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Improvement of fire hydrant design to enhance water main flushing

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Abstract

Flushing is a good practice to avoid problems related to sediment, bio-film growth, and corrosion. Artificial sediment was removed from fire hydrant with pilot scale water distribution main. The sediment removal in fire hydrant and main was carefully compared with different flow rate with velocity ranged from 0.3 to 3.0 m/s and the depth of fire hydrant from 0.5 m to 1.3m. The drain capability of fire hydrant decreased as the flow rate increased. Sediment with higher density was hard to remove from water main. The length effect of upward fire hydrant was relatively minor. Downward drain showed better efficiency for both sand and actual sediment.

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Keywords: Flushgin, Distribution, Drain valve, Fire hydrant, Water supply

1. Introduction

Water authorities make a lot of efforts to improve water qualities in the drinking water treatment plant but cannot avoid the deteriorated quality in the poorly managed water distribution mains. Water quality tends to decrease in the water distribution system through the formation of bio-film, internal corrosion and leaching, tuberculation and sloughing, and pipe breakage by Annie carriere et al. (2005) Although water distribution pipe is

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carefully rehabilitated and maintained by water authorities, particulate matter is accumulated in the water distribution mains. They encroach into water mains during pipe construction, by intrusion through pipe cleavage, through tuberculation sloughing, by scale formation, and by residual alum coagulation. Water authorities make flushing to remove accumulated particulate matters, bio-film, and precursors of DBP. Pipe flushing is economical alternatives to replacing or rehabilitating aged water pipe. Flushing is particularly beneficial when it is impossible to carry out trenching because of heavy traffic or residents' opposition by Akira Koizumi et al. (2005)

Flushing is being performed according to guidelines of water authorities by Jae-Chan Ahn and Kwang-In Park et al. (2005). Water velocity from 0.9 m/sec to 1.5 m/sec is required to remove silt, sediments, and bio-film. Although flushing is carried out once or twice a year, triple flushing is required a year for many places. Flushed sediments are often removed from fire hydrants. The removal efficiencies depend on the flow velocity in a pipe, sediment density, and the geometrical shape of fire hydrant. The objectives of this research are to elucidate optimal velocity for drain, effect of sediment density, and beneficial shape (i.e., flow direction) of fire hydrant for flushing.

2. Experimental methods

The experimental apparatus was made from transparent acrylic glass as shown at the Figure 1. Fire hydrant was installed at the end of pipe to enable upward and downward drainage of turbid matter. The diameter of main pipe and fire hydrant are 30 mm and 16 mm, respectively. The flow rate was ranged from 0.3 to 3 m/s. The flow was measured using ultra sonic flow meter (GSA-500, Kometer).

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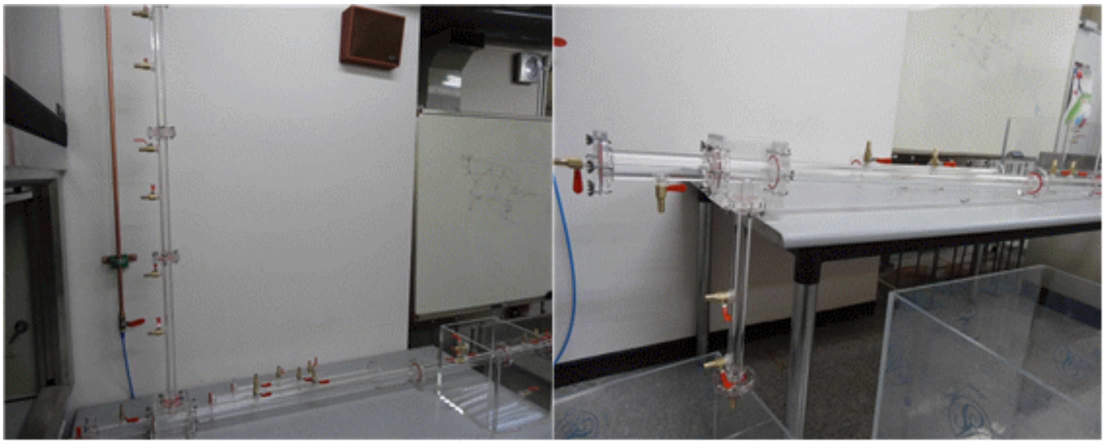


Fig 1. (a) Up-stream device; (b) Down-stream device

Sand and debris from actual aged water pipe was used for this experiment. The sand was from sand filter and has density ranged from 2.6 to 2.65. The results of sieve analysis are shown at the table 1. Debris from aged pipe was collected from a city in Korea and has density of 3.2. The particle size ranged from 150um to 2.0mm.

