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The Critical Velocity and Heat of Smoke Outflow in Z-shaped Passage Fires Under Weak Stack Effect

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Abstract : The Z-shaped passage, widely used in metro entrance/exit passageways, inclined mining laneways, and other applications, features steep slopes and a combination of horizontal and inclined sections. These characteristics lead to notable differences in airflow patterns and temperature distributions compared to conventional confined passages. In fires occurring within Z-shaped passages under natural ventilation with a weak stack effect, the induced airflow may be insufficient to fully confined smoke downstream of the fire source. This can cause smoke back-layering upstream, with the possibility of smoke escaping from the lower entrance located upstream of the fire. Consequently, not all the heat from the fire source contributes to the stack effect. This study combines theoretical analysis and fire simulations to examine the influence of various heat release rates (HRR), passage structures, and fire source locations on the induced airflow velocity driven by the stack effect. An empirical equation is proposed to quantify the strength of the stack effect under different conditions. Additionally, predictive models have been developed to determine the critical induced airflow and to estimate the heat of smoke escaping from the lower entrance of the passage.

Keywords : stack effect, critical velocity, heat outflow, numerical simulation
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