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Guidance on Smoke Control to Common Escape Routes in Apartment Buildings

Scope

The Smoke Control Association (SCA) has recently published its 'Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)', which is available for download from www.feta.co.uk/smokecontrol.

The SCA's publication should be a welcome reference point for all concerned in the design and approval process of these systems as the prevention of smoke spreading through access areas such as means of escape corridors, lobbies and stair cores is of critical importance. This document brings together all the relevant details, and gives recommendations not previously covered in other standards, and will make an excellent contribution for everyone involved with smoke control in residential buildings.

Within the document there are sections on the various systems available and their functions while also covering information regarding legislation, associated standards, codes of practice and the importance of using certified products for the various smoke control applications.

Smoke control in common escape routes within apartments, flats and maisonettes is required to improve the conditions for means of escape and fire fighting. This is achieved by limiting obscuration, toxicity and thermal exposure in common escape routes and improving the conditions for fire and rescue services.

Purpose

For the design and approval process to be successful, the design team should make sure that the system objectives, any Computational Fluid Dynamics (CFD) analysis, the scenarios to be calculated or modelled, the modelling criteria and the pass and fail criteria are all agreed and documented prior to the commencement of design. Particular care should be taken regarding the different operating modes for:

- Means of escape
- Fire fighting operations.

It is the responsibility of the designer of the smoke control systems to ensure that any proposed systems complement the building fire strategy and provide the correct level of fire safety.

As there are no other suitable published guidance documents for either designers or approving authorities, the SCA document sets out the information and parameters that the designer should include into the design when using calculations and/or CFD models.

Included in the document there is a complete section relating to Terms and Definitions for all associated professionals to use, this being excellent information to be made available.

Objectives of the Document

Where the building design and the ventilation system is in direct conformity to Approved Document B (ADB) of the Building Regulations, there is no requirement to consider objectives or performance criteria, as the ventilation system is deemed to be suitable by virtue of its prescription in ADB. This section then does not apply.

In other cases it is necessary to consider the objectives and performance criteria for the system. Until recently there was no guidance on these issues other than a requirement to provide 'equivalence' to the prescriptive systems in ADB. Recent work by the Building Research Establishment (BRE) to support the 2006 edition of ADB, while not specifically intended to provide such guidance, has now given some insight into both the objectives and performance of systems prescribed in ADB.

Under ADB, 2006 edition, the common spaces requiring smoke ventilation are the stairs and the lobbies and/or corridors opening onto the stairs.

As with any alternative solution, there are a number of methods, which allow the investigation of its performance. These range from 'hand calculations' through to more sophisticated computer models such as zone models and CFD. Each method offers different benefits with associated limitations, ranging from fast calculations with limited spatial and temporal resolution to a great amount of spatial and temporal resolution with extended calculation time.

It is the responsibility of the assessing engineer to determine which method of investigation should be used. It is recommended, however, that the technique to be used be agreed with the relevant approving authorities prior to an assessment being performed.

Recent work by BRE, confirmed in ADB, has made it clear that it is not possible to keep common corridors and lobbies free of smoke (except possibly by pressurisation systems with protection extended to the entrance door to each dwelling). Furthermore it is clear that it is considered more important to protect the stairs than the corridors as stairs will be used by greater numbers of people if a fire occurs.

Any system should be designed to keep the stairs relatively free of smoke under the design conditions. The system should also be designed to promote tenable conditions for travel through the ventilated corridors/lobbies during the escape period. It should be noted that this might only be possible when apartment doors are closed.

Before setting any performance criteria it is necessary to set the design conditions under which these criteria should be met.

BRE used 'steady-state' conditions in their work, assuming a number of design fire outputs and fixed door openings. While this approach allowed easy comparison of multiple geometries, it may not provide a good representation of reality, where conditions are expected to be transient, with a fire developing and doors opening and closing as time progresses.

Nevertheless, since these steady-state conditions are readily available and simple to use, they can provide useful design conditions. The alternative is to use time dependent conditions with a set timeline of actions. This is more realistic but requires more complex analysis and time dependent performance criteria.

Performance criteria should be based on tenability. The main criteria of interest are therefore likely to be visibility, temperature, thermal radiation and toxicity within the ventilated corridors and lobbies. For stairs these criteria should be adjusted to reflect 'relatively smoke free' conditions, although protection of the stairs can also be indicated as a function of maintaining a suitable positive ventilation flow from the stair to the corridor or lobby.

Design conditions and performance criteria should be agreed with the approving authority as part of the approval process, preferably in advance of detailed calculation or modelling.

SYSTEM TYPES

Natural Ventilation

ADB, while allowing both natural and mechanical ventilation to common corridors/lobbies, makes the presumption that natural ventilation is the norm and mechanical ventilation is an alternative.

Natural ventilation has many benefits including simplicity, reliability, low noise and low energy use. However its performance can be sensitive to wind effects and, for natural shaft systems, there is a relatively large loss of floor space.

