

An Experimental study on Fire Resistance Rating of the Wood Fire Door

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ABSTRACT

Recently in Korea, there are increasing use of the environment-friendly material for building elements, and it's on the tendency that enlarging users demand the application of nature-friendly wood for the fire doors. However, the existing wood fire doors developed are made of mineral insulation such as ceramic wool, some problems may occur because of the increased weight of door, deformable and deflectable insulation in the long-term, and particulates. This study is on the consideration of whether the wood fire door can have fire-resistance performance by reinforcing insulation material. Fire-resistance test and analysis was carried out with each alternatives including fire-retardant board, vermiculite filler, intumescent fire-retardant sheet, intumescent fire-resistance paint and fire-retardant paint for wood use.

Keywords: wood fire door, fire-resistance rating, fire-reinforcement

1. INTRODUCTION

Building fire safety codes in many countries prescribe the Fire-resistance performance of entrance door around fire compartmentation in order to prevent the spreading flame in case of fire.

Korean Building laws and codes state the standards of Fire-resistance performance for fire door. However, most of domestic fire doors are made of steel, which its choice for external appearance and material is very limited, while other countries generally use wood and wired glass for the fire door.

Recently, according to the increasing use of the environment-friendly building materials in Korea, it is on the tendency that enlarging users demand the development and application of nature-friendly wood fire doors with apparently attractive and environment-friendly merits.

However, the existing wood fire doors developed are made with mineral insulation such as ceramic wool, some problems may

occur because of the increased weight of door, deformable and deflectable insulation in the long-term, and particulates.

In this study, we have evaluated the fire-resistance performance of the wood fire door with light-weight materials of less particulates occurrence instead of heavy-weight insulation, in order to develop light-weight and environment-friendly fire door.

We have carried out the fire-resistance rating test for each wood fire door reinforced with fire-retardant board, vermiculite filler, intumescent fire-retardant sheet, intumescent fire-resistance paint and fire-retardant paint for wood use respectively. During the tests we measured the integrity and temperature increasing on unexposed side of the fire door

2. FIRE-RESISTANCE TEST

2.1 Specimen Planning

To secure the Integrity and Insulation of the wood fire door for 30 minutes in case of fire, we have set the following five options and carried out a test for each case respectively.

As you see in the Table 1, each case used 1) fire-retardant board on both inner sides of finish of the door, 2) vermiculite filler between inner frames of the door, 3) intumescent fire-retardant sheet on the inner side of one-side finish of the door, 4) intumescent fire-resistance paint on inner frames of the door and both inner sides of finish of the door, and 5) fire-retardant paint for wood use on both inner sides of finish of the door.

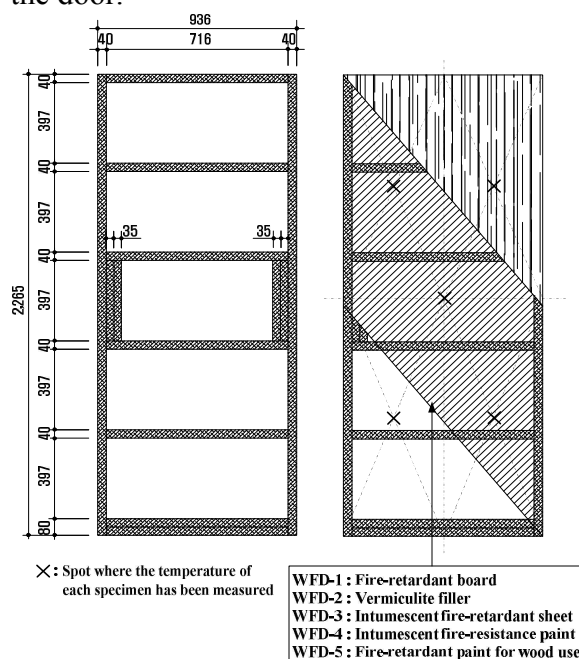


Table 1 : Specimen List

Specimen	Reinforcing insulation		Reinforcing Location
	Material	Thickness	
WFD-1	Fire-retardant Board	6 mm	On both inner sides of finish of the door
WFD-2	Vermiculite Filler	-	Between inner frames of the door
WFD-3	Intumescent fire-retardant Sheet	2 mm	On the inner side of one-side finish of the door
WFD-4	Intumescent fire-resistance Paint	2 mm	On Inner frames of the door and both inner sides of finish of the door
WFD-5	Fire-retardant paint for Wood use	3 mm	On both inner sides of finish of the door

