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Measurement of the Time Taken for Initial Water Discharge According to the Number of Kinks in the Fire Hose of the Indoor Hydrant System

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Abstract

In this study, we tried to examine how the kinking of the fire hose affects the time taken for initial water discharge by measuring and analyzing the time taken for initial water discharge with different number of kinks at different locations of the hose. The average time taken for initial water discharge was obtained by measuring the time in the unkinked state of the fire hose. Based on this standard, we conducted the experiment by selecting the kinking locations in the hose near the water outlet and nozzle, and setting the number of kinks to 3, 6, 9, and 12. The results of this study are as follows: First, if the fire hose has 5 kinks or more near the nozzle, no water was released. Second, when comparing the case of no kinks and 4 kinks near the nozzle, there was no significant difference in the time taken for initial water discharge. Third, when the fire hose was kinked 10 times near the outlet, the time required for initial water discharge increased by 1.62 seconds on average compared to the case with no kinking, but there was no problem with water discharge. Lastly, regarding the kinking locations of the fire hose, it was found that the greater the number of kinks near the nozzle than near the outlet, the greater the effect on the discharge. As a result, it is concluded that it would be preferable to install non-kinking devices near the nozzle of the fire hose.

Keywords: *Indoor hydrant system, Fire hose, Number of kinks, Kinking locations, Time taken for initial water discharge*

1. INTRODUCTION

The fire hose is a conduit for discharging firefighting water and is connected to a fire hydrant or a water outlet of a fire pump in case of a fire. It is composed of a hose and a metal sphere connected to it.[1]

In general, fire hoses are used for extinguishing fires and are important firefighting supplies to protect life and property. They are loaded inside the firefighting vehicles used by firefighters and are usually installed inside or outside specific firefighting facilities.[2]

Fire hoses should be durable to be used for a long time and should be manufactured from materials that can ensure convenience and safety in emergency situations. However, most of the fire hoses that are currently connected to the outlet of the fire hydrant are kinked in a direction that impedes the activity of firefighters during firefighting. They can also be bent or kinked by neglected facilities around the fire hydrant, making it difficult to extinguish fire.

Therefore, research and product development are underway to solve the kinking, bending, and warping phenomena of fire hoses. In particular, the non-kinking fire hoses are designed so that the existing fixed

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connection type fire hoses can be naturally rotated and released by pressure of water when it comes out of the hoses. These anti-tangle hoses provide convenience and practicality for firefighters who use them professionally or for in-house firefighters at manufacturing sites of hazardous materials. The hoses can prevent safety accidents due to kinking and bending and can also be helpful in terms of practicality by meeting the golden time requirement when they need to be opened quickly.

In a study on non-kinking fire hose connectors, Gong Ha-Sung et al. (2012) mentioned problems in using fire hoses, such as reducing the amount and range of water discharge due to bending of the hose in emergency situations. To solve these problems, they designed an anti-kink swivel connector.[3]

Jo Song-Jae et al. (2008) conducted a study on fire hoses for fire hydrant to prevent their kinking and bending. They recognized that fire hoses could become kinked or bent when passing through corners, failing to properly spray water, and causing waste of time to straighten the fire hoses, leading to failure in early suppression of the fire. To solve the problem of hose kinking or bending, they put metal springs into the fire hoses and weaved them together so that the force of the spring could stretch the hoses.[4]

In a study on re-illumination of non-kinking fire hoses, Park Se-Hum et al. (2017) mentioned that there are excellent products such as fire hose rotary connectors and articulated rotary couplings that can prevent hose kinking and bending, but they are not often used in the field due to their w8 and inconvenience in use.[5]

Most of the previous studies dealt with problems that could occur due to kinking of the fire hoses, and they focused on developing a non-kinking fire hose as a solution. However, what was lacking in previous studies was the time required for initial water discharge depending on the number of kinks in the fire hose. In this study, we intend to analyze the relationship between the number of kinks in the fire hose and the initial discharge start time, and in addition, whether water release is possible according to the kinking locations.

2. THEORY

2.1 Types of Fire Hoses and Prevention of Damage

The types of fire hoses include rubberized fire hoses, flax fire hoses, wettable fire hoses, and firefighting reel hoses, and among them, the currently used ones are rubberized fire hoses and firefighting reel hoses. In general, the exterior material of the fire hose is woven with polyester filament yarns, and the interior material is polyurethane because it offers good resistance to abrasion, chemicals, ozone, and weather.

2.2 Rubberized Fire Hoses

A rubberized fire hose refers to a fire hose with rubber or synthetic resin embedded in the jacket. The jacket is a cylindrical fabric woven with longitudinal warp threads and transverse weft threads and can be divided into a single jacket and double jacket.

A single jacket has rubber or synthetic resin attached to the jacket and is used in schools, apartments, and buildings. A double jacket hose has a jacket coated on the outside of the rubberized fire hose, and is used for firefighting vehicles, power plants, chemical plants, oil refineries, and production facilities and industrial sites.

