Investigation on steep gradient sewerage pipe in the Suzaka City		
Period	2000.9 -2001.11	85P～94P

(Purpose)

By the 2000 fiscal year, the Sewerage penetration ratio reaches at 66.6%, and with the improvement of main residential area is almost finished, the improvement areas are shifting to the suburb districts from urban district in the Suzaka City, Nagano Prefecture. when the public sewerage sewer of whole line 6,200m are laid, which collects the sanitary sewage of the Minenohara highlands district (Suzaka 2-4 treatment minute ward : 201.4 ha) and brings to disposal facility in the Suzaka City, the scientific research is carried out on the application of the steep gradient sewerage sewer method as one of cost reduction countermeasure, because this route runs though the steep landform division.

On the application of steep gradient sewer method, though the safety of utilities which flow at high speed had been confirmed by the hydraulic model study until now, that the dispersion of sanitary sewage and instability of the flowing water are considered as problems due to the generating air fluctuation in pipe flowing at high-speed of over 3.0m/Sec.

In this study, the hydraulic model experiments were conducted for the study on aeration quantity into water of flowing downward at high-speed and air entrainment quantity running with flowing water on water surface of sewer, and the investigation research for the quantification of aeration quantity and entrainment quantity was carried out in order to plan effective plumb and exhaust utilities in design.

(Result)

This study carried out following items.

1. Decision for application range and laying route of steep gradient sewer method

In sewer laying plan, the following were carried out: design approved the whole line stretch of L=6200m of and comparative examination of the construction cost of steep gradient sewer method. As the result, stretch L=885.5m of large gradient topographer was decided to use the steep gradient sewer method within the whole line stretch L=6200m. The optimum route was selected by considering the topography element (topographer contour, soil condition, etc.) .

2. Execution of hydraulic model study

The hydraulic model study was carried out by using the real scale model (contraction scale of 1/1) in order to satisfy the similarity on the behavior of air. As sewer items of the experiment object, it was carried out on the basis of plan items decided in above article 1 (the diameter:f200mm, the largest gradient I =830‰, Q=0.016m3t/Sec).

And, the installation of the energy dissipater is required, because in end (the joint of downstream with usual sewer) of steep gradient sewer, hydraulic jump or strike wave are generated in pipe, and unstable downward flow phenomena such as service area blockade and water level raising occur. In additional, the energy dissipater should be decided by the hydraulic model study, because the design technique of energy dissipater was not clearly verified.

The result of hydraulic model study is shown as the following.

(1) Hydraulic model study for the quantification of aeration quantity and air entrainment quantity.

①Aeration quantity.

From the result of hydraulic model study, it was possible to deduce the empirical formula shown in the following by calculating the Froude number (the Fr value) derived from water depth and flow velocity.

Classification	Aeration ratio
Case by average water depth	m=0.0465Fr-0.24
Case by maximum water depth	m=0.0586Fr-0.13

②Air entrainment quantity

The air entrainment quantity can be calculated by the empirical formula Vap=0.51×Vw which is flow

velocity (Vap) of empty cross section in sewer ,and derived in respect of the speed ratio with flow velocity (Vw) of flowing water itself.

(2) Hydraulic model experiment of the energy dissipater installed in the end of steep gradient sewer.

By the hydraulic model study of original design structure which was decided from existing design example and hydraulic model experiment result, the problem (generation of plane vortex, length of apron length, full flowing condition of outflow pipe) which arose in the original design plan was solved.

Installation of the chute block (plane vortex resolution, apron length shortening).

Installation of training wall in sill lower reach (the open channel flow of outflow pipe).

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Key Words	steep gradient sewage sewer, behavior of air in pipe, energy dissipater