The 2023 World Congress on
Advances in Structural Engineering and Mechanics (ASEM23)
GECE, Seoul, Korea, August 16-18, 2023

Fire Damages on Concrete Slabs under RABT and RWS Curves

*Nag-young Kim[1)], Jae-won Shim[2)], Jee-hee Jung[3)], Ji-ung Lee[4)]

[1), 2), 3)] *Korea Expressway Corporation Research Institute, Hwaseongsi 18489, Korea*
[4)] *Department of Architectural Engineering, Chung-Ang University, Seoul 06974, Korea*
[1)] *ynagkm@ex.co.kr*

ABSTRACT

Fire may cause not only human losses but also enormous property loss, so various fireproof materials have been released on the market. Because the quality control for fireproof materials has been managed by different time-temperature curves in various countries, it is difficult to find a level of quality control to the country.

For these reasons, the fire resistance tests based on RWS and RABT method, which used to commonly imitate tanker fire scenario in Netherland and Germany, respectively, were carried out for fireproof panels. The fireproof performances for concrete and fireproofing have been investigated by checking the explosive spalling and the temperatures of concrete and steel bar.

1. INTRODUCTION

As people have experienced big fire accidents in tunnel of highway recent years, the safety issues have had a high profile in Korea. Because the uncontrolled fire in tunnel especially may cause not only human losses but also enormous property loss, the fire protection in tunnel has become the most important concern of all other civil engineering fields. For similar reasons, more than 20 years ago, interest in tunnel fire protection measures increased in Europe and various fireproof methods have been released on the market. (Haack, A. 1998) But the quality control for most of fireproof materials has been managed by different criteria in various countries and it is difficult to find a level of quality control to the country. (Carvel 2002)

For these reasons, the fire resistance tests based on RWS and RABT method, which used to commonly imitate tanker fire scenario in Netherland and Germany, respectively, were carried out for fireproof panels. In this study, the fireproof performances for concrete and fireproofing have been investigated by checking the

---

[1)] Chief Researcher
[2)] Senior Research Fellow
[3)] Senior Researcher
[4)] Ph.D. Candidate

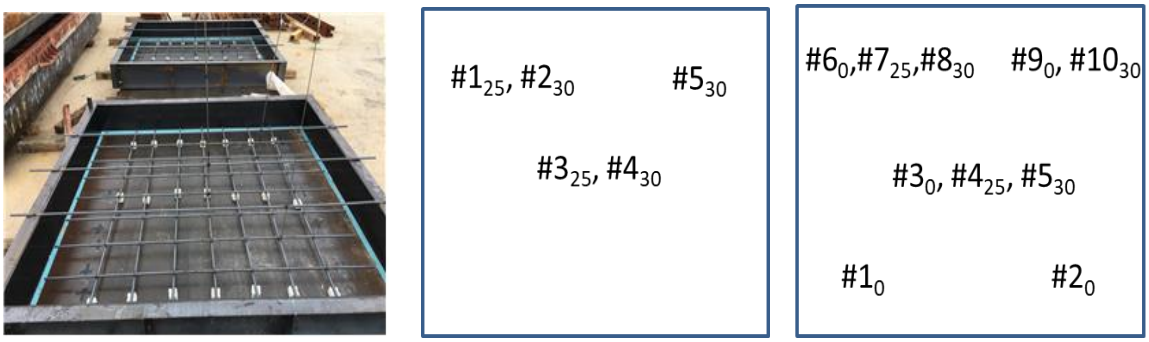
explosive spalling and the temperatures of concrete and steel bar in order to find the differences between two quality control curves.

2. SPECIMENS

The test slabs were divided into two categories : reference slabs and fireproof slabs, which were fireproofed by 20mm-thick panel. High strength concrete slab were used to investigate the spalling of them under RWS or RABT fire load curve. The reinforced concrete(abbreviated as RC) test slabs used for this project are as shown below table 1. (Choi 2021)

Table 1 Information of Test Specimens

Compressive Strength(MPa)	Slab Size (mm)	Rebar Spacing (mm)	Measuring Depth(mm)	Number of Thermocouple	Panel Thickness
50	1800×1800×250	Sides 300, Spacing 6@200	25, 30mm	Reference Slab: 5ea, Fireproof Slab: 10ea	20mm



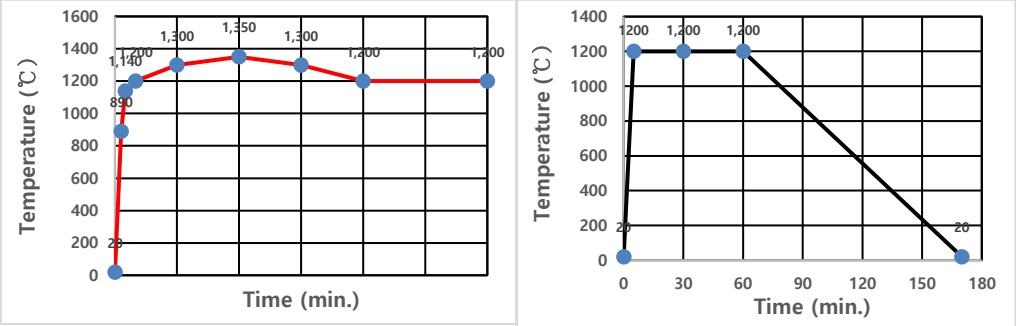
※ The number means the measuring location and the lower subscript is the measuring depth.

