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THE BACKGROUND TO THE SYMPOSIUM

(critical look at some current problems of escape route planning and a glimpse of the future).

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INTRODUCTION

The hazards of escape routes:

Few people actually burn to death - the majority are overcome first by smoke and hot gases: it should be appreciated that these gases may leave the immediate fire area at temperatures in the region of 1000°C and, although they will cool when mixed with the atmosphere of the building, they may still retain very high temperatures even when as much as 200 ft away: furthermore, even if cooled to a tolerable degree, the concentration of carbon monoxide and other toxic gases may still be lethal. As little as 0.5 per cent carbon monoxide in the atmosphere will cause death within minutes - and greater concentrations than this would be common. Thus, on escape routes the immediate concern is with smoke and the movement of that smoke is very fundamental to the planning of the route itself.

The nature of the problem:

It has been contended in certain quarters that there are no real escape route problems; it is said that the present accepted principles of escape provide a system which works reasonably well - and even if it doesn't, then rescue by fire brigades can be relied upon in most cases. The figures for deaths in fires in buildings tend to support this view. In 1966 there were 266 deaths in buildings other than two-storey dwellings (a separate problem) and only a small proportion of these could possibly be attributed in any way to a faulty escape route. The majority of the casualties may well have been in old buildings to which modern standards of fire protection had not been applied - thus there appears to be some justification for claiming a measure of success for our escape route planning. Even if this view is accepted, there are other aspects which appear to be far from satisfactory.

The principles upon which present Codes of Practice on escape[1] are based were formulated some years ago and it becomes increasingly more difficult to apply them to rapidly changing modern developments. Furthermore, some of the requirements have little scientific basis - thus, where knowledge is lacking they tend towards excessive caution which can prove to be very expensive. It is the purpose of this paper to pursue these contentions further under the following headings:-

1. The background to the codes and their relationship to present - day needs.
2. The basic components of an escape route and their usage.
3. The defects in present escape route planning.
4. New trends in means of escape thinking and the possibilities for the future.

1. The background to the codes and their relationship to present-day needs

The background to Codes of Practice on Means of Escape:

The theory of means of escape was first expounded by the Fire Prevention panel under the chairmanship of Mr. Digby Solomon in 1935 and in 1952 the Fire Grading Report No. 29[2] was published. This report was based upon a mixture of such scientific knowledge as was then available, practical experience, and common sense. The present Codes of Practice all stem from it and were formulated to suit what we might now term 'traditional' and comparatively low-rise buildings.

The restrictions imposed by the present codes:

In many instamces the codes force architects to think along very rigid lines; a rather inflexible system imposes strict limitations to travel distance, enclosed staircases, balconies, lobbies, and ventilation standards often difficult to achieve.

The conservatism of the codes is fully understandable if one takes a realistic view of human failings. It was appreciated that doors would sometimes be left or wedged open and that maintenance might be poor; furthermore, it was known that ventilation requirements were mainly based upon rule-of-thumb methods with little scientific evidence to support them. Given favourable conditions it was hoped that these requirements would keep the escape route reasonably clear of smoke but there was no guarantee that this would always be the case. Thus, fire prevention officers will tend to ask for as many precautions as possible in doubtful cases and they are very right to do so for in the event of a tragedy public opinion would not support them if they did not.

The present Codes of Practice and modern building developments:

Since the war there have been immense changes in both building technique and the design and sheer size of buildings: it becomes increasingly more difficult to apply these self same recommendations to such complexes as the central area developments of our new towns and to very tall buildings. In the future we face the challenge of more complicated and higher buildings; even towns built over the sea are forecast.

It is by no means suggested that the present recommendations for escape route planning are entirely wrong for the circumstances for which they were evolved -- they have performed a very excellent service and much of what was written in 1952 is just as true today. However, some of the requirements of Codes are at least questionable now and there are instances where some of the provisions are known to have failed when put to the test. In recent years a considerable amount of research into fires has been carried out and the developing trends in modern design and town planning demand that the new knowledge acquired should be used for a reappraisal of theory and practice: but considerably more research will be required before more sophisticated Codes can be produced.

2. The basic components of escape routes and their use

The escape route problem:

Any study of the movement of smoke on escape routes must be related to the principles by which escape routes are planned; and the principle overriding all else is that, in theory, a man should be able to turn his back on the fire and escape by his own unaided efforts. Thus, the problem for the designer is to provide a route which will withstand fire and smoke during the period it is assumed that the occupants of the building will be escaping.