Sand and actual sediments from actual aged water pipe were used for this experiment. The sand had density ranged from 2.6 to 2.65, which was often used for sand filter. The results of sieve analysis are shown at the table 1. Sediments from aged pipe were collected from a city in South Korea and had density of 3.2. The particle size ranged from 150μm to 2.0mm.

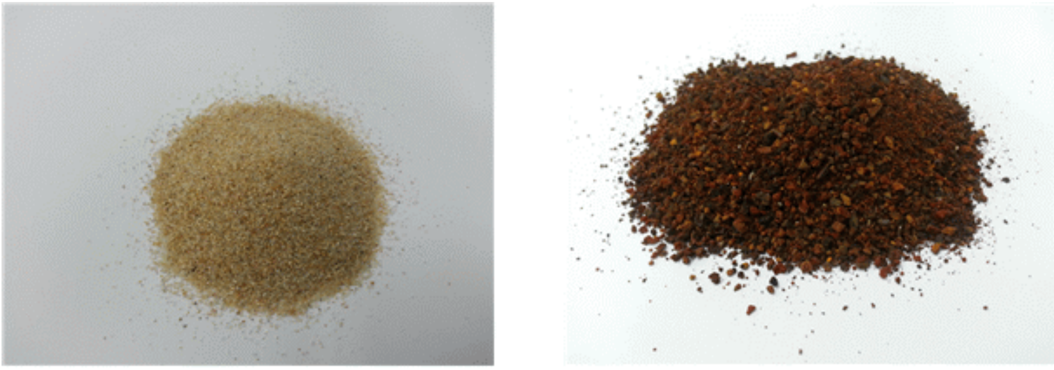


Fig 2. (a) Using sand; (b) Using Scale

Table 1. Sand Size Analysis

Sieve Size	Remaining sand in Sieve %
850 μm	Below 1.0
600 μm	Above 95.0
300 μm	-
Clay	Below 0.4

The length of pipe C (in figure 3) was changed from 0.5 meter to 1.3 meter for upward drain. The length of C for downward drain was fixed to be 0.5 meter(in figure 4). The experimental procedure was like followings. Experimental scenarios are summarized at table 2.

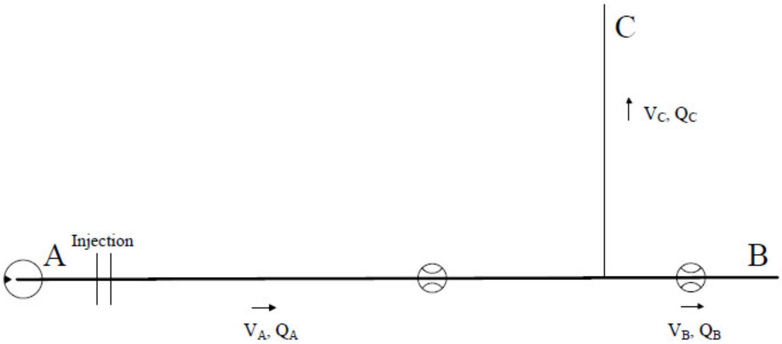


Fig 3. Up-stream design

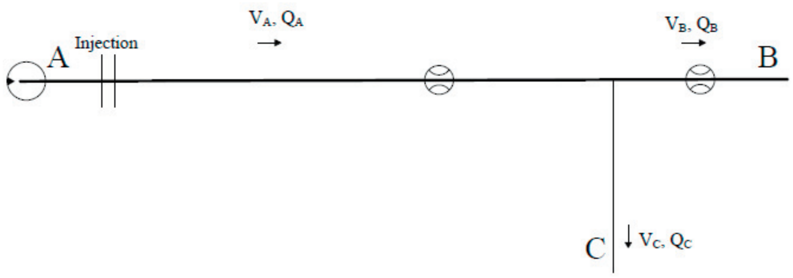
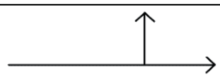
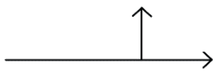
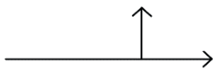
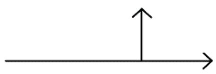
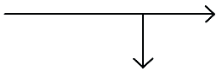
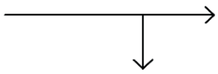


