NO smoking

Ruud van Beek and Georges Dons outline the results of fire tests using longitudinal tunnel ventilation aimed at controlling smoke spread in underground car parks

TOTALLY ENCLOSED underground car parks are commonly found adjacent to places visited by many people, such as shopping centres, theatres and office buildings. Because of the high level of vistors, it is vital that smoke control systems are in place in underground car parks to ensure that, in the event of a fire, people inside can escape safely and the fire service can gain access to the structure.

However, existing smoke ventilation methods are currently failing to deal adequately with smoke spread in underground car park fires. During a fire in an underground car park the smoke cannot flow through openings in the roof to the outside. In addition, the height of each level is limited to 2.5 to 2.7m, which means there will be no smoke layer. After a few minutes, the car park will be filled with smoke over the whole height and area of the car park level, making it very difficult for people to escape and for fire service personnel to locate and extinguish the fire.

This prompted Novenco to develop a longitudinal tunnel ventilation system to deal with the problem. With longitudinal ventilation used in tunnels, ventilating air is supplied as well as extracted in the direction of the longitudinal axis of the tunnel. The longitudinal airflow created by external factors can be controlled simply and the permissible air speeds are not imposed by duct restrictions. The longitudinal airflow can, in principle, be created by means of jet fans installed in the tunnel tube just outside the clearance space.

The jet fans move a proportion of the tunnel air at high speed so that a driving force is created by the difference in speed of the tunnel air and that of the airflow from the ventilator. This driving force must overcome all types of resistance, such as the effects of wind on the tunnel openings, the input and output losses, the resistance of the tunnel tube, vehicle resistance and thermal effects in the case of fire.

Car park tests

Initial tests indicated that longitudinal ventilation functioned very well by using an exhaust shaft in combination with small jet fans positioned on the ceilings of the car park. The smoke could be controlled within limited areas between the fire location and the exhaust shaft. Because the smoke was only downstream of the fire, the fire service could easily approach the fire from the upstream side.

Consequently, 18 large full-scale fire tests using longitudinal ventilation were carried out in the Fleerde car park in Amsterdam. The tests were undertaken by TNO, the independent scientific body for fire research linked to the Dutch Government, in co-operation with Novenco and the Directorate General of Public Works and Water Management.

The tests were aimed at examining the effectiveness of thrust ventilation in combination with exhaust fans and inlet openings in car parks. The objectives of the research were to:

- assess the effectiveness of thrust ventilation as fitted to control the spread of smoke and heat in the event of fire in the car park
- investigate the design options for a ventilation system with jet fans using simple and advanced calculation models based on a fire model (the design fire)
- compare the effectiveness, in the event of fire, of ventilation systems using jet fans and lateral ventilation

Test results

During the tests, 25% of the car park was filled with parked cars. In 17 tests one car was set on fire (with the spread of fire to other cars being prevented), while in one test the spread of fire to two adjacently parked cars was examined. Measurements of the following variables were carried out at various locations in the car park: air temperature, rate of heat release (RHR), radiation, smoke density and air velocities and loss of weight of the burning car.

The research produced the following results:

- a 'design fire' – a schematic representation of a car fire in terms of RHR, fire burning time and smoke production for the design and monitoring of ventilation systems using computer and mathematical models
- a general description of the options for and the limitations of ventilation with jet fans in underground car parks
- an assessment of the applicability of simple design models
- an assessment of the options for using computational fluid dynamics (CFD) models to simulate the situation in the event of fire and a description of the required ventilation approach

A number of conclusions can be drawn from the tests. In particular, the ventilation system with jet fans broke up the thermal stratification and thereby reduced the risk of spread of fire. High temperatures can only be expected in the

Developing a ventilation system

THE LONGITUDINAL ventilation fire test at the Fleerde car park in Amsterdam enabled Novenco to design and develop a ventilation system to control smoke in case of a fire in an totally enclosed underground car park. The design, which included jet and exhaust fans, had to take into account the rules for how to ventilate car parks in case of fire which are set out in Comité Européen de Normalisation standards and through the recommendations of local authorities and fire brigades.