Figure 1 : Composition of WFD(Wood Fire Door) Specimen

2.2 Fire-Resistance Test and Measurement

In this fire-resistance test, the following Standard time/ temperature curve has been applied according to KS F 2257-1(Fire-resistance test for building structural members) and ISO 834-1(Fire-resistance tests-Elements of building construction). The integrity and insulation on unexposed side of the Specimen have been measured. [1] [2] [3] (see Fig. 2)

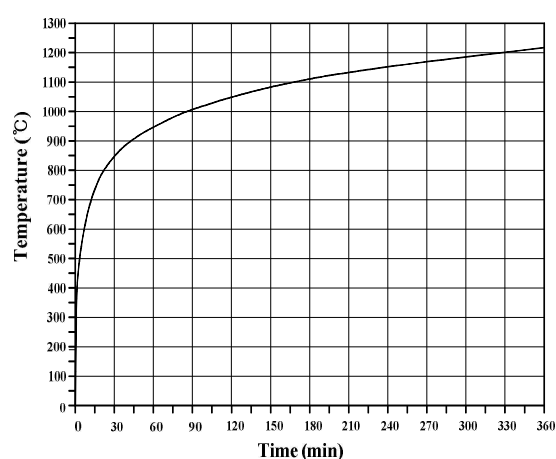


Figure 2 : Standard time/temperature curve

We installed the wood fire door at the 3m specimen frame in width and length, and then made the wall by laying concrete blocks around the door, in order to carry out the fire-resistance test.

For the measurement of Specimen's Integrity, we checked whether the flame which lasts longer than 10 seconds continuously occurs on the unexposed surface. For the measurement of Insulation, we attached K-type thermocouples of copperplates in 12mm diameter at 5 spots on unexposed side of the specimen to measure the temperature.

As you see in the Figure 1, the temperature of unexposed side of specimen is measured at the following spots; the middle of specimen and middle parts of 4 division surface of the door. In case of WFD-5 specimen, the temperature is measured at 3 spots on the top, middle and bottom vertically. The installed specimen and fire-resistance test views are shown in the Figure 3 and Figure 4.



Figure 3: Installed specimen view



Figure 4: Flame occurrence on specimen

3. TEST RESULTS AND ANALYSIS

As a result of fire-resistance test for the wood fire doors, the integrity of each case is distributed between 15 minutes and 35 minutes. The temperature distribution on unexposed side seems not so significant in same specimen. The temperature on unexposed side of each cases measured as soon as the test has been completed ranges from 106°C to 199°C.

3.1 Integrity

Integrity of the Specimen is the performance whether continuous flame occurs on the unexposed side for more than 10 minutes. [4] The test results are shown in the Figure 5.

The WFD-1 specimen with 6mm fire-retardant board has 17minutes Integrity. The integrity of WFD-2 specimen including non-organic vermiculite filler was 35 minutes, which was superior to the others.

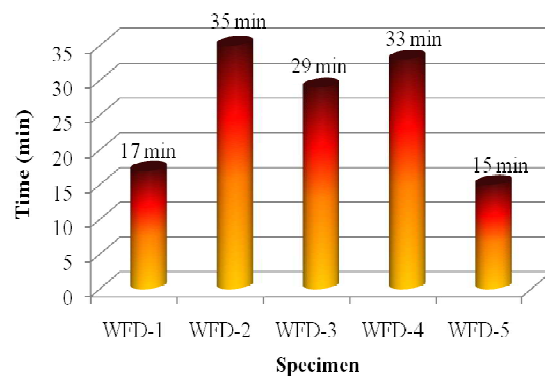


Figure 5 : Result of WFD Specimen Integrity

In case of WFD-3 specimen containing intumescent fire-retardant sheet and WFD-4 specimen containing fire-resistance paint, it shows that the integrity about 30 minutes has been secured because some intumescent layer is formed between the frames of the specimen. However, WFD-5 Specimen containing fire-retardant paint for wood use shows the integrity of 15 minutes, which is the weakest capacity among all the specimens.