Fig 4. Down-stream design

Table 2. Case of experiment

	Model	Length of Pipe C	Diameter of pipe	Sediment of Obtaining place
No.1 (upstream)		0.5m	Φ30 × Φ16	Pipe C
No.2 (upstream)		0.5m	Φ30 × Φ16	Pipe B and C
No.3 (upstream)		1.3m	Φ30 × Φ16	Pipe C
No.4 (upstream)		1.3m	Φ30 × Φ16	Pipe B and C
No.5 (downstream)		0.5m	Φ30 × Φ16	Pipe C
No.6 (downstream)		0.5m	Φ30 × Φ16	Pipe B and C

3. Results and discussion

3.1. Drains from fire hydrant

The upward drain capability of sand was slightly dependant to the length of pipe C. As the length of pipe C increased from 0.5 to 1.3 meter, recovery rate decreased from 97.67% to 95.87% as shown at the table 3. Efficiency of downward drain of sand was almost 100% as shown the table 3. Downward drain showed better drain efficiency than upward one.

The upward drain capability of actual sediments from pipe C showed lower rate than sand because of higher density. Like the result of sand, upward drain capability was slightly affected by the length of C. As the length of pipe C increased from 0.5 to 1.3 meter, recovery rate decreased from 95.73% to 95.20% as shown at the table 4. Downward drain also showed better drain efficiency than upward one. Efficiency of downward drain of actual sediment was only 98% and showed lower efficiencies than sand. It was thought to be caused from the higher inertial force of sediments with higher density.

Table 3. Result of Sand(Total 30g) using Pipe C

	Length of Pipe C(m)	Sediment in Pipe C(g)	Recover rate (%)	Velocity of Pipe A(m/s)	Velocity of Pipe C(m/s)
No.1 (upstream)	0.50	29.30	97.67	1.01	3.55
No.3 (upstream)	1.30	28.76	95.87	1.01	3.56
No.5 (downstream)	0.50	29.93	99.78	0.90	3.15

Table 4. Result of Scale(Total 25g) using Pipe C

	Length of Pipe C(m)	Sediment in Pipe C(g)	Recovery rate (%)	Velocity of Pipe A(m/s)	Velocity of Pipe C(m/s)
No.1 (upstream)	0.50	23.93	95.73	1.01	3.55
No.3 (upstream)	1.30	23.80	95.20	1.01	3.56
No.5 (downstream)	0.50	24.50	98.00	0.90	3.15

3.2. Drains from fire hydrant and main pipe

The efficiencies of drain from fire hydrant were dependant on the flow rate of water main as shown from figure 5 to 7. B/C velocity ratio is the velocity ratio between water main (B) and fire hydrant (C). B/C sediments ratio is the ratio of residual sediments of water main and fire hydrant. As shown at the figure 5, 6, and 7, the drain capability of fire hydrant decreased as the flow rate of water main increased because of higher inertial force. When we compared sand and actual sediment, actual sediment was more affected by flow velocity of main than sand since it had much higher density. The effect of upward fire hydrant length was relatively minor when we compared figure 5 and figure 6 for both sand and actual sediment. The downward drain efficiency was phenomenal to upward drain as shown at the figure 7. Comparing upward and downward drain with sand, B/C sediment ratios were 105.74 and 1.69 for upward and downward drain, respectively, when B/C ration was 2.0. For actual sediment, B/C sediment ratios were 56.78 and 0.94 for upward and downward drain, respectively, when B/C ration was 2.0. Downward drain showed far better efficiencies for both sand and actual sediment.

