Fire Resistance Design Method for Structure Built above Railway Track

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From the standpoint of construction work efficiency, most station buildings and other structures utilizing space above railway tracks (Fig. 1) are of steel frame construction. Therefore, due consideration must be given to their fire resistance and safety in a fire. However, if the steel frame is provided with a fire resistive covering as are ordinary buildings, there is a fear that the covering may exfoliate under the vibrations of running trains. Besides, the fire resistive covering may increase the cross-section shapes of the columns, preventing the smooth flow of passengers in narrow places. On the other hand, compared with the other floors, the floor at the same level of the railway track (track floor) is characterized by these facts: ① Flammable objects are limited to the kiosks and cars and it is unlikely that large volumes of unspecified flammables will be brought in, ② The floor height is determined almost entirely by the train cross section and ③ The floor generally offers wide open space with few outer walls. Therefore, establishing a rational fire resistance design method for the track floors that have those characteristics is meaningful from the standpoint of building safety and economy.

The fire resistance design of a building consists of verifying the structural safety of the building against possible fires. In fire resistance design, the fire resistance and safety of the building are evaluated by using the flow shown in Fig. 2. With the aim of establishing a fire resistance design for track floors, we first investigated the flammables on the station yard. As a result, it was found that the kiosks on the platform can be a major origin of fire. Then, in order to grasp the characteristics of a kiosk fire, we carried out a combustion experiment with a full-scale model of a kiosk (Fig. 3). In the experiment, the combustion weight, flame temperature, flame shape, radiant heat quantity, etc. were measured. On the basis of the experimental results, we proposed a fire model that permits calculating the gravitational combustion speed and flame shape.

Fig. 4 shows the measured gravitational combustion speed and the value calculated by using the fire model. The two values agreed fairly well. As shown in Fig. 5, the track floor space is divided into three zones—fire zone, near-ceiling zone and other zone—and the temperature rise of each of the steel frame members of the track floor in a kiosk fire is calculated by using a heat balance equation prepared from the heat balance between each of the zones and structural members (Fig. 6). Finally, the stress and strain produced in the frame by the temperature rise of the members are analytically obtained to demonstrate that the building will not collapse and evaluate the fire resistance and safety of the building.

This fire resistance design method verified that even a track floor without fire resistive covering has sufficient fire resistance and safety. So far, it has been applied to the design of more than 10 buildings utilizing space above the railway track. In the future, we intend to carry out studies on the flow of smoke, the evacuation/safety of passengers, etc. in a fire.

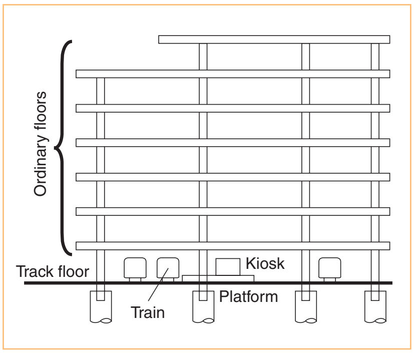

Figure 1. Building utilizing space above railway track

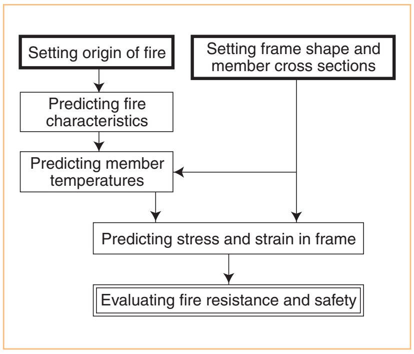

Figure 2. Fire resistance design flow

Figure 3. Combustion experiment using full-scale model of kiosk

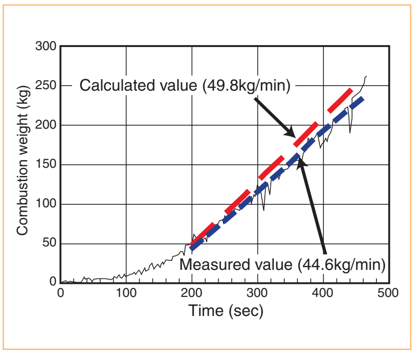

Figure 4. Relationship between combustion weight and time

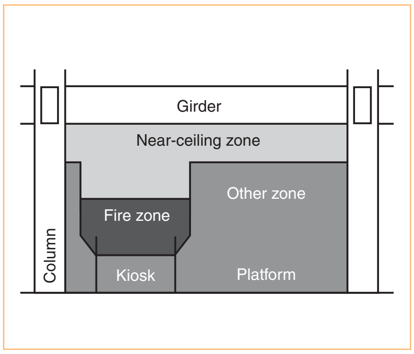

Figure 5. Division of track floor into zones

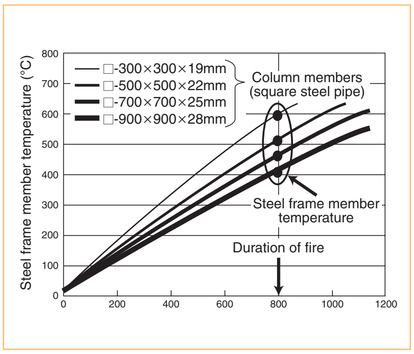

Figure 6. Examples of calculation of steel frame member temperature