ADB provides recommendations for natural wall vents, natural vent shafts and vents at the head of the stair. The guidance in this section is intended to support that contained within ADB. Natural ventilation works by harnessing the natural forces of wind and thermal buoyancy to drive airflow through the ventilator.

For this application, the intended driving force is the buoyancy of hot smoke from the fire. Since the buoyancy forces can be small compared to wind forces, the performance can be significantly affected by wind.

For natural ventilation to operate effectively there needs to be both a source of inlet air and an exhaust opening. For a wall mounted vent, the vent generally provides both inlet at the bottom of the vent and exhaust at the top. Otherwise inlet air can be provided through the stair door when it is opened. To assist this, and to vent any smoke that enters the stair, a vent is needed at the head of the stair.

A key factor to consider, when designing smoke ventilation and smoke & heat exhaust ventilation (SHEV) solutions is the 'free' open area of windows and smoke shaft doors, when they are actuated to allow smoke to escape. Clearly, the further that doors, windows and ventilators can be opened, then the greater the area available to allow smoke to vent from the building.

Providing that the free area is achieved, the designer is therefore free to use any form of vent. Normal choices would be a louvred vent or bottom or side pivoting window or ventilator.

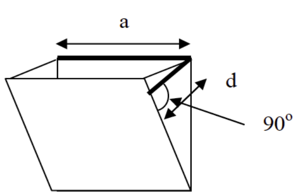
A result of this freedom is that vents could be selected and located so that they are highly susceptible to adverse wind effects, potentially blowing smoke back into the corridor/ lobby and into the stair. Designers should consider mitigation of wind effects when selecting and locating vents, despite the lack of a regulatory requirement.

Where a roof light is used as an automatic opening vent, in accordance with BS EN12101-2:2003 a minimum opening angle of 140° will help mitigate any adverse wind effects.

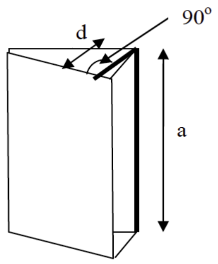
Where an outward opening bottom or side hung corridor/ lobby vent is used, the free area is calculated as shown in the diagram below, by multiplying the length of the vent opposite the pivot mechanism (a) by the distance the ventilator opens (d), measured at 90° to the opened flap or window.

A similar method is used for smoke shaft doors, which uses the door's height and the distance it opens in the calculation. While most smoke shaft doors do not open fully, SE Controls is the only manufacturer to provide doors that open to the maximum 90°, which provides a considerably greater free area to improve smoke ventilation through the shaft.

In accordance with ADB, the measured free area of the open ventilator should be measured in the plane where the area is at a minimum and at right angles to the direction of the airflow, as illustrated below.



Bottom hung



side hung

Pressure Differential Systems

It is generally recognised that pressure differential systems (usually pressurised as opposed to depressurised in this context) can provide a high level of protection to stairs and lobbies.

The aim of a pressure differential system is to establish a pressure gradient (and thus an airflow pattern) with the protected escape stair at the highest pressure and the pressure progressively decreasing through lobbies and corridors.

With the correct level of pressure differential it is possible to be certain that smoke from a typical apartment fire will not enter the stair under normal conditions.

Unfortunately, pressure differential systems tend to be the most expensive as well as the highest performance solution. A decision as to whether such a system is appropriate for a particular project should be taken in context with the overall design strategy for the means of escape, fire-fighting and property protection within the building.

General Principles

Air will naturally try to move from an area of higher pressure to an area of lower pressure. By increasing the pressure in the protected areas (i.e. the escape routes) above that in the areas where the fire is likely to occur (in this case apartments), it is possible to prevent smoke spread into these escape routes.

This is usually achieved by pressurising the parts of the escape route to be protected. Although it is possible to achieve the same effect by depressurising the apartments, this is not usually a practical option.

In a building, the movement of smoke and air is restricted by the building fabric. If the building fabric is leak free, a pressure differential could be maintained, once developed, with no further action. However, since buildings leak, air needs to be continually blown in to maintain the pressure differential.

The amount of air that is required will be dictated by how much leakage is present. This is usually a function of the number of doors, which will permit leakage around the perimeter, the area and type of wall construction and any other openings that could let air escape from the protected space.

A difficulty is that when doors to the protected space are opened as people escape and the fire service attend, the leakage area increases substantially, making it difficult to maintain a significant positive pressure. It is therefore necessary to design a system that is robust enough to provide significant protection even under conditions where some doors are open while also being capable of limiting the pressure differentials achieved with all doors closed.

Too much pressure when all doors are closed will make doors opening into the pressurised space difficult to open and will impede escape into the protected area.

BS EN 12101-6 provides guidance on the performance to be achieved by a pressure differential system under both "doors closed" and "doors open" conditions and provides guidance on which doors should be considered open for the purposes of calculation and system design.