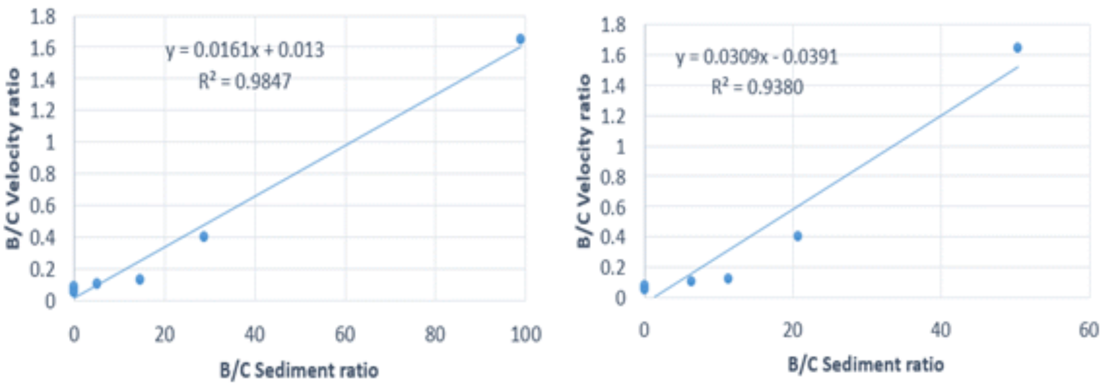


Fig 5. (a) Velocity and sediments removal of sand in 0.5 m upstream; (b Velocity and sediments removal of actual sediment in 0.5 m upstream

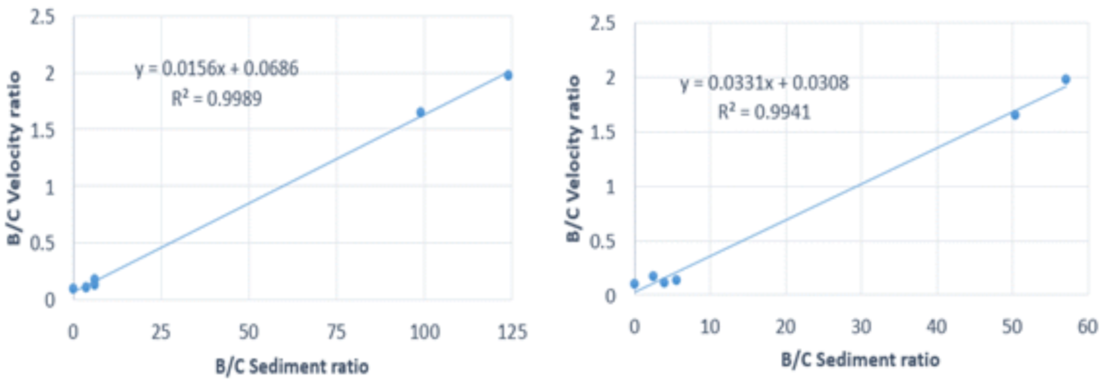


Fig 6 . (a) Velocity and sediments removal of sand 1.3 m upstream; (b) Velocity and sediments removal of actual sediment in 1.3 m upstream

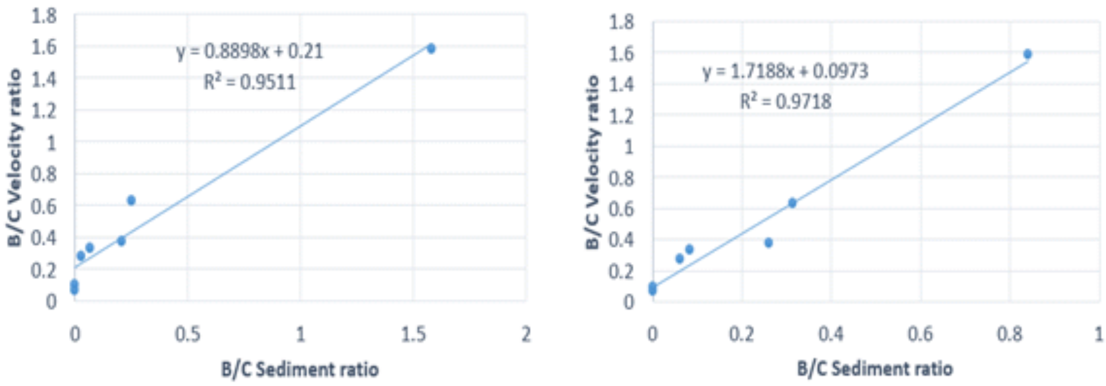


Fig 7 . (a) Velocity and sediments removal of sand in 0.5 m downstream; (b) Velocity and sediments removal of actual sediment in 0.5 m downstream

4. Results and discussion

The drain efficiency from fire hydrant was affected by flow rate, sediment density, and flow direction of fire hydrant. The drain capability of fire hydrant decreased as the flow rate of water main increased because of higher inertial force. Sediment with higher density was hard to recover from water main. The effect of length of upward fire hydrant was relatively minor. Downward drain showed far better efficiencies for both sand and actual sediment.

Acknowledgements

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