Fig. 1 RC test slabs (L) and Measuring Locations: Reference (M) and Fire-proofed (R)

3. FIRE LOADING

Fire Loading were defined as a specified time-temperature relationship for a concrete member subjected to a fire. The temperature were measured in a furnace at the specified distance from the face of the member as shown on Fig. 1. (EFNARC 2006)

The two fire load curves, RWS and RABT were used with this study (Fig. 2). The furnace used for RWS was shut down at 120 minutes after the start of the test but that for RABT was not shut down at 60 minutes. Temperature measurements in the specimen were continued and reported until the temperature of the thermocouples embedded in the concrete and nearest the furnace exposed face fall to below 200°C. (Chang 2006)



※ Two curves have been used to imitate tanker fire in Netherland and Germany, respectively.

Fig. 2 RWS (L) and RABT (M) Fire Load Curves

4. FURNACE

All specimens were placed on a top opening furnace, and the furnace had a minimum nominal top opening of 1500 mm x 1500 mm to accept the test slab and the capacity to increase the temperature up to 1400 °C at the time intervals required by the tested fire curve. (EFNARC 2006)

Type K thermocouples, IEC 584-3, were used in the test slab and Type S thermocouples, IEC 584-3, were used for measuring the furnace temperature. Thermocouples were calibrated and the date of last calibration of temperature measuring equipment was recorded in the test report.

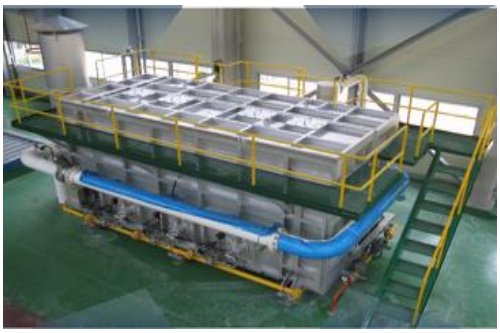


Fig. 3 The Furnace used for this study

5. TEST RESULTS

5.1 Time-Temperature Curve

The test was carried to assess the temperature profile in the furnace, at the fire protection interface with RC concrete and through the RC concrete. This will provide information on the thermal transmission of the fire protection and be indicative of likely residual strength of the concrete and the effect on any rebar placed within the concrete.

Graphs of the time-temperature curves at the interface, and each thermocouple level, were drawn to assess the rate of heat transfer through the specimen as shown on Fig. 4 and 5. Although a 20mm-thick fireproof panel has endured RABT fire load, it was

found that the panel under RWS condition did not play its role after a certain period of time.

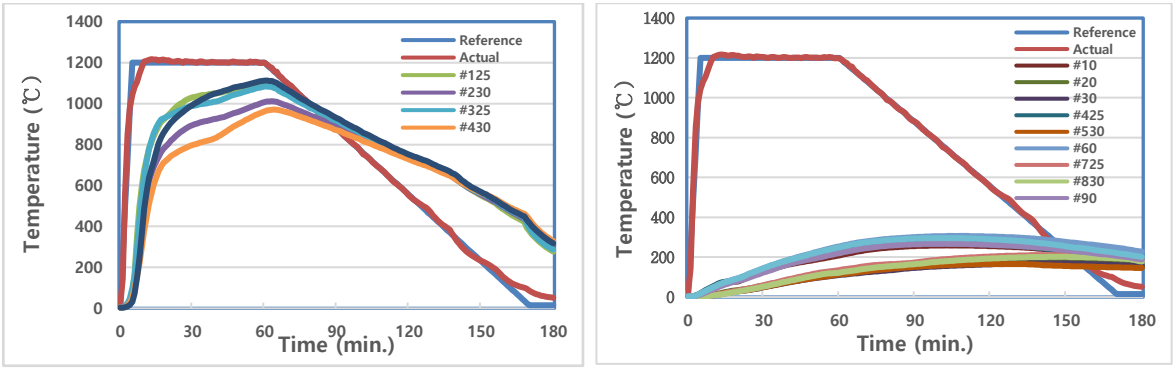


Fig. 4 Time-Temperature Curves for RABT : Reference (L) and Fire-proofed (R)