As a result of Integrity measurement to consider the fire-resistance capacity for each specimen, non-organic fire-resistance materials or intumescent reinforcing materials show about 30 minutes integrity.

On the other hands, it means that fire-retardant board and non foamal fire-retardant paint are unsatisfactory to secure appropriate level of fire-resistance performance by themselves, so an additional reinforcing plan needs to be studied.

3.2 Insulation

In case of WFD-1 Specimen, the highest temperature on the unexposed side of door at 17 minutes when the time of integrity failed was 199°C.

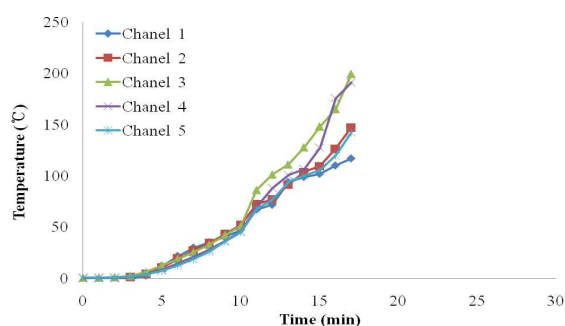


Figure 6 : Result of WFD-1 Time-temperature Measurement

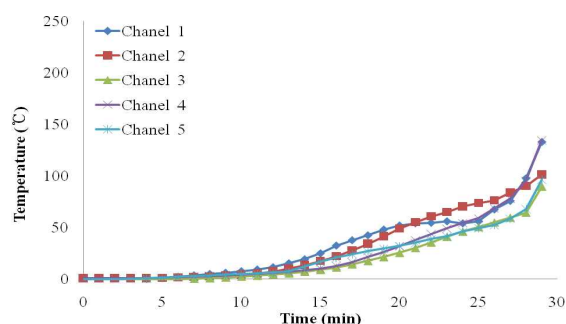


Figure 7 : Result of WFD-3 Time-temperature Measurement

The WFD-2 Specimen was excluded from the test results as data error came out as soon as the test had been started.

The highest temperature on WFD-3 Specimen was 133°C on the top of Specimen at 29 minutes.

The WFD-4 Specimen containing intumescent fire-resistance paint showed relatively consistent temperature on ever place and the highest temperature was 106°C at 33 minutes.

All specimens except WFD-1 and WFD-5 do not exceed the maximum temperature 180°C(pure increasing temperature except initial temperature) prescribed by the KS F 2268-1(Fire resistance test for door assemblies). [1]

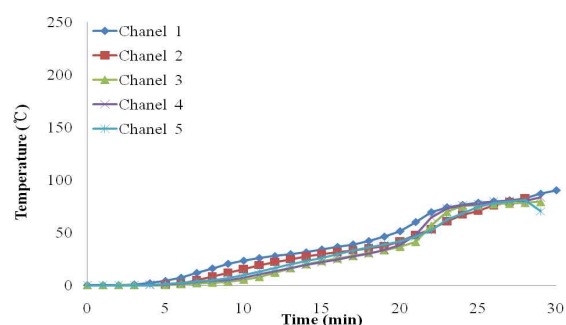


Figure 8 : Result of WFD-4 Time-temperature Measurement

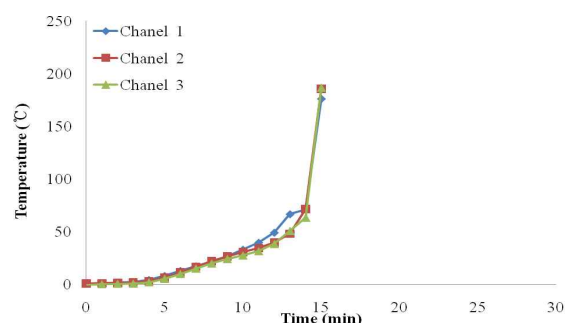


Figure 9 : Result of WFD-5 Time-temperature Measurement

In case of WFD-5 Specimen containing fire-retardant paint for wood use, a significantly increasing temperature of over 180°C has been observed at nearly 15minutes. At that time the flame went through both sides of the specimen.

