PREDICTION OF FLAME SPREAD ALONG A WOODEN SURFACE OF WALL AGAINST LOCALIZED FIRE

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ABSTRACT: In this paper, experiments were carried out by using a burner in order to predict flame spread along the wooden surface of wall in the case of localized fire scenario and the result was compared with the values obtained by using numerical model. On the basis of agreement between the theoretical and experimental results, the calculation for flame spread of localized fire of 3MW for 1200 seconds was carried out.

KEYWORDS: flame spread, wood, fire resistance verification method, localized fire

1 INTRODUCTION

Fire resistance verification method in case of localized fire scenario is reasonable way to adopt timber construction for roofs of gymnasiums as shown in Fig.1, if the performance for fire resistive buildings or quasi-fire resistive buildings is required. But in order to use this method, the prediction of flame spread for the wall is necessary if wood is chosen as material of the front surface of the wall. And in order to be easier for practical engineers to handle this method, the way to calculate has to be simplified such as using spread sheets which are very popular and convenient for most of them. Therefore in this paper, the solutions relative to flame spread obtained by using spread sheets on basis of theoretical model was compared to the result of experiments made with a burner, prior to predicting of flame spread along a wooden surface of wall against localized fire of 3MW with 1.5 m × 1.5 m (dimensionless energy release rate=0.98) for 1200 seconds.

2 EXPERIMENTAL METHOD

The test was carried out under the condition of free burning along a vertical panel. Fig.2 shows the shape of specimen for the test. The size of the test panel was 2.0 m width and 3.08 m height from the top of it to the surface of the floor, which were covered with silicic acid calcium board with 25 mm depth, of the equipment. The front surface of the test wall was covered with boards made of cryptomeria which has a thickness of 18 mm on silicic acid calcium board with 25 mm thickness.

Figure 1: Timber structure by using fire resistance verification method in case of localized fire scenario (gymnasium for elementary school in Noshiro, Akita, Japan)

The width of the burner set up to the floor of the equipment was 0.5 m and 0.5 m and one side of the burner was attached along the panel. The energy release rate of the burner was 192.5 kW (dimensionless energy release rate= 0.98). Then test was carried out for 1200 seconds.

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3 CALCULATIONS

The mathematical formulation to predict flame spread is the conduction equation and the initial condition and the boundary condition lead to the following equation (1).

\[ T_s - T_0 = \frac{I}{h} \left[ 1 - \exp \left( \frac{h}{k} \right) \right] \text{erfc} \left( \frac{h}{k} \sqrt{\alpha t} \right) \] (1)

where
- \( T_s \): temperature of the surface (°C)
- \( T_0 \): ambient temperature (°C)
- \( I \): heat flux (W/m²)
- \( h \): convection heat transfer coefficient (W/m²·K)
- \( k \): thermal conductivity (W/m·K)
- \( \alpha \): thermal diffusivity (m²/s)
- \( t \): time (s).

Horizontal propagation was calculated for 1200 seconds. The relationship between the distance from the center of the board and ignition time of the surface of board is shown in Fig.3.

4 COMPARISON BETWEEN CALCULATED VALUE AND EXPERIMENTAL RESULT

The length of the surface to have been ignited was measured after the experiment. It was about 90 cm each from the center of the board, that is in agreement with the value of the theoretical result in general.

5 DEVELOPMENT

The flame spread along the board made of cryptomeria against localized fire of 3MW with 1.5 m × 1.5 m for 1200 seconds can be predicted by using the numerical model shown in Fig.4.

6 DISCUSSION

In this paper, the upward wall flame spread which is considered more complicated to predict was ignored because the height of solid flame is higher than 3m which is the height of the wall covered with wooden board in case of gyms like the one shown by Fig.1 against localized fire of 3MW. To utilize noncombustible materials or fire retardant materials at the part of a surface of wall higher than 3 m leads to simplify to employ fire resistance verification method in case of localized fire scenario.

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