INTRODUCTION
City of Yokohama, with an area of 42,531ha and a total population of approximately 3.74 million, has enormous amount of assets compared to other sewerage facilities — 99.9% coverage of sewerage supply system, approximate 11,900km in total pipe length of the sewerage pipeline facility, about 530,000 pieces of manholes, about 1,400,000 pieces of inlets and service connections, and investment of about 2.7 trillion yen already made (approximately 70% of total amount of investment). Currently, approximate 880km (7%) of total pipe length has ended its 50 years of standard service life. It’ll be expected to get deteriorated rapidly, like approximate 1,900km (24%) after one decade and approximate 7,900km (67%) after two decades. This time, we will report about engagement in collaborative investigation into the medium to large diameter pipe that makes up approximate 1,900km of total pipe length, toward the practical use of a new investigation technique utilizing unmanned aerial vehicles (hereinafter, drones) that are gradually utilized for infrastructure inspections, etc. Aims of this investigation:

- To ensure the workers’ safety in pipelines that are difficult to investigate
- To reduce the cost for inspections (improve productivity)
- (reduction in the inspection cost by improvement of running speed, etc. compared to conventional underwater visual inspections and self-propelled TV camera car, etc.)

Keywords: Drone, Industry-academia-government, Sewerage inspection survey, Medium to large diameter pipe

METHODS

【Flight control styles of drones】
- "Manual flight": visual flight that you operate while directly watching a drone, or non-visual flight that you operate while watching a screen image at hand.
- "Automatic flight": control a flight with a variety of sensors mounted on a drone.

【Problems in applying drones to pipe inspections】
- Non-GPS environment
- Darkness
- Sewage is flowing
- Narrow space
- Needs to carry inspection equipment from a manhole cover.

⇒ Compared to the other infrastructure inspections conducted with drones, this application faces the hardest environment.

RESULTS

【Investigation results】
- Stable flights are confirmed in circular pipes from φ1800mm to φ3000mm.
- In φ1500mm of circular pipe, a flight is not stable due to reflecting wind made by a drone itself.

【Inspection level (trouble confirmation accuracy)】
- Got similar images as pictures along the direct vision in the underwater visual inspections.
- Got a result that rank A and B were basically available to be judged.

【Flight length】
- 45m to 500m
- Stable automatic flight hasn’t been achieved
- It costs about 2/3 of conventional cost
- Its utility as a screening inspection has been proved

CONCLUSIONS

【Manual flight】
- Aimed at reducing costs, LED lights, etc. are customized based on commercial aircrafts.
- "Automatic flight"
- Aimed at flying automatically while estimating locations, a variety of sensors, like lasers, and a spherical guide are mounted by our original development.

Picture 1  Diagram of inspection with a drone

Figure 1  Diagram of inspection with a drone

Figure 3  Pattern diagram of inspection work by drone

Table 4  Summary of flight experiment results

Table 1  Investigation aims

Table 2  Criteria

Table 3  Overview of the aircrafts used in this study

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Figure 2  Division of rules of investigation community

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