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A Study on Performance Design Using a Sprinkler System for Fire-Spread Prevention of a Building Exterior

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ABSTRACT

A glass exterior material is normally used in buildings, but it also comes with a disadvantage—it is easily damaged by fire. If the glass exterior material is damaged, a fire can rapidly propagate inside the building space, leading to a lot of damage from the flame transfer to the other space. In this study, the performance of a sprinkler for flame propagation prevention was evaluated during an experiment with an actual proof fire. The study found that where the sprinkler is installed with the glass exterior material, the temperature does not exceed 60°C until the end of the test due to the effect of the water curtain. In the glass exterior material where the sprinkler is not installed, the temperature rapidly increased just after starting the experiment, and caused damage 21 minutes and 30 seconds after starting the test.

1. INTRODUCTION

In general, multicoating glass is used for the glass curtain in buildings as an exterior material, and the heat-strengthened glass is used for the exterior. Since using the glass material has advantages, such as lighting, view, openness (especially for dividing the usage of the space), reduction of construction costs, etc., it tends to increase the use for the interior design as well as the exterior wall. However, the glass exterior material holds up poorly in fire which can cause the glass to collapse and the flame to rapidly propagate to the adjacent space. In this study, the method forming the water curtain to the general glass wall is to be verified by the actual proof experiment to prevent the fire propagation in buildings where the glass exterior material is used.

2. METHODS

This experiment is the actual proof experiment to verify the system for preventing fire in buildings from destructing the glass exterior material and being propagated. The experiment was carried out in open space. The time of firefighting and operation in open space rather than district space can be delayed compared to operation time in the actual space. The specimen of glass curtain wall fabricated to carry out the fire experiment is shown in Figure 1, and a horizontal sidewall sprinkler head was installed in the right side of the glass exterior material. During the fire experiment, the temperature change was surveyed by installing the temperature measurement sensor in the left part of the glass exterior material where firefighting facilities were not installed and the right exterior material where the sprinkler head was installed. The location of the temperature measurement sensor installed in the surface of the glass exterior material is shown in Figure 2.

