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Hot smoke at Brussels Airport

This article describes the experimental tests carried out at Brussels Airport in April 1994 in which trays of industrial methylated spirits were burnt in order to assess the smoke venting systems within the shopping mall of the new airport terminal building. The article which first appeared in 'Fire Safety Engineering' describes the test fires, calculations, and the results.

On April 27 and 28, 1994, staff from the Fire Research Station, in collaboration with De Smedt Consulting BVBA, conducted a hot smoke test in the new, unfinished, terminal at Brussels Airport, in order to assess the smoke venting system.

The new terminal at Brussels Airport includes a large duty free shopping mall about 85m long 12m wide and 17m high. Part of the fire protection system in this mall consists of a smoke exhaust ventilation system intended to ensure safe escape of shoppers from the two mall levels by maintaining any smoke layer above the heads of people on the upper level.

The vents were fitted into the glazed barrel vault roof, and, with a smoke curtain in the barrel vault, formed two reservoirs (one inlet, one outlet) each having 80m² of vent area.

Unlike most of the other active systems in a building, a smoke exhaust ventilation system that

depends on natural buoyancy cannot easily be tested other than for simple mechanical operation of its parts. HVAC engineers can test their systems with an anemometer and sprinkler installers can test their systems with a pressure gauge. The smoke ventilation system, depending as it does on the buoyancy of hot smoke from a fire, cannot be similarly tested - except with a fire. In addition, the calculations used to design smoke venting systems are based on simple geometries and their application to more complex designs of building require both judgement and approximation. There is always the possibility that some unexpected or unusual feature in the

building will overcome the safety margins. In addition, in all systems there is the possibility that a misunderstanding or error during design and/or construction could result in an installation that does not correspond to the design intention; or the smoke control system might interact with other systems in an unexpected way.

Feasible procedures

While the ventilation engineer will commission the completed system by tests and measurements, such a procedure has not usually been thought feasible for smoke ventilation schemes.

However, the Brussels Airport Terminal Company, BATC, wished to prove their system and the Fire Research Station collaborated with De Smedt Consulting of Belgium to organise and carry out a test programme.

The use of hot smoke tests for large buildings has been pioneered in Australia^{1,2}. An ad-hoc atrium test involving real fires was carried out in Preston in 1991³.

The Fire Research Station (FRS) developed a method of test based on its experience of large fire experiments. When tailored to the present case each test consisted of a 2 MW industrial methylated spirits fire (IMS) (1 MW in each of two trays) that was burnt in a fire compartment specially built into a shop space to protect the structure close to the fire. The fire size was calculated to avoid heat damage to higher parts of the building structure and IMS was used since its combustion products contain no visible particles, are non-corrosive and largely non-toxic. The fire gases were made visible

by the use of non-toxic and non-corrosive artificial white smoke that was introduced to the plume above the fire compartment. This smoke needed only to be sufficiently dense to make the smoke layer visible; it was not intended that it be as thick as real smoke from a 2 MW fire. Indeed, it was a requirement to be able to see through the smoke to judge details of its movement. Also, it was an advantage for the smoke to be thin in case the smoke control system did not work as expected since observers might then be engulfed in smoke.

Modifications

The building, being not yet completely fitted out, was modified for the fire test by blanking off some openings in which doors or smoke screens had not yet been fitted. The decorative stone floor had already been laid and so had to be protected against heat. The smoke detection system was not active. In consequence, during the tests the vents were operated manually once the fire was established. The sprinkler system was in place but not charged. The test was planned around the need to ensure the safety of occupants and to avoid damage to the building.

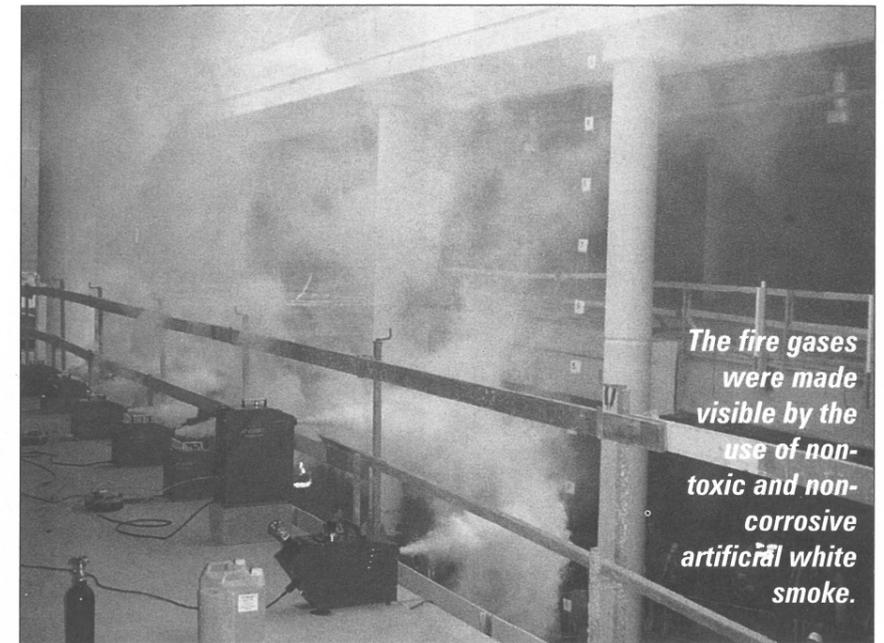
Instrumentation was deliberately kept to the minimum needed for the test. Thermocouples were used to measure the temperature of the hot gases emerging from the fire compartment and a thermocouple column was hung from the roof to measure the smoke layer temperature and also later to determine the smoke layer depth. Height markers were also hung from the roof so that observers could visually assess the smoke layer depth. There was extensive video and stills camera coverage of the tests.

Calculations

Calculations were carried out prior to the fire tests to select the optimum fire size, and after the test to extrapolate from the test results so as to predict the performance of the system with a 5 MW design fire in a shop. Calculations were based on published methodologies⁴.

Three criteria were used to assess the success of the smoke ventilation system:

- The component parts of the smoke ventilation system operate according to design.
- The extrapolated calculations show that the system would be satisfactory for full design fire sizes.
- No smoke should affect areas not allowed for in the smoke ventilation design.



Since these tests assessed only one zone of the building it was still necessary to generalise from the results for the whole building.

Successful

Both tests proved successful in that the necessary results were obtained to enable the assessment to be carried out. The building was undamaged and remained completely safe throughout. (A large number of visitors, including the Minister of the Interior, observed the second fire test).

In the latter part of both tests, at the request of BATC, the smoke vents were closed so that visitors could see the smoke layer deepen (the vents were reopened well before there was any risk to people in the building).

As in all large scale fire tests there were technical difficulties; for example in the second test all power was lost to the entire building just before the fuel was ignited. The vents demonstrated that they would fail open, as intended. Power was restored after some minutes and the test resumed.

Weather

The weather during the test was fair with a light breeze.

The smoke venting system was clearly effective with the 2 MW fire in keeping the smoke layer well above heads of people both on the lower and upper floors. Calculations showed that even with the 5 MW design fire, the smoke venting system in the airport terminal building would work successfully.

The tests did, however, identify a number of design features which allowed smoke to travel elsewhere in

the building and which would need some remedial action. Smoke collected in some limited-area stagnant zones which could cause problems for escape were people to linger and where it would be particularly important to ensure rapid evacuation.

Overall, this hot smoke test successfully demonstrated the effectiveness of the smoke venting system in Brussels Airport and also the feasibility of a hot smoke test of this type.

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The hot smoke test in progress at the new airport terminal building at Brussels Airport.