Research on the Long-distance Inclined Pipe in Eba, Hiroshima City

Year of research	2009～2010	Implementation of anti-inundation measures

(Purpose)

Hiroshima city is constructing a stormwater trunk line in the Eba area as part of its flood control project. The trunk line (hereinafter called "extension pipe") is 4,750 mm in diameter and 2.7 km in length. The pipe is laid under more than 20 m of earth. There is a large height difference between the extension pipe and the existing stormwater pipe, from which water flows into the extension pipe. Some device is required in the connection between the pipes. However, a drop shaft or other commonly used drop structures cannot be used because of restrictions on the construction imposed by the aboveground construction conditions and other underground constructions. We considered connecting them with an inclined pipe. Connection with an inclined pipe has been rarely employed for a stormwater pipe with a large flow rate (pipe diameter 800 mm) and a large drop (20 m) like this facility. Many hydraulic problems remain unaccounted for. Design methods have not been established. To see whether an efficient and safe structure can be built using an inclined pipe for the large drop, we have conducted a hydraulic model experiment under the actual construction conditions. We have verified hydraulic functions of the inclined pipe and required measures.

(Results)

(1) Verification of the original design and discussion of causes of problems

We built a 1/10-scale model of a structure from the inlet manhole to the inclined pipe and to the extension pipe. We examined the flow in the designed structure and the functions. (See Figure 1.)

Inclined pipe diameter φ800mm, 600mm
Drop: 20 m、 Angle: 85°, 60° and 45°

Figure 1 General view of the experiment model

As the inclined pipe was to be connected to near the top of the extension pipe, air in the extension pipe could be released to the surface of the ground via the inclined pipe. As well as testing with atmospheric pressure in the extension pipe, we tested the model with restricting the upstream and downstream flows of air in the extension pipe so that air would pass through the inclined pipe (water level rise). The design flow rate of the inclined pipe (Q_d) was 1.2 m^3/s. We gradually increased the flow rate from 0.5 Q_d and checked the flow.

Under the condition of water level rise, the flow was unstable even at 0.5 Q_d. As the flow rate increased, pulsation and other phenomena became more and more significant. In an extreme case, rainwater with air gushed out of the inlet manhole. This happened because the cross section of the joint between the manhole and the inclined pipe was filled up with water and air flow was blocked.

(2) Examination of measure and verification of its effect

Water flows fast in the inclined pipe. When the pressure in the extension pipe is low, water flows down together with air. When the pressure in the extension pipe is high, air tends to go up in the inclined pipe out to the surface of the ground. The verification result of the original design shows that the volume of air flows into the inclined pipe depends on the joint between the inclined pipe and the inlet manhole. We have devised an air pipe with air intake and exhaust capability and air deflecting function (air pipe with air deflector) to be installed at the joint.

(See Figure 2.)

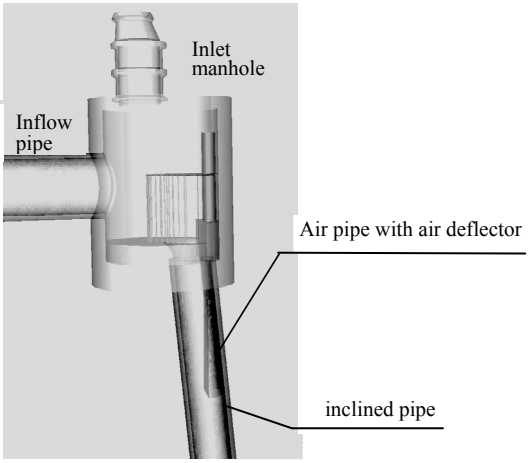

Figure 2 Conceptual image of the air pipe

As a result, water flowed stably at the design air flow of Q_d = 1.2 m^3/s with an inclined pipe diameter of ϕ 800 mm and a drop of h = 20 m (when connected at the bottom). From these experiment results, we have compiled a guide to inclined pipe design (draft).

Please note that the verification experiment was conducted with the exhaust capacity of up to 2 Q_d where the water flow rate was 1.0 Q_d. The verification results are based on those conditions.

(Notes on designing)

The basic structure and the application range are obtained from the result of the experiment of the hydraulic model simulating an inclined pipe connection system. This system will not be suitable if the size or the flow rate of the inclined pipe exceeds the application range. Also, the inclined pipe connection system tends to cause a huge gush of water and air when the application range is exceeded. To employ this system, precise flow control by a diversion manhole or air removal for the entire stormwater trunk line will be required. About using an inclined pipe for a water system with a large drop, bear those notes in mind and consider carefully whether to employ it.

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Key words	Drop structure, Inclined pipe, Air pipe