As a result of the test, the temperature rising behavior of each measuring point increases relatively consistently. Therefore, in this study, we simply have compared the time-temperature measurement result at the middle point of specimen with the result of

steel fire door from the preceded study.[5]
The results are described in Figure 10.

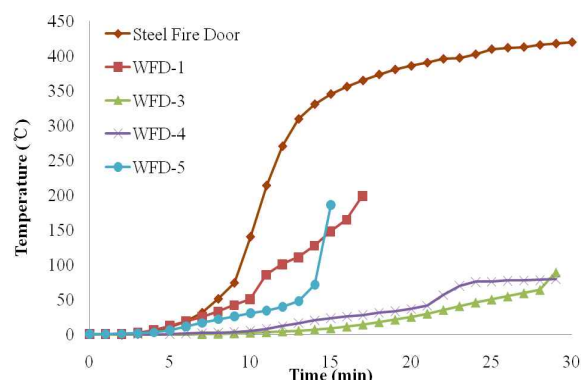


Figure 10 : Result of Time-temperature Measurement at Middle Point of Specimen

On the steel fire door, which was made of steel plate as finish and honey comb as inner stiffener, temperature of 214°C was measured only after 11 minutes since the test had been started. We observed that the temperate continuously increased after that. [5]

From the above comparative test result, it can be possible to say that the fire-protection performance of a fire door is closely related to the thermal conductivity of the main finish material itself, the fire rating of wood fire door is relatively advantageous than that of the steel fire doors.

On the specimen with fire-retardant board (WFD-1), the temperature relatively significantly increases in proportion to the testing time, compared to other wood door specimens. The temperature on the specimens containing intumescent fire-retardant sheet (WFD-3) and fire-resistance paint (WFD-4) slowly increases that we consider the intumescent reinforcing material keeps the insulation capacity in a certain period by maintaining some foamy layer.

In case of the WFD-3 Specimen, the sheet has not come off, but the temperature increase and some flame occur at 29minutes. From that we may guess the radiant heat is transferred to the unexposed finish.

In case of the WFD-4, the foamy layer may becomes damaged because of flame

and high pressure around 22 minutes and relatively increasing temperature has been observed in some areas. Accordingly, if the foamy layer can be maintained, we consider that the intumescent fire-resistance paint can sufficiently secure fire-resistance capacity of over 30 minutes.

Lastly, in case of the WFD-5 specimen, reinforced by fire-retardant paint for wood use, the frame of wood fire door, which was not reinforced by fire-retardant paint, does not form uniform carbon layer although the reinforced both inner surface of the door could keep the uniform wood carbon layer.

4. CONCLUSION

The results of fire-resistance tests on the wood fire doors reinforced by fire-retardant board, vermiculite filler, intumescent fire-retardant sheet, intumescent fire-resistance paint, and fire-retardant paint for wood use instead of general mineral insulation material are as follows;

First of all, the Integrity, which is the performance standard of fire door on the subject of Korean building laws and codes, has been observed between 15 and 35 minutes depending of each reinforced material. Especially, vermiculite filler, intumescent fire-retardant sheet, and intumescent fire-resistance paint as a reinforcing material can be a effective alternative to maintain the performance of wood fire door for 30 minutes.

Secondly, as a result of insulation measurement on unexposed side of the wood fire door, the temperature on the specimen with fire-retardant paint for wood use was the highest, which was 187°C at 15 minutes. In case of intumescent fire-retardant sheet and intumescent fire-resistance paint, the highest temperature on unexposed side was each 133°C and 106°C at 29minutes and 33minutes, which meets the maximum insulation temperature 180°C.

Therefore, they can be applicable to the wood fire door with 30 minute capacity.

Thirdly, we have confirmed that it is possible to develop externally attractive and lightweight wood fire doors with insulation 30 minutes capacity by using environment-friendly material, wood. And consider that we can develop even an wood fire door which have 60 minutes fire-resistance capacity in terms of integrity and insulation.

REFERENCES

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