Study on Effect of Air Entrainment and Confluence Loss on Flow of Combined Sewer Storage Tunnel

Whole term | 2004.12～2006.3

(Purpose)
The objectives of the present work were to clarify complex hydraulic phenomena that are expected to occur in the Chiba City combined sewer storage tunnels (main trunks 1, 2, 3, 4) which are large scale downstream storage type stormwater mains, and in particular in the No.1 main trunk. To investigate measures for improvement, hydraulic model tests were carried out and the structure for the junction manhole at the confluence of the No.1 and No.2 main trunks was investigated. A proposal was made to provide an air vent facility at the high head drop connection location in the No.1 main trunk.

(Results)
1. Loss characteristics of the junction manhole (confluence of the No.1 and No.2 main trunk)
   (1) Test results
   From a hydraulic model test that reproduced the confluence portion shown in Figure-1, the amount of rise in water level due to the confluence was obtained. From this result, the loss characteristics of the confluence were deduced as follows.
   
   \[ f_{\gamma,\beta} = -0.56q_B^2 - 1.62q_B - 0.66 \]  
   \[ f_{\gamma,\alpha} = 0.03q_B^2 - 0.41q_B - 0.48 \]

   \[ q_B \]: Flow rate ratio of the No.1 and No.2 main trunks
   \[ f_{\gamma,\beta} \]: Confluence loss of No.1 main trunk
   \[ f_{\gamma,\alpha} \]: Confluence loss of No.2 main trunk—No.1 main trunk

   (2) Proposals based upon the test results
   It was found from the hydraulic investigation the effect of the water level rise accompanying the confluence on the storage quantity could be mitigated by changing the No.2 main trunk confluence from a pipe bottom connection to a water surface connection, i.e., the storage losses from the confluence were solved. Therefore, for a water surface connection structure, a method was proposed in which the level of the bottom of the pipe of the No.2 main trunk was raised, and by a head drop process (slope portion) with a stilling portion the water level rise due to the head loss is absorbed (Figure-2).

![Figure-1 Confluence portion of the junction manhole](image1.png)

![Figure-2 Proposal for improved confluence portion for junction manhole](image2.png)

2. Verification of the air venting effect of a new type air vent facility (air collection pipe)
   (1) Test results
   For two representative manhole locations, in one of which the pipe connected from the side (Figure-3) and in the other the pipe connected at the top (Figure-4), the quantity of air entrained was determined, and the air venting effect of an air collection pipe was verified.

   The quantity of entrained air brought from the high head drop connection into the storage tunnel as a percentage of the design flow rate was 5.0–13.0% (pipe partially full—pipe full) for the pipe side connection method, and 2.0–7.3% (full pipe condition) and 13.8–27.4% (pipe partially full) for the top of pipe connection method.
In contrast to this, when an appropriate air vent pipe was provided and the quantity of air entrained downstream was measured, nearly 100% of the air could be vented. Tests were carried out regarding the shape and dimensions of the air collection pipe including setting the opening diameter, length, air collection holes, etc., to clarify the basic dimensions of the air vent opening (method of setting the opening diameter, length, diameter and arrangement of standard air collection holes) for both the pipe side connection manhole and the top of pipe connection manhole.

![Diagram](image)

**Figure-3 Side pipe connection method**

**Figure-4 Top of pipe connection method**

(2) Proposal of air collection pipe structure based upon test results

Based upon the test results for the No.1 construction area of the No.1 main trunk and other high head drop water intake manholes of the central stormwater main trunks, the basic structure of the air vents for each manhole consisting of an air collection pipe (horizontal pipe provided with small holes) installed in the top of the pipe, a curtain, and an air vent pipe (vertical pipe) as an air vent facility for removing entrained air brought into the storage pipe from the high head drop connection was proposed.

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**key words**

Downstream storage pipe, Confluence losses, Hydraulic model test