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Sultan, M. A.

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Sultan, M.A.

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Furnace tests

By Mohamed A. Sultan

In recent years, fire-rated floor and wall assemblies formed with new materials and construction methods have been used increasingly in residential buildings. To determine the fire resistance performance of these assemblies, full-scale tests are usually required. However, these tests are expensive and time consuming, and there is a need on the part of design engineers and architects, at least in the development of assemblies, to find an alternative solution. To satisfy this need, the National Research Council of Canada (NRC)has been developing a simpler and less expensive test method for these purposes.

As part of these efforts, NRC has just completed the construction of an intermediate-scale furnacethat can be used for testing loaded and unloaded wall and floor assemblies. However, to ensure that this furnace reflects full-scale test results, it must be characterized. Heat exposure in the furnaces is one of the critical parameters in determining the fire resistance performance of specimens. This article presents results of the heat exposure characterization tests carried out by NRC in both its full- and intermediate-scale fire resistance floor test furnaces. Details about the furnaces and specimens are shown in Table 1.

Table 1. Details on furnaces and specimen sizes.

	Size	Wall construction	Specimen size
Full-size furnace, m	4 by 5 by 3	Insulated fire brick	4 by 5 by 0.15
Int.-size furnace, m	1.2 by 1.8 by o.5	Insulated fire brick	0.8 by 1.2 by 0.15

The Furnaces

The full-scale and intermediate-size furnaces areshown in Figures 1 and 2 respectively. . The tests in each were carried out by exposing the specimens to heat using the propane-fired horizontal furnace. The average furnace temperature in each case followed as closely as possible the CAN/ULC-S101-M89 standard time-temperature curve that is similar to the ASTM E119 curve.

Figure 1 NRC Full-scale Floor Furnace

Figure 2 NRCIntermediate-scale floor furnace

Test Specimens

The full-scale floor test specimen was a castable refractory slab, 4 m wide by 5 m long by 0.15 m thick. The intermediate-scale specimen was also a castable refractory slab, 0.8 m wide by 1.2 m long by 0.15 m thick. The total heat exposure (radiative and convective) to the test specimen was measured by two Gardon Gauge heat flux sensors (see Figure 3), 2.5 cm diameter and 2.5 cm long copper cylinder, with an accuracy of 63%. The sensors were installed flush to the surface of each specimen and are located each at the centre of the half specimen.

Figure 3 Water Cooled Gardon Gauge Heat Flux Sensor

The Tests

To study the effect of furnace size on the heat exposure in the two test furnaces, six tests were conducted: three repeat tests using the full-scale furnace and three repeat tests using the intermediate-scale furnace. The duration of each test was two hours and measurements were recorded every minute.

Results

A comparison of the average heat exposure of the three repeat tests using the two furnaces is plotted in Figure 4. The results showed that the heat exposure in the intermediate-scale furnace is approximately 15% higher than in the full-scale furnace. These results suggest that the effect of furnace size on heat exposure is significant.

Generally, the heat received by a test specimen in fire resistance test furnaces is by radiation and convection. The radiative part is much greater than the convective part. In full-scale furnaces, the convective heat occurs by natural convection while, in the smaller size furnaces, it occurs by forced convection. Heat transfer by forced convection is greater than by natural convection. As the furnace size increases, the convective heat to the specimen decreases, which may explain why the heat exposure in an intermediate-scale furnace is higher than in a full-scale furnace.

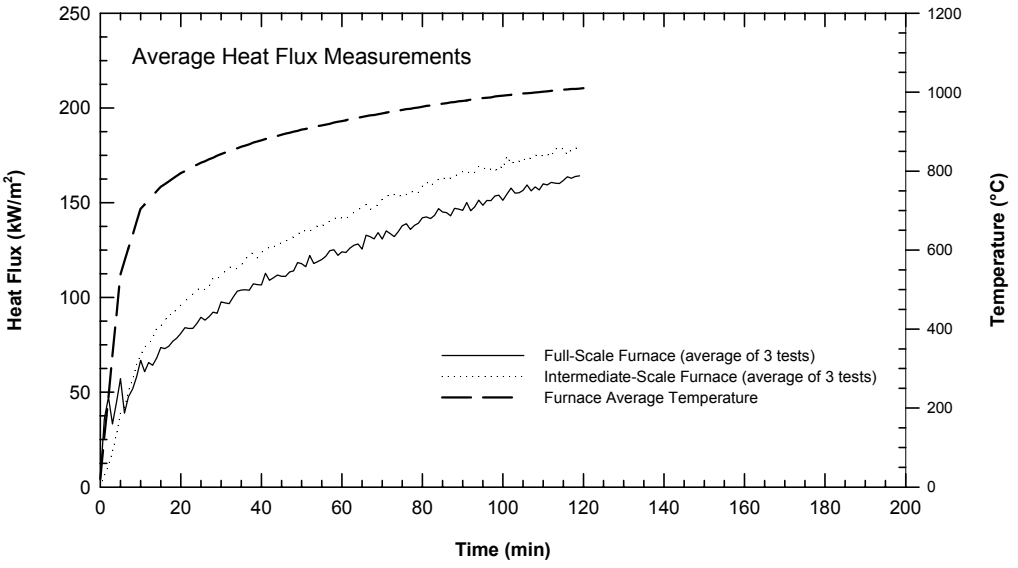

Figure 4 Comparison of Heat Exposure in Full-scale vs Intermediate-scale

Conclusions

The heat exposure to test specimens in an intermediate-scale (1.2 m wide by 1.8 m long by 0.5 m deep) fire resistance furnace is 15% higher than in a full-scale (4m wide by 5 m long by 3 m deep) furnace.

For more information, contact Dr. Mohamed Sultan, who is a senior researcher in the Fire Risk Management Program of the National Research Council's Institute for Research in Construction. He can be reached at mohamed.sultan@nrc.cnrc.gc.ca