Research on the Construction of Rainwater Reservoir Facilities by the Unmanned Pneumatic Caisson Method

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(Purpose)
Recently, urbanization has increased the volume of rain water discharged, and flood damage has occurred frequently because of extraordinary heavy rain – caused by typhoons or localized torrential downpours – far over the planned rainfall standard. In order to prevent such damage, the “Rainwater Reservoir Facility” has attracted attention as one kind of solution to this problem. However, it is very difficult to obtain the area necessary to construct this facility in densely built-in areas and where underground embedded facilities are concentrated in an urban area.

Therefore, a method of rationally constructing and managing facilities with sufficient rainwater storage functions in confined areas must be developed.

The purpose of this research is to establish design and work performance methods for rational underground water reservoir facilities with vertical shapes deep underground constructed applying the unmanned pneumatic caisson method (Figure 1) adopted in urban areas. It is also intended to study a total effective management & maintenance system for such facilities.

(Results)
(1) The facility design study
1) Scale and specification of reservoir facilities; capacity of a facility built using an unmanned pneumatic caisson is 10,000 – 30,000m³ and its depth is 20 – 60m.
2) Specification of storage facilities (Structural design); the trial design model (Figure 2) was calculated respectively by two-dimension frame calculation and three-dimension FEM analysis. The weight of the re-bars based on a three dimension FEM model is lower than that obtained by a two dimension model.
3) Execution range of caisson; the minimum area is 113m², maximum is 4,900m² and the maximum depth is 70m.
4) Effective drainage method; the deeper the storage facility the greater the head and fluctuation. It can be effectively drained by devising pump combinations, pump arrangements, and the storage facility structure (One tank type, upper and lower division type) or a storage method.

Figure 1 Outline of unmanned pneumatic caisson method
Figure 2 Outline of reserve facilities (Trial design examination models)
(2) The study of work performance (Planning construction for narrow areas)

5) Work procedure and performance method; the necessary area for the working yard when executing the unmanned pneumatic caisson method, a method suitable for a narrow area, is about 70% of the area for the diaphragm wall method. Moreover, it is actually 50% of that with the diaphragm wall method, because the remote control room equipment is installed underground.

6) Construction cost reduction; it was calculated by the trial design model (capacity 10,000m³ and 40m in depth). Four ground conditions, from weak ground to hard ground, were hypothesized.

- The construction cost of the unmanned method is about 80% and about 50% of the cost of the manned method in soft ground and hard ground respectively.
- Regarding the unmanned method, its construction period is about 50% and its construction cost is about 80% of that with the diaphragm wall method.

As a result of the study, The results of this research have been compiled in a technical manual “Technical manual of the Construction of Rainwater Reservoir Facilities by the Unmanned Pneumatic Caisson Method”.

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