation process is as described below.

① Preparation



(Interior before relocation)


(Placement of crane vehicle)


(Attaching hoisting device)

② First time (first half)


(Removal from base)


(Moving while hoisting)


(Installation and securing)

③ Second time (second half)


(Removal from base)


(Moving while hoisting)


(Installation and securing)

④Final stage


(Relocation completed)


(Full view)


(Old disposal facilities site)

2) Discussion

This is the first case of relocation of the covering of CS facilities in Japan. The relocations was completed in three working days. The hoisting system may require considerations on the opening and displacement of the bottom of the covering when hoisting it and on the foothold of crane that rides on the neighbor old disposal facilities site, though no problems were experienced during this relocation case.

8.6.2 Katori Kouiki Jimu Kumiai, Daini Ijichiyama Municipal Disposal facilities
Operation from: April, 2006
Structure of roof: Framework membrane structure
Dimensions of roof: 37.2 m(W)×41.4 m (L)×10.0 m(H) (Gross weight 100 tons)
Time of relocation: March, 2009 (4 years after beginning of operation)
Relocation method: Sliding system (with rollers)

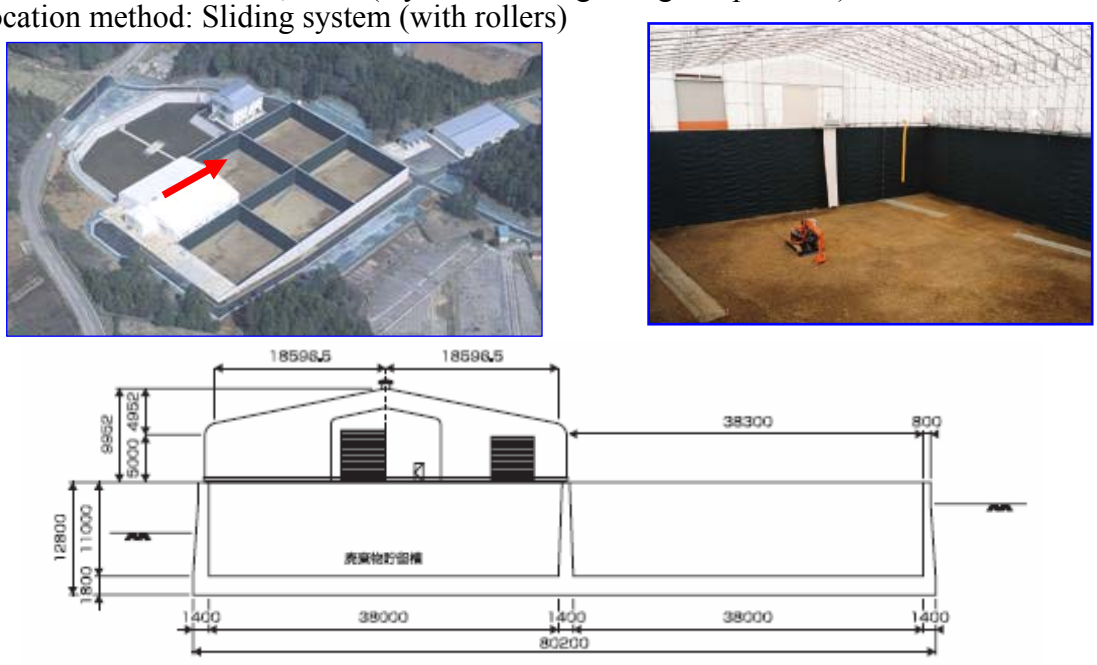
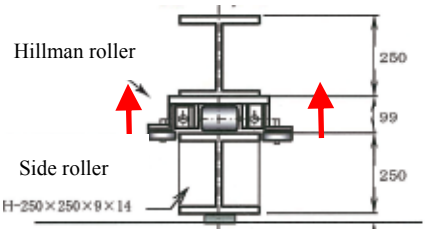


Figure 6. Daini Ijichiyama Municipal Disposal facilities

1) Covering relocation process

① Removing securing bolts → Jacking up at foot (H-shaped steel beam) → Attaching Hillman rollers



Jacking up

State of Hillman rollers and side rollers attached
(Side rollers are used to prevent run off of the structure.)

② Moving the structure to predetermined position by using winch

Drawing using winch

2) Discussion

This is the first case of relocation of the covering facility by using the sliding system in Japan. The relocation of the main covering was completed in five working days (half a day for movement of the roof). When moving the roof, wires were set for preventing opening of the cove ring, which were effective for prevention of opening and deformation of the main covering. For the CS disposal facilities of which covering relocation is made by using the sliding system, the work is made on the block next to the one that is not filled with waste, and thus, preparation of the foofhold for the work may be an issue to be considered in the future cases.

9.CLOSING REMARK AND FUTURE TASKS

The challenges facing typical horizontally enlarged CS disposal facilities 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 CS disposal facilities, storage and liner structures, and unmanned landfill equipment and methods suitable for deep facilities are required.
When locating a CS disposal facility in an urban area, complying with the laws concerning the construction at the location is a great challenge.

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1) "FY2006 Study Report, 2nd edition" by Working group for study on large capacity disposal facilitiess, Research Committee for Closed System Disposal Facilities.