

### 4-3 Construction of the subsurface dam

#### (1) Excavation

The construction of a subsurface dam requires much larger excavation than the size (length, width, depth) of its body. Excavation for construction site access roads is also necessary.

In the case of the subsurface dam in Nare, the scale of the excavation was as follows:

- Length: 307.1 m (including the excavation for construction site access roads)
- Width: 50 m maximum
- Depth: 12.9 m maximum
- Total amount of excavation: 55,590 m<sup>3</sup>

The total amount of excavation was thus 7.8 times as much as the volume of the dam.

During excavation, the following difficulties had to be dealt with:

- 1) Although the excavation was carried out during the dry season when the groundwater decreased in the fossil valley, it encountered difficulties due to water springing from the sandy layers at an intermediate depth of the fossil valley sediment or from the boundary between the sediment and the basement rock. Because subsurface dams are constructed across shallow groundwater channels, this water springing during the construction is not rare. It is thus necessary to pay sufficient attention to the choice of season and the construction method.
- 2) On the right bank, the buried structure of the fossil valley proved to be the same as that estimated from the preliminary survey, but on the left bank, the fossil valley extended beyond the estimated limit. In general, the results of the preliminary survey are not always completely accurate, and the participation of geologists experienced in supervising construction is thus very important.

#### (2) Construction of the dam body

As the material of the dam body, the heavily weathered layer of basement rock (clayey silt), which was extracted 300 m from the dam site, was used.

Before the construction of the dam body, filling and pressing tests with the material were carried out to establish quality control standards for filling:

- Thickness of spread layer per filling: 30 cm
- Thickness of pressed layer per filling: 25 cm
- Number of pressings: 6 back-and-forth passes with Komatsu roller JV100
- Water content of the material before filling: Optimal water content  $\pm$  1%
- Dry density of the pressed layer: Higher than 90% of the maximum dry density
- Permeability coefficient of pressed layer: Lower than 10<sup>-5</sup>cm/sec

After excavation down to basement rock of the fossil valley, filling the dam body was carried out according to the quality control standards described above. In the process of filling, the following quality tests were carried out:

- Tests of the water content of the material: 52 layers, 130 points in total
- Tests of the dry density of the pressed layers: 52 layers, 130 points in total
- Measurements of the permeability coefficient of the pressed layers: 12 layers, 38 points in total

All the results of the quality tests were good and satisfied the standards. The permeability coefficients of the pressed layers were about  $10^{-7}$  to  $10^{-8}$  cm/sec ( $10^{-6}$  cm/sec at only 2 tests out of 38), which were much better than the required value.

It should be remembered that the foot and base of the dam must protrude into basement rock of the fossil valley to prevent water leakage.

As stated above, the material of the dam body was extracted from the heavily weathered layer of basement rock (argillaceous silt) located about 300 m from the dam site. However, surplus soil (fossil valley sediment) produced by excavation at the dam site might be usable as the material of the dam body. Such re-use would reduce "the devastated area" by the construction of the subsurface dam. For future "subsurface earth dam" projects, it is thus recommended to survey in detail the geological nature of the dam site from this viewpoint as well.

### (3) Backfilling of the excavation

Parallel to the construction of the dam body, the excavated space of both the upstream and downstream sides of the dam body was backfilled. The backfilled portion was pressed by 3 back-and-forth passes with Komatsu roller JV100.

The excavation was initially backfilled to the crest level of the dam. Then, to obtain good permeability, gravel with a similar diameter was laid about 1 m thick, followed by additional backfilling (also pressed by 3 back-and-forth passes with the roller).

As the dam body was made of material from the other site, surplus soil, the amount of which was almost equivalent to the volume of the dam, was left after backfilling. This surplus soil was used to fill back the site from which the material of dam body was extracted.

### (4) Treatment after construction

After backfilling was completed, the landform of the dam site was almost restored. However, restoring the natural vegetation was so slow that the ground remained bare for about two years after the dam construction. To protect the natural vegetation from possible grazing by livestock animals, a wire fence was set around the construction site and *Acacia senegal* was planted within it in 2001. The rate of survival was about 60% (in January 2002), but plenty of natural vegetation was growing and the construction site had the appearance of shrub forest.



Photo 4.1: Construction of the subsurface dam -1



Photo 4.2: Construction of the subsurface dam -2



Photo 4.3: Construction of the subsurface dam -3



Photo 4.4: Construction of the subsurface dam -4