4. Construction of a subsurface dam

4-1 Methods of construction of a subsurface dam

The various construction methods of a subsurface dam are listed in Table 4.1.

In some countries including Japan, there have already been several examples of subsurface dams. The majority of them were constructed by a method known as "cut-off wall by underground diaphragm wall (e.g. soil-cement mixing wall method)". Theoretically, a subsurface dam utilizes a "cut-off wall" for groundwater storage, and can be built using the “cut-off wall” method appropriate for local conditions.

Table 4.1: Methods of construction of a subsurface dam

Category	Type of construction method	Construction method and structure	Features
Application of method of cut-off wall under ground	Wall of steel sheet	Piling steel sheets continuously	This method is suitable for weak ground, but piling into gravel layers or basement rock is difficult.
	Wall of steel tubing	Piling steel tubes continuously	
	Underground diaphragm wall	Casting reinforced concrete wall on-site	There are various methods according to the ground conditions. They all require highly sophisticated equipment.
	Column-type underground diaphragm wall	Casting wall of mortar piles continuously on-site	This method was used to construct the subsurface dam at Miyako Island in Japan. It requires highly sophisticated equipment.
Application of ground improvement method	Grouting method	Injection of mortar into boreholes drilled intermittently	This method was partially used in the construction of the subsurface dam at Miyako Island. It is widely applicable because small and medium-size equipment can be used. However, confirmation of the effect of water cut-off is somewhat difficult.
Application of general dam construction method	Method of concrete dam construction	Structure of concrete dam under ground fully or by half (excavation/construction of dam body/filling back)	This is suitable for the "torrent dam"-type subsurface dam whose crest is exposed above the ground surface (there are some examples in countries such as Kenya). The construction costs are higher than those of the "earth dam"-type subsurface dams. Countermeasures against water leakage are required. For deep excavation, the costs would be too high.
	Method of earth dam construction	Structure of earth dam under ground	This method was used for this project. Dams of this type can be constructed using ordinary civil engineering equipment, and construction management is easy. However, countermeasures against water leakage are required. For deep excavation, the costs would be too high.

In this project at Nare, the "earth dam" method shown at the bottom of Table 4.1 was adopted for the following reasons:

1) The "fossil valley" was buried deep (about 8 m below the ground surface), and it had almost no groundwater run-off in the dry season. It was thus possible to apply this method.

2) This method does not require sophisticated machines and could be carried out with those available in Burkina Faso.

3) The cost of construction, including transportation and rental of machines, was the lowest.

4-2 Characteristics of the subsurface dam built at Nare

The characteristics of the subsurface dam built at Nare for this model project are as follows:

(1) Site
In the fossil valley in the Koulikare Quarter, Nare Village, Tougouri District, Namentenga Province, Burkina Faso

(2) Structure of the dam body
"Subsurface earth dam" (see Fig. 4.1)

- Depth of the base: 3.0 m to 11.4 m below the ground surface (maximum height of the dam: 8.4 m)
- Crest length: 216.3 m
- Width (thickness): 8.6 m at the base, 3.0 m at the crest
- Volume: 7,144 m^3
- Filling materials: clayey silt (heavily weathered layer of basement rock)
- Permeability coefficient: 10^{-7} to 10^{-8} cm/sec (very partly, 10^{-6} cm/sec)

At the upstream side of the base of the dam, an "anchor key" with about a 3- to 4-m width and a 1.5-m depth (protrusion into the basement rock) was formed to protect the base. At a level just above the crest, about a 1-m-thick layer of gravel with a similar diameter was laid to ensure good permeability.

(3) Water source of the subsurface dam reservoir
Shallow groundwater within the fossil valley buried along the Kolongo River, a tributary of the Gouaya River that is a part of the Niger River basin

(4) Dimensions of reservoir

- Maximum extent of reservoir area: 13.4-km length, about 150-m average length (lowest estimate), about 2-km^2 area
- Volume of reservoir layer: About 9,000,000 m^3 (estimate)
- Water storage capacity: About 1,800,000 m^3 (estimate)

(5) Amount of construction work

- Excavation: Excavation of soil: 51,213 m^3, excavation of rock: 4,377 m^3, total: 55,590 m^3
- High-density filling (the dam body): 7,144 m^3