Functional testing of ventilation systems in schools during activated fire alarm

Coherence with the fire safety strategy

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Keywords:
Fire safety, ventilation system, schools, functional testing, smoke extraction.

Abstract

The purpose of this paper is to present results from functional testing of ventilation systems in schools during activated fire alarm. It was investigated whether the results had coherence with the ventilation strategy in the fire safety concept and the function description for the ventilation system.
Functional testing was performed at several schools in three different municipalities in Norway. Results from the preliminary mapping showed that some of the personnel responsible for maintenance of the ventilation systems lacked knowledge about the system's function during fire. Older schools often don't have a fire safety strategy at all, whereas newer schools and renovated schools normally have well documented fire safety strategies, including the ventilation system's function during fire. However, there is little or no information in the building's MOM-documentation (management, operation and maintenance) about how functional testing must be performed.

The functional testing showed several incoherencies with the fire safety strategy of the school buildings.

Introduction

This study is part of the research project BRAVENT–Efficient smoke ventilation of small fires, where it aims to use the existing balanced mechanical ventilation systems, such as ducts and non-fire rated dampers, including variable air volume dampers (VAV-dampers) to control smoke and pressure in the event of small-size fires in schools. Demand-controlled ventilation (DCV) can reduce building energy consumption while delivering good levels of occupant comfort [1]. DCV-systems automatically adjust the air flow rate according to a demand at room level measured by e.g., CO_2 and temperature sensors [2]. Separate ventilation networks are required for exhaust and supply air. Each ventilation network is equipped with a fan to control the total air flow rate. Depending on the configuration, a single fan may serve from several rooms to the entire building. Figure 1 shows the concept of the extraction strategy using the ventilation system. The principle is to increase the speed of the supply and exhaust air to full balanced mode in the event of a fire, so that smoke can be extracted out of the building while mitigating the fire-induced pressure. This concept, if it can be proven safe and effective, can be easily adopted to buildings equipped with balanced mechanical ventilation systems.

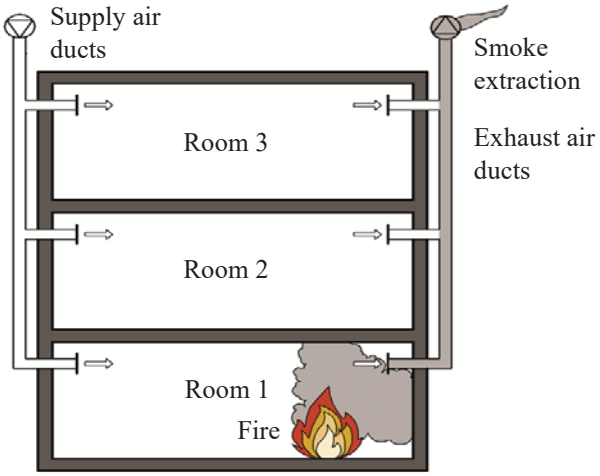

Figure 1. Schematic of the extraction strategy using the ventilation system (based on Byggforskserien [3]).

The Norwegian Building Code is performance-based and sets functional requirements for buildings [4]. Technical installations like the ventilation system, shall be designed and perform in such way that the system does not increase the risk of a fire starting and that fire and smoke are spreading. The companies responsible for building design and construction are responsible for providing documentary evidence of the fire safety. A fire safety strategy is created during the design phase of the building project and describes a main strategy for the ventilation installation.

Methods

To assess whether the extraction strategy can be applied to the existing ventilation systems in schools to handle smoke control for small-sized fires, the first step was to perform a mapping of the fire safety strategies for each school and get

an overview of how the ventilation systems in school buildings operate in the event of a fire. Functional tests were done to check if the ventilation system were operating in coherence with the fire safety strategy and the function description for the ventilation system. Functional testing procedures of the ventilation system were developed to investigate if the system functions according to the fire safety strategy. Functional tests were performed in schools in the municipalities of Oslo, Bergen and Trondheim, Norway.

The strategy for functional testing of the ventilation systems included an interview with the operation officer on site, who is responsible for technical maintenance and inspection routines at each school. The purpose of the interview was two-folded; to get overall information about the ventilation system before the functional testing was performed, and to map how familiar each operation officer was with the ventilation system and how well they knew the fire safety and ventilation strategy for the building.

The ventilation system was tested in day mode and night mode, including triggering the smoke detector in the supply air duct to verify if the air handling unit (AHU) stopped. Triggering was executed during normal operation as well as when the fire alarm was already on. The functionality of randomly chosen VAV-dampers and fire dampers was verified by visual inspection upon activated fire alarm.

Results and discussion

The year of construction varied for the schools included in this project and some were also renovated in the later years. Most of the schools included in the functional testing were designed with an extraction strategy, which implies that the normal operation mode of the ventilation system changes to smoke control mode when a fire is detected in the building. This extraction strategy usually includes a bypass fan for the extraction air to ensure safe operation, which prevents hot smoke from passing through filters and regenerators. However, the bypass fan was not present in many of the ventilation systems that were investigated. A few of the schools included in the mapping had a shutdown strategy, where the ventilation system stops, and fire dampers, installed in the ventilation ducts passing through compartmentations, close.

The preliminary mapping showed that some of the personnel responsible for maintenance of the ventilation systems lacked knowledge about the system's function during a fire. For example, they were not sure whether there were fire dampers installed or not, or whether the ventilation system would stop when activating the fire alarm or not. This shows that there may not be enough focus on the topic when it comes to operation and maintenance routines in schools.

Older schools often don't have a fire safety strategy at all, and there is no documented strategy for the ventilation system during fire either. Newer schools normally have well documented fire safety strategies, including the ventilation system's function during fire. However, there is little or no information in the buildings' MOM-documentation about how functional testing must be performed.

The functional testing showed several incoherencies with the fire safety strategy of the school buildings, including:

- VAV-dampers not going in open position
- Opening of supply air and exhaust fan does not start simultaneously, causing unbalance in the extraction strategy
- Delayed/slow start of the supply and exhaust fans, which will disturb the balance and the smoke control
- AHU does not restart during night-mode
- VAV-dampers located in the ducts are not affected by the fire alarm
- The extraction function shuts down the supply air and gears down the exhaust air to 20 %
- After test termination, the AHUs must be physically restarted in the technical room, they cannot be restarted through the central control and monitoring system
- Smoke detection in the supply air gives no signal to the central control and monitoring system or the fire alarm system

The reason for the incoherencies is unknown, but a possible explanation is that the systems are not sufficiently tested after installation.

Conclusion

The functional testing showed several incoherencies with the fire safety strategy of the school buildings. The results indicate that there is a need for better documentation on how the "as built" ventilation system is performed compared to the design solutions given in the fire safety strategy. Clear guidelines for functional testing should be established and implemented in the MOM-documentation.

Acknowledgements

This study is a part of the project "BRAVENT – Efficient smoke ventilation of small fires", and is funded by the Research Council of Norway, project number 321099.

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