In the case of a single jacket for an indoor fire hydrant, a diameter of 40 mm is mainly used, and the operating pressure is 0.17 MPa.

Fire hoses are divided into plain weave and twill weave according to the jacket structure. A plain weave jacket has two warp and weft yarns in each weave unit, and each weft thread alternately crosses the warp threads. A twill weave jacket has 3 or more warp and weft threads in each weave unit with diagonal lines at 45 degrees across the weave.[6]

2.3 Fire-fighting Reel Hose

A firefighting reel hose refers to a fire hose whose end always maintains a circular shape during use or storage.[7] The firefighting reel hose is installed to always keep a circular shape by winding it around a drum. With its low repulsive force during use, it can be easily used by weaker people and the elderly and can also be used alone. Since the drum installed in the firefighting reel hose has a loosening prevention function, it is convenient to use without worrying about loosening during storage and use.

3. EXPERIMENTS

3.1 Selection of Fire Hoses

We studied the fire hose, which is a major component of indoor hydrant system, which are mostly installed in university buildings in Korea with a total floor area of 3,000 m2 or more.[8] In the experiment, we used a rubberized single jacket fire hose woven with plain weave that is mainly used in Korea, and two firefighters observed the experiment process for fairness and guidance.

3.2 Experiment Environment

The fire hose should have a horizontal distance of 25 m or less from each part of the specific firefighting object to one indoor fire hydrant outlet. To satisfy this condition [9], we made a 30 m hose by connecting two 15 m hoses. The hose diameter was 40 mm with its nozzle diameter of 13 mm, and the pressure of the discharge water was maintained at 0.2 MPa at the nozzle end. The temperature was 14℃ with the humidity of 56%, and the wind speed was less than 0.5 m/s. The environment of the test site is shown in Table 1.

Table 1. Environment of the test site

Classification	Description
Location	XX University
Temperature (℃)	14
Humidity (%)	56
Wind speed (m/s)	Windless

4. RESULTS AND DISCUSSION

All experiments were carried out 5 times according to each scenario, and the kinking locations were set near the nozzle and the water outlet, respectively, and the number of kinks was set for each situation to observe whether water was released.

Table 2. Time taken for initial water discharge for a hose No kinks

Experiment Count	Lead time for Water discharge (s)	Water Discharge
1	6.92	▯
2	7.13	▯
3	6.85	▯
4	7.09	▯
5	6.91	▯
Average	6.98	▯

Table 2 shows the measured time taken for initial water discharge from the fire hose without kinking, and this was set as the standard value to compare to the cases with different number of kinks in the hose. The time taken for the initial discharge was 6.98 seconds on average with a maximum of 7.13 seconds and a minimum of 6.86 seconds.

Table 3. Time taken for initial water discharge from the hose with 3 kinks

Experiment Count	Location of kinks	Lead time for Water discharge (s)	Water discharge
1	Near the nozzle	6.95	▯
2	Near the nozzle	6.96	▯
3	Near the nozzle	6.99	▯
4	Near the nozzle	7.13	▯
5	Near the nozzle	7.10	▯
Average	-	7.02	▯

Table 3 shows the time taken for initial water discharge when there were 3 kinks near the nozzle with a maximum of 7.13 seconds, a minimum of 6.95 seconds, and an average of 7.02 seconds, showing a slightly delayed time compared to the case with no kinking.

Table 4. Time taken for initial water discharge from the hose with 6 kinks

Experiment Count	Location of kinks	Lead time for Water discharge (s)	Water Discharge
1	2 kinks near the nozzle, 4 kinks near the outlet	7.09	▯
2	3 kinks near the nozzle, 3 kinks near the outlet	7.08	▯
3	4 kinks near the nozzle, 2 kinks near the outlet	7.05	▯
4	5 kinks near the nozzle, 1 kink near the outlet	-	×
5	6 kinks near the nozzle	-	×
Average	-	7.07	-

Table 4 shows the measurement of the time taken for initial water discharge from the hose with 6 kinks, and the time required was 7.09 seconds when there were 2 kinks near the nozzle and 4 kinks near the outlet. The time required for initial water discharge was 7.08 seconds for the hose with 3 kinks near the nozzle and 3 kinks near the outlet, and 7.05 seconds with 4 kinks near the nozzle and 2 kinks near the outlet. When there were 5 kinks or more near the nozzle, no water was released. The reason for this result is that if there is a lot of kinking near the nozzle, the pressure of the discharged water is reduced due to the increase in friction. In this case, the length of the hose is increased, so the kinks cannot be loosened, thus preventing water from being released.

Table 5 shows the measurement of the time taken for initial water discharge from the hose with nine kinks, and when there were more than 5 kinks near the nozzle, no water was released. The time required increased when there were more kinks near the outlet. On average, the time required for initial water discharge was increased compared to the case of 6 kinks, and it was increased by 0.52 seconds from the standard average time. If there are more than 5 kinks near the nozzle, no water is released. The reason is that as the length of the hose increases, the pressure of water decreases due to friction. Therefore, if the kinking of the hose exceeds a certain limit, loosening it is not enough to resolve the problem.