Under the 2005 edition of EN 12101-6, for a residential building, a system intended to protect means of escape is Class A and a system designed to assist fire-fighters is Class B.

Mechanical (Powered) Smoke Ventilation

General Principles

Mechanical smoke ventilation may be used as an alternative to natural ventilation systems, as recommended in ADB. The SCA guide's recommendations in this section are based on the assumption that a shaft system will be used, but there is no reason why any floor level should not have its own dedicated powered system.

The benefits of mechanical systems include specified extraction rates, low wind sensitivity, known capability to overcome system resistances and reduced shaft cross sections.

Requirements of powered systems include the need for maintained power, temperature classified equipment, fire resisting wiring and standby fans. Internal pressures within the building need to be considered and limited so that doors remain operable.

It is necessary to provide air inlet to the communal area to prevent damage to the system, as well as to ensure that excessive pressurisation or depressurisation of the ventilated area does not occur. By avoiding excessive pressurisation or depressurisation it ensures that large amounts of smoke are not drawn from the apartment of fire origin and elevated pressure differentials are avoided which could render escape doors either inoperable or pull them open.

Designs should be based on a single floor level being affected by the fire and therefore only the smoke vents on the floor of fire origin and any other design critical vents (such as the head of the smoke shafts and staircase) are required to open. System designers should avoid opening ventilators on multiple floor levels, especially where connected by a smoke shaft, to avoid smoke spread to otherwise unaffected parts of the building and/or reducing the smoke removal rate from the floor of fire origin.

Smoke shafts should be constructed of non-combustible materials and all vents to the lobbies/corridors should have a fire/smoke resistance performance at least equivalent to that of an E30S fire door.

Activation of the system is subject to discussion with the approving authorities and other interested stakeholders, however the system is typically activated on detection of smoke in the common corridor/lobby. Upon activation of the system, the smoke vents on the fire floor, the vents at the top of the smoke shafts and the vent at the head of the stairway should open and any fans should run at the design speed.

Basic mechanical systems are commonly provided simply as an equivalent to the natural ventilation systems described in Approved Document B. It is possible to design systems providing a higher performance, which may then be used to allow extended travel distances in corridors, although care should be taken when considering removal of corridor sub-division doors. As well as limiting the potential travel distance through smoke, these doors may also limit the number of apartments requiring evacuation by fire fighters, which helps protect fire fighters. Removal of these doors may compromise fire fighter safety.

Installation and Equipment

All equipment should be chosen to meet the specific performance requirement of the system. Without proper installation of all its components, the system may not operate correctly nor meet the performance targets for which it has been designed. A detailed engineering plan should be prepared which should include size, location and identification of all equipment, together with power supply ratings, the sizing and routing of cables as well as a cause and effect summary.

When selecting and installing components, environmental conditions, user safety, ease of access and protection should be taken in to account.

All installed components should be capable of being safely maintained and cleaned. Access should be planned for routine maintenance tasks such as lubrication and cleaning. Doors or access panels should be provided as required. To aid the removal and repair of components, lifting eyes or beams should be installed where required.

Components should be installed so that smoke and heat does not discharge on to any adjacent or nearby structure. The exhaust discharges should not point at walls or windows and any combustible parts of the roof structure near the exhaust opening should be protected.

The document includes an equipment list for all relevant equipment associated with these smoke control systems, the equipment refers to: Products, Locations of kit, type, application and Associated Standards including Regulatory Guidance.

Acceptance Testing

Testing any form of ventilation system is a fundamental part of the process of setting to work and the proving of its performance against the design criteria.

As smoke control systems are primarily life safety systems and/or for assistance to the fire and rescue service, it is imperative that the smoke control system is tested by the installer and then witness tested by the approving authority to prove its compliance with both the project specification and the approved design criteria.

Documentation

Any smoke control system should be handed over to the end user with a complete set of documentation including:

- Design information detailing the performance criteria for the system and a description of the system
- A control philosophy or cause and effect diagram
- As installed drawings
- Relevant CE marking or type test certificates
- Installation and commissioning certificates
- Witness testing certificates or other evidence that the system was tested in front of the approving authority
- Maintenance and testing instructions
- Instructions for fire service use

This information should meet the requirement of regulation 16B of the Building Regulations (England and Wales), requiring the person carrying out the work to provide sufficient information for persons to operate and maintain the building in reasonable safety. It will also assist the eventual owner/occupier/employer to meet their duties under the Regulatory Reform (Fire Safety) Order.

Conclusion

The SCA's guidance document is a hugely valuable and freely available point of reference for everyone involved in the design, supply, installation and approval of smoke control systems for residential developments. Industry experts have collaborated to share their vast experience with the intention of setting recognisable minimum acceptable standards to ensure these life safety systems operate correctly when needed.

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