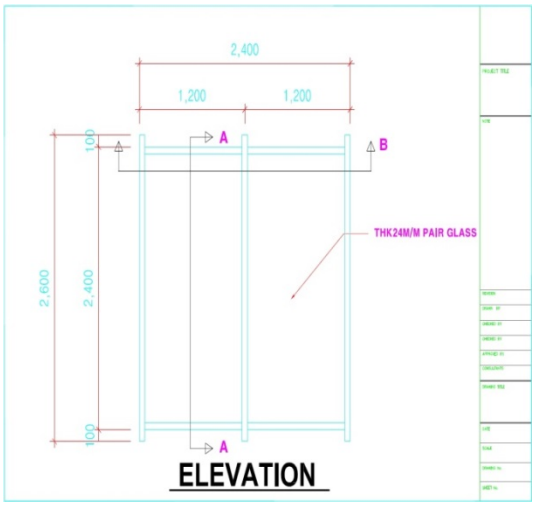


Figure 1. Size of the specimen of glass curtain wall

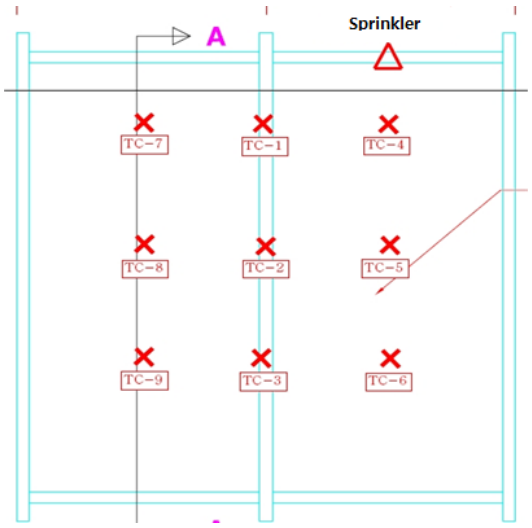


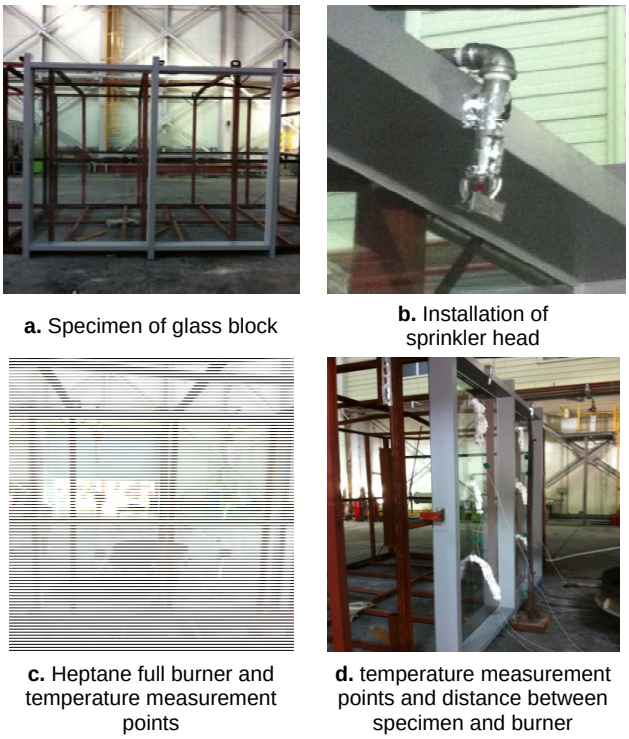
Figure 2. Installation location of temperature surveying line

A total of nine temperature measurement sensors were attached to the surface of the glass exterior material and central frame. They were installed 90 cm, 150 cm, and 210 cm from the floor. The horizontal sidewall sprinkler head used for the fire experiment was set to be operated at 68°C, and a heptane full burner used as the fire source was installed approximately 50 cm from the specimen. The installed glass exterior material specimen, full burner, and the horizontal sidewall sprinkler head are shown in Figure 3.

3. RESULTS

The fire experiment of the glass exterior material was carried out for 22 minutes, and the sprinkler installed in the right side has been operated approximately 2 minutes after starting the experiment. For the glass exterior material in the left side where the sprinkler was not installed, a crack generated after 2 minutes and 36 seconds. Also, the glass exterior material burst 5 minutes after the start. The process of the actual proof fire experiment with the glass exterior material is shown in Figure 4.

The temperature measurement sensor (TC1–3) installed in the frame of the specimen with the glass exterior material was installed in the vicinity of the fire source. Then the temperature change was measured. The temperature rapidly decreased 1 minute and 56 seconds after operating the sprinkler due to the effect of the sprinkler head installed in the



a. Specimen of glass block

b. Installation of sprinkler head

c. Heptane full burner and temperature measurement points

d. temperature measurement points and distance between specimen and burner

Figure 3. Installation of the specimen for the fire experiment

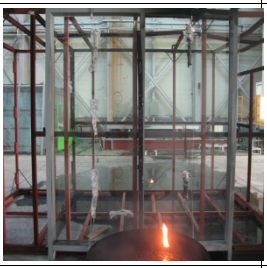
Time	Photo	Time	Photo
0 minute 1 second		0 minute 30 seconds	
	Ignition		Normal of frame and glass
1 minute 54 seconds		1 minute 56 seconds	
	Good, no work of sprinkler		Operation of horizontal side wall sprinkler installed in the right and top panel
2 minutes 36 seconds		5 minutes 20 seconds	
	Crack in the right center of left panel		Crack in glass of left panel and overall burst (Photo of rear curtain wall)
21 minutes 30 seconds		22 minutes 00 seconds	
	Failure of inside left panel. Stop operating the sprinkler of the top and right panel		Experiment finish. Generally failed in the left panel glass (Photo of rear curtain wall)

Figure 4. Process of curtain wall failure by the full-scale experiment

right section of the glass exterior material. The temperature change in the frame of the specimen is shown in Figure 5.

Figure 6 shows the temperature change of the right glass exterior material where the sprinkler has been installed. The temperature decreased at 1 minute and 56 seconds, the time when the sprinkler was operated due to the effect of the water curtain, but it gradually increased after 3 minutes. However, the rapid increase of the temperature of the glass exterior material was restricted due to the effect of the water curtain by the sprinkler. According to the temperature change for each height, the temperature of the low window was higher than that of the window situated in a high position. This is because the water curtain spilled down the glass wall and led to the cooling effect of the top glass wall.

