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Elevator shaft pressurization for smoke control in tall buildings: The Seattle approach

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ABSTRACT

CONTAM simulations of both commercial and residential tall building models are conducted in order to study recently adopted Seattle code requirements for elevator shaft pressurization systems. In contrast to the International Building Code (IBC) requirements, the Seattle approach specifies across elevator door pressure minimums and maximums on only four "fire floors" (including one above, and two below, the fire floor). This is accomplished using a minimal pressurization of the entire elevator shaft in conjunction with venting of the four fire floors. The present study adresses the feasibility of calibrating such a system to meet the design objectives in tall buildings (system performance during an actual fire event is not considered). The two building models correspond to 37 story buildings with dual elevator and dual stairwell shafts extending the entire height of the building. Each model is calibrated to experimental data. Simulations are conducted for a variety of ambient temperatures and exterior building door positions. Coupled pressurization of the stairwells is also considered. The system requirements are found to be achievable for both elevator only and coupled elevator and stairwell pressurization systems. However, the observed pressure differences do change with changes in the ambient temperature as well as changes in the ground floor exterior door position. It is therefore recommended that such systems should be calibrated for pressure differences intermediate to the prescribed minimum and maximum values to compensate for changes to the system performance. Providing a relief vent to ambient on any recall floor may also be advisable.

1. Introduction

Stairwells and elevator shafts can be dangerous conduits of smoke migration throughout buildings during fire situations. Smoke penetrating the shaft can spread through both the buoyancy of hot gases as well as by the stack effect which occurs when there is a temperature difference between the air in the shaft and the air in the outside environment [1]. One method for controlling smoke flow is by using shaft pressurization. The intent of pressurization systems is to use outside air to pressurize a shaft such that only positive across door pressures are achieved on all floors. This requires the specification of a suitable minimum pressure needed to prevent smoke from entering the shaft, as well as the specification of a suitable maximum pressure difference in order to ensure proper door functioning. For example, the pertinent sections of the International Building Code (IBC) 2009 relevant to stairwell pressurization systems states in part (Section 909.20.5): "the vestibule is not required, provided that interior exit stairways are pressurized to a minimum of +25 Pa and a maximum of +87 Pa in the shaft relative to the building measured with all stairway doors closed under maximum anticipated stack effect pressures." Stairwell pressurization has been approved and adopted for a relatively long time. In contrast, the use of elevator shaft pressurization has only recently received approval by the IBC and relatively little research has been done in this area. The pertinent section of the code relevant to elevator shaft pressurization (Section 708.14.2) states in part: "Elevator hoistways shall be pressurized to maintain a minimum positive pressure of +25 Pa and a maximum positive pressure of +62.5 Pa with respect to adjacent occupied space on all floors. This pressure shall be measured with all elevator cars at the floor of recall and all hoistway doors on the floor of recall open and all other doors closed."

The author has sought to fill this gap in the literature and has been studying elevator pressurization using numerical simulations [2–5]. The results of these studies have shown that elevator pressurization is much more complex than stairwell pressurization. Stairwells are characterized by relatively well sealed doorways which are in the closed position during pressurization operation. As

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