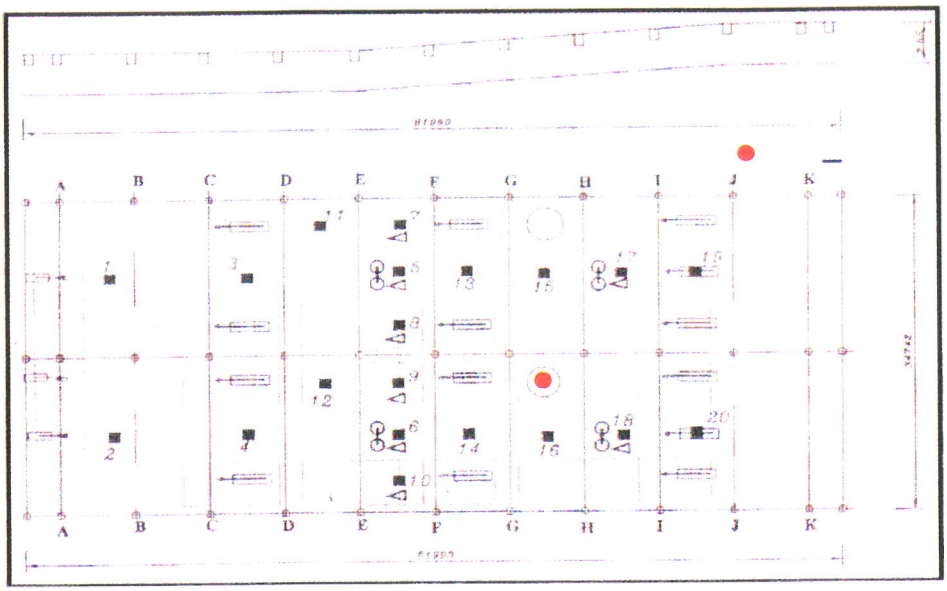

Figure 1: The layout of the car park

In a fire situation there are theoretically two possible options: shut off the jet (thrust) fans and start the exhaust fans. The supply fans must supply the air. Theoretically, a balance arises between the quantity of smoke produced and the exhaust volume and this will give a theoretical smoke layer. In a car park with an average height of 2.5m, a smoke layer will not be formed and the total height/cross-sectional area of the car park will be filled with smoke. This is the conventional lateral ventilation system.

By switching on the jet fans the smoke can be controlled. Assuming that enough smoke will be exhausted and enough air will be supplied, the smoke in a particular area can be controlled. This situation gives horizontal smoke control instead of vertical smoke control, which is the convention in high buildings. To use jet fans for this application, a precise analysis of the possible fire situations and escape modes is necessary.

Other factors that should be considered include:

- the escape route options
- how the smoke will develop and what its temperature will be
- how long it will take for the fire brigade to arrive
- how the fire brigade will approach a fire in the building
- the location of the smoke exhaust points
- the level of smoke spread permitted within a given time

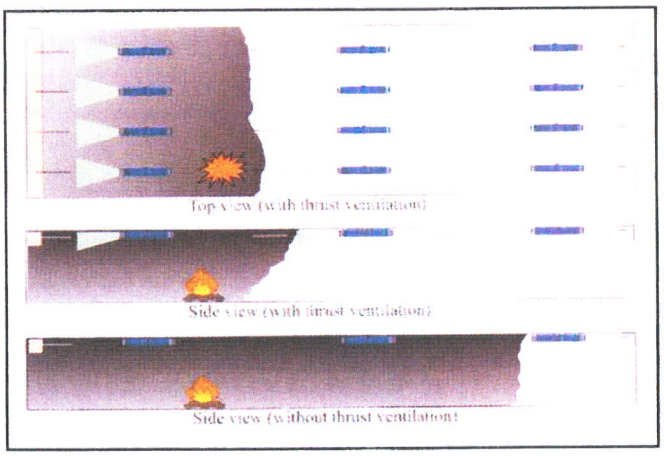

Figure 2: Fire safety with jet fans

vicinity of the fire. After the jet fans were switched on, an immediate mixing and spread of the smoke took place downwind of the fire. Visibility downwind was strongly reduced within a short period of time and would therefore make escape practically impossible.

It is advisable that the extractors operate immediately following detection. This means the stratification is not disrupted despite a portion of the smoke gases being extracted quickly. It is recommended that the thrust ventilation only be switched on once the people present have had the opportunity to escape. Once the jet fans have been switched on, the smoke will quickly spread to the downstream section.

The jet fans change the velocity distribution of the atmosphere within the car park and are of limited influence on the 'average' flow through the car park. The average flow is to a significant degree determined by the extraction fans in combination with the intakes.

The jet fans provide – through induction and mixing – a considerable reduction in the temperature below the ceilings of the car park. This temperature is a significant