Since the sprinkler was not installed in the left glass exterior material sample, it was directly exposed to the flame. Figure 7 shows the result on the temperature measurement. Since the water curtain did not have an effect on the left glass exterior material, the temperature gradually increased. Therefore, as a result of the actual proof fire experiment, the surface temperature of the glass exterior material increased to over 100°C 20 minutes after starting the experiment.

4. CONCLUSION

This study is to verify the poor point against the flame of the glass exterior material generally used as an exterior material in buildings and to evaluate the application adequacy of the sprinkler to settle the poor effect. The actual proof fire experiment of the glass exterior material has been carried out with the comparison experiment for the glass exterior material in two cases in which a horizontal sidewall sprinkler was and was not installed. In particular, the temperature change and the operation time of the sprinkler were measured. As a result of the actual proof experiment, the maximum temperature did not exceeded 60°C due to the formation of a water curtain in the glass exterior material where the sprinkler was installed and, therefore, failure did not occur. However, when a sprinkler was not used, a crack formed in the glass exterior material after 2 minutes and 36 seconds and the glass exterior material failed after 5 minutes. The experiment has been finalized due to the failure of the glass exterior material 21 minutes and 30 seconds after the start. Based on this experiment, it is considered that the fire propagation and expansion can be restricted during a fire by properly using a firefighting system, such as a sprinkler. In addition, it is determined that proper operation time of the sprinkler can affect the prevention of the fire propagation by protecting the glass exterior material and can be a critical factor in the performance design.

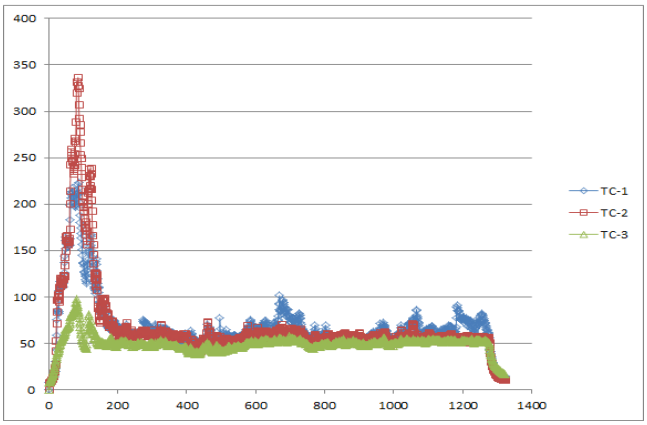


Figure 5. Result on the survey of temperature change in the center of the specimen

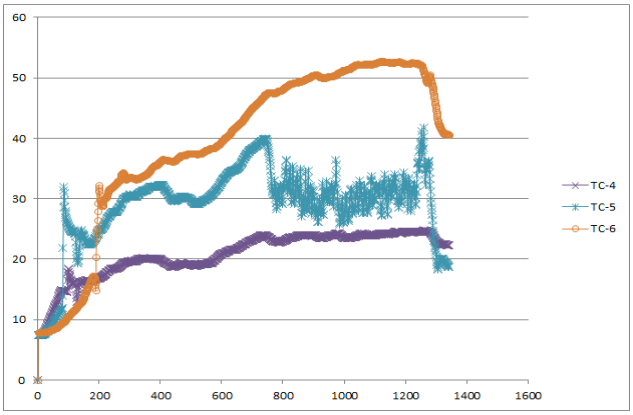


Figure 6. Result on the survey of temperature change for the glass block with sprinkler (right side of the specimen)

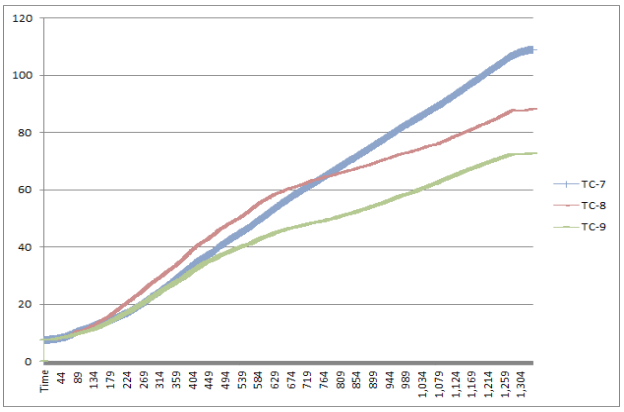


Figure 7. Result on the survey of temperature change for the glass block with no sprinkler (left side of the specimen)

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