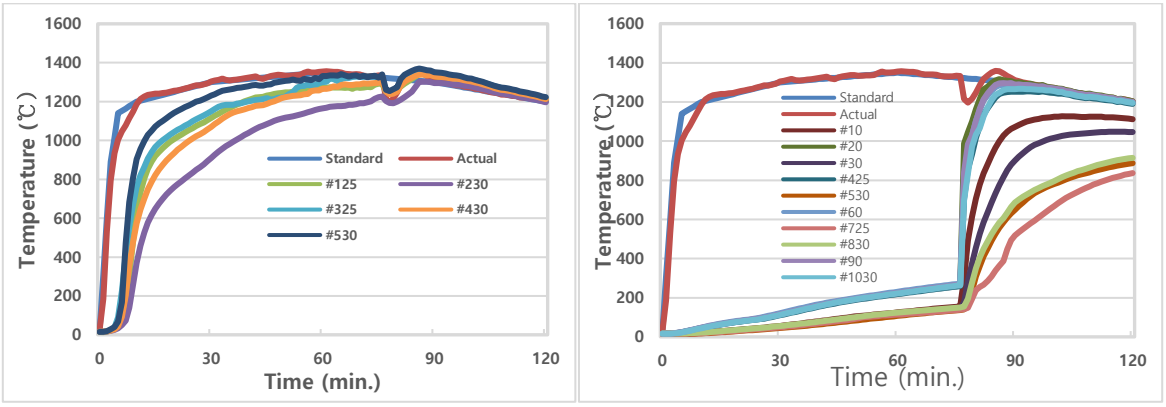


Fig. 5 Time-Temperature Curves for RWS : Reference (L) and Fire-proofed (R)

5.2 Spalling

Spalling was judged by sound because spalling could be difficult to observe during the test. So the time when spalling occurred could not found, but the maximum depth of spalled area was measured.

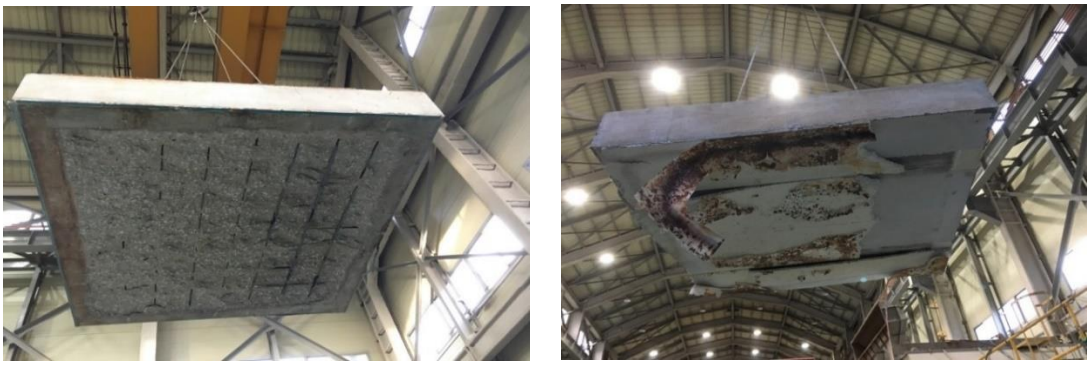


Fig. 6 Spalling of RC Slab for RWS : Reference(L) and Fire-proofed(R)

Fig. 7 Spalling of RC Slab for RWS : Reference(L) and Fire-proofed(R)

The maximum depth of spalling for reference concrete was about 60mm-thick and the horizontal and vertical cracks occurred but the concrete with fireproof panel was not spalled under RABT condition.

Under RWS fire load, the maximum depth of spalling for reference concrete was about 80mm-thick and the horizontal and vertical cracks occurred for reference concrete but the concrete with fireproof panel was not spalled before a certain period of time and then the horizontal and vertical cracks occurred and seriously spalled 160mm-thick.

6. CONCLUSIONS

As the results of fire loading test for the reference and the fireproof concrete under RWS or RABT condition,

1. All specimens of reference concrete under RWS or RABT condition were seriously spalled about 60mm-thick or 80mm-thick and the horizontal and vertical cracks occurred. As expected, it was confirmed that the fireproof panel was very effective in preventing spalling.

2. The specimen of the concrete with fireproof panel under RABT condition was not spalled but the slab with fireproof panel under RWS fire load were not spalled before a certain time and then the horizontal and vertical cracks occurred and seriously spalled 160mm-thick. Through this phenomenon, it was found that if the fireproof panel thickness is insufficient a more severe spalling may occur.

3. Therefore, the fire loading test should be performed before applying the fireproof panel and the fire load should be previously determined based on the risk of fire in tunnel. For example, if the level of fireproofing is differentiated based on the fire-fighting activities and the length of tunnel, it could be cost-effective fire resistance design.

REFERENCES

Carvel, R. (2002), “The history and future of fire tests”, Tunnels & Tunneling International, 34-35.

Chang, S.H., Choi, S.W., et al (2006), “Evaluation of Fire-induced Damage to Structural Members in Tunnels”, KSCE *J., KSCE,* **26**(3), 219-228.

Choi, S.W. and Kang, T.S. (2021), “Evaluation of Segment Lining Fire Resistance Based on PP Fiber Dosage and Air Contents”, KSCE *J.,* **31**(6), 469-479.

EFNARC (2006), “Specification and Guidelines for Testing of Passive Fire Protection for Concrete Tunnels Linings”.

Haack, A. (1998), “Fire Protection in Traffic Tunnels: General Aspects and Results of the EUREKA Project”, Tunneling and Underground Space Technology, Vol. 13, No. 4, 377-381.