Table 5. Time taken for initial water discharge from the hose with 9 kinks

Experiment Count	Location of kinks	Lead time for Water discharge (s)	Water Discharge
1	6 kinks near the nozzle, 3 kinks near the outlet	-	×
2	5 kinks near the nozzle, 4 kinks near the outlet	-	×
3	4 kinks near the nozzle, 5 kinks near the outlet	7.51	▯
4	3 kinks near the nozzle, 6 kinks near the outlet	7.52	▯
5	2 kinks near the nozzle, 7 kinks near the outlet	7.53	▯
Average	-	7.52	-

Table 6 shows the measurement of the time taken for initial water discharge from the hose with 12 kinks, and when there were 5 kinks or more near the outlet, no water was released. In the case of kinks near the nozzle, water was still released even with 8 kinks or more, but the time required was 8.6 seconds, showing an average increase of 1.62 seconds when compared with the case of no kink. The kinks near the outlet can be sufficiently released by the pressure of the discharged water, but the kinks near the nozzle cannot. This is because as the length of the hose increases, the water pressure decreases due to friction loss. In addition, when there are more kinks near the water outlet, it takes shorter time for the initial water discharge. This means that even if there is a lot of kinking near the outlet, the kinks can be sufficiently untangled by the pressure of the discharged water. However, in the case of multiple kinks near the nozzle, it will take some time to untangle them because the friction reduces pressure as the water moves from the outlet to the nozzle.

Table 6. Time taken for initial water discharge from the hose with 12 kinks

Experiment Count	Location of kinks	Lead time for Water discharge (s)	Water Discharge
1	6 kinks near the nozzle, 6 kinks near the outlet	-	×
2	5 kinks near the nozzle, 7 kinks near the outlet	-	×
3	4 kinks near the nozzle, 8 kinks near the outlet	8.62	▯
4	3 kinks near the nozzle, 9 kinks near the outlet	8.61	▯
5	2 kinks near the nozzle, 10 kinks near the outlet	8.59	▯
Average	-	8.6	-

Looking at the above results, it was confirmed that the initial water release was generally delayed when the hose was kinked, and the time required increased as the number of kinks increased. Figure 1 shows the time taken for initial water discharge according to the number of kinks.

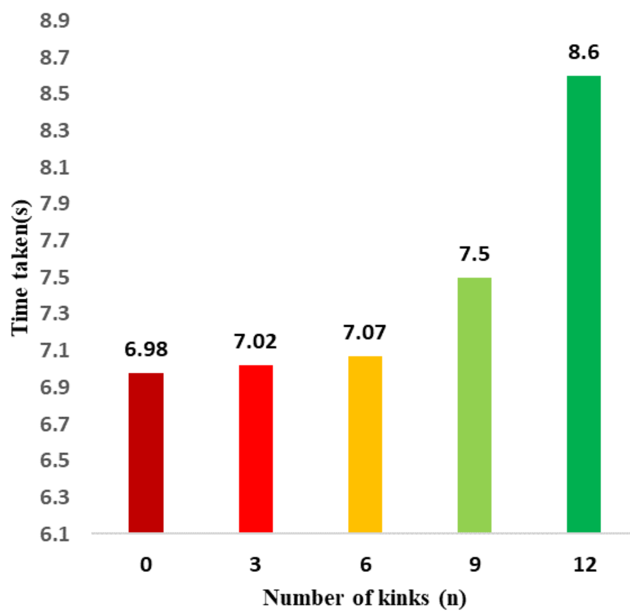

Figure 1. Average time taken for initial water discharge according to number of kinks

5. CONCLUSION

In this study, we tried to examine how the kinking of the fire hose affects the time taken for initial water discharge by measuring and analyzing the initial discharge time with different numbers of kinks at different locations of the hose. The average time taken for initial water discharge was obtained by measuring the time in the unkinked state of the fire hose. Based on this standard, we conducted the experiment by selecting the kinking locations in the hose near the water outlet and nozzle, and setting the number of kinks to 3, 6, 9, and 12. The results of this study are as follows:

(1) If the fire hose has 5 kinks or more near the nozzle, no water was released.

(2) When comparing the case of no kinks and 4 kinks near the nozzle, there was no significant difference in the time taken for initial water discharge with only an average difference of 0.09 seconds.

(3) When the fire hose was kinked 10 times near the outlet, the time required for initial water discharge increased by 1.62 seconds on average compared to the case with no kinking, but there was no problem with water discharge.

(4) Regarding the kinking locations of the fire hose, it was found that the greater the number of kinks near the nozzle than near the outlet, the greater the effect on the discharge.

As a result, it is concluded that it would be preferable to install the non-kinking device near the nozzle of the fire hose.

In a future research project, to find out whether water is released, and the time required for initial water discharge when kinking occurs in the middle of the fire hose as well as near the nozzle and the water outlet, it will be necessary to install non-kinking fire hose connectors near the nozzle, between the fire hoses and near the outlet.

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