A BRIEF NOTE ON THE HISTORY OF "ACCEPTABLE CLEAR HEIGHTS" FOR SMOKE AND HEAT EXHAUST VENTILATION SYSTEMS IN THE UK

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The fundamental theoretical basis of Smoke and Heat Exhaust Ventilation was developed [1] in the early 1960s, although the qualitative principles of smoke ventilation have been known for Millennia. (If your hut/tent/yurt had a fire inside it needed a hole in the roof and an open door if you wanted to sit down without smoke getting in your eyes!). At its simplest, hot smoke rises upwards, is vented from the building, and is replaced by clear air from outside entering the building through low-level inlets.

Before 1970, the general consensus was that the smoke should be safely above people's heads. The Government committee which drew up the Town Centre Redevelopment Guide No. 1 (published 1972) [2] suggested the basis of what has since developed into the orthodox approach to smoke ventilation of shopping malls. In 1972 this advice was limited to guidance on single-storey malls, and set a minimum clear height of 2.5 m, preferably 3 m. Peter Hinkley (a scientist at the Fire Research Station, UK) took part in the committee, and later told this author that the basis for its recommendation was an assessment of the effect on the public's psychology as they used escape routes beneath the smoke layer. In other words a committee guess, based on the common-sense need to protect tall people as well as the average.

This author's early research into 2-storey malls suggested that the smoke layer base was not a sharp discontinuity, but takes the form of a gradual change in concentration and temperature over a finite range of height. The extent of this "fuzzy layer base" is greater when the layer is cooler. The effect was felt to be more significant for a multi-storey building (due to the greater entrainment in a taller mall or atrium, e.g. ref. [3]) than for a single-storey building, and so it was recommended that another half-metre should be added for multi-storey applications. This was generally accepted by our central government regulatory departments, and had become the new orthodoxy by the time of publication of "BRE 34" in 1979 which summarised the available design guidance [4].

Even though these clear heights had originally only become accepted for shopping malls, they gradually became adopted for other public assembly applications where Means of Escape were protected by a smoke ventilation system.

The next change came in BSI, during the development of BS 5588 Part 10 on shopping complexes [5] (published in 1992). It was felt that a Standard could not say "preferably", and so the upper limits of the earlier advice became the new orthodoxy - i.e. 3 m for a single-storey mall and 3.5 m for a multi-storey mall. Note however that for offices and other buildings where the occupants are familiar with the building, the view has been that people are less likely to be so frightened, are more likely to escape in an orderly manner, and are less likely to suffer adverse psychological effects when escaping. Consequently it has been generally accepted that the lower limits of the acceptable band could be used (i.e. 2.5 m and 3 m) for such occupancies.

Discussions in a CEN Working Group in the 1990s led to a new committee view, that we should go back to the original arguments, and rephrase them solely in terms of heights and layer parameters rather than in terms of building storeys. A little arbitrarily, this led via some still-unresolved complications within CEN, to BR 368 [6] borrowing the result of the CEN committee discussion and changing the criterion for adding the extra half metre from a "storey" based assessment of height to a committee judgement of what constituted a "cool" smoke layer. This change has been accepted by UK regulatory authorities, possibly because it has meant little change in practical applications.

Car Parks have always been recognised as being an exception because of their low ceilings and relatively low population densities. You cannot have a 2.5 m clear layer if the ceiling is at 2.2 m! Working on the principle that some smoke control is better than none, the CEN committee adopted the idea that 1.8 m or 0.8 times the ceiling height should be the lower limit of clear height. This guidance was adopted by the authors of BR 368. This guidance also appears to have been informally accepted by UK authorities (note that UK government departments had their own representatives on all the relevant committees when these things were being discussed). Unfortunately the CEN committee has still not actually managed

to publish its own work as a result of difficulties concerning acceptability of performance-based Codes in different countries. Meanwhile the UK is imminently about to publish BS 7346 Part 4, which is closely based on the CEN committee's work.
Some additional aspects to note:

Yamana and Tanaka's work [7] in the mid 1980s, reinterpreted by Peter Hinkley [8] shortly afterwards, suggested that when the clear height becomes 0.1 times the ceiling height, the filling mechanism changes from a layer-like behaviour to a convection-cell-like behaviour which is faster.

Many studies on ceiling jets, including Hinkley's work on the experiment in Ghent [9] in the late 1980s, show that a ceiling jet occupies about 0.1 times ceiling height, and so design layer depths shallower than this will not be physically feasible (except for small fires producing very weak plumes – a scenario which is rarely used for design).

It has long been recognised that where a smoke ventilation system is NOT intended to protect occupants escaping, but is instead intended to assist fire-fighting by the fire services, different criteria will apply because of the helmets, protective clothing, and training available to firefighters. Establishing the appropriate criteria has always been left to negotiation between the designer and the fire services, but Section 20 requirements under the London Building Acts require 1.75 m minimum clear layer for fire-fighting purposes [10]. This seems reasonable, given that occupant escape must be satisfactory under other provisions e.g. travel distances, detection, good alerting, etc.

There is a view that no experiment on minimum clear height can be valid unless the naive subjects are in genuine fear of their lives. In other words, any valid experiment would be unethical! Hence no such experiments have ever been done.

Note that all clear heights stated in this Note are minima. Greater clear heights for reasons of architecture, convenience, whatever, have always been acceptable provided that other critical parameters (e.g. low layer design temperature) are not compromised.

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