2. (cont'd)

The main divisions of an escape route:

As far as multi-storey buildings are concerned escape routes can be broadly sub-divided as follows:-

(i) The horizontal route on any floor to the staircase.

(ii) The vertical route down the staircase.

(iii) The route from the foot of the staircase to the final exit doors of the building.

Travel distances and enclosed staircases:

The dominant factor in most escape planning is the travel distance which usually decides the number and to some extent the position of the staircase (a rather gross simplification of a complicated subject!). In certain buildings of very limited size and population a simple "open" staircase may be permissible. In this case the travel distance is measured from any point on a floor, down the staircase and to the final exit doors of the building. In other cases the staircase will be required to be enclosed with fire-resisting construction and the travel distance is then usually measured from any point on a floor to the doors of the enclosure.

Staircase Protection lobbies:

Where additional hazards occur - such as great height, high fire loads, basements or some sleeping risks - an enclosure to the staircase may not be considered sufficient protection. In these cases a staircase protection lobby may be required. This lobby serves two purposes; it can form a bridgehead for fire fighting and it is intended to protect the staircase from smoke penetration.

Ventilation of Escape Routes:

As has been emphasized, smoke and hot gases are the chief dangers to escape routes and in order to clear any smoke that may penetrate the route, ventilation is required. The normal method is to ventilate the staircase to ensure that once escapees have reached thus far they are in a comparatively safe and smoke-free area and can then evacuate the building without further stress.

2. (cont'd)

Ventilation of Escape Routes (cont'd)

As regards the type of ventilation required the various Codes differ but, generally speaking, permanent ventilation is preferred for staircases and openable windows are considered the next best choice: some Codes permit staircases not exceeding 60 ft high to have permanent ventilation of 50 per cent of the enclosure area at the top in lieu of windows or other forms of permanent openings. The Shops Code[1] suggests that where none of the above methods are suitable, then the ventilation of the staircase might be achieved by an internal vertical air shaft or by mechanical pressurisation. For staircase protection lobbies, a permanent opening of 15 sq ft is usually preferred.

Because of the additional hazard of height and sleeping risk the High Flats Code[1] required horizontal routes from the flat entrance door to the staircase to be sub-divided and at least one sub-division to be ventilated if there was no alternative means of escape from each flat and the only escape route was an internal corridor. The sub-division was intended to ensure a maximum travel of 15 ft through possibly severe smoke conditions to a protected area.

The assessment of travel distance:

It has been generally accepted that it may not be possible to keep the first (horizontal) stage of the escape routes clear of smoke and the travel distance restrictions here are designed to limit the distance a person may have to travel through smoke before reaching the safety of the staircase enclosure. The assessment of the actual distance of travel will depend upon a number of factors related to the nature of the risk, age and mobility of the occupants and the height of the building: it is normally accepted that if escape is possible in two directions then the distances may be longer.

3. The defects in present Escape Route planning

Fire Check Doors:

The weakest link in any escape route is almost invariably the fire door. A door placed across a line of communication forms an obstruction and when not required for amenity (i.e. for privacy or to prevent draughts) then it is likely to be wedged or otherwise secured in the open position - where its value as a smoke or fire check is nil! Such securing may be acceptable in some department stores and other buildings where well-trained staff can be relied upon to close the doors in an emergency; indeed, it is possible to justify the practice where large numbers of persons circulate through a building at the same time. However, in many situations it may be extremely dangerous to rely upon staff to close the doors in the event of a fire. One alternative to the wedge or cabin hook is an automatic door-closing system linked to either a fire alarm or a smoke detector: unfortunately such systems are expensive.

The importance of ensuring that fire doors function properly is illustrated in Figure 1, which gives the results of a recent analysis of 26 fires in which personal hazard was involved. It will be seen that the failure of a door to perform its fire function was reponsible for nearly half the total of those killed, injured, rescued, or escaping from the fires; most of the remainder of these categories are attributable to the failure to provide a door at all (i.e. unenclosed staircases, etc.).

The provision of a good fitting door to a rebated frame does not necessarily mean that it will prevent the passage of smoke under all circumstances. It has been demonstrated[3] that a difference in atmospheric pressure of 5 mm (0.2 in) water gauge across a doorway is sufficient to prevent smoke penetration around the edges of the closed door but penetration will be just as easily assisted if the direction of the differential is reversed. In either case the gap at the bottom of the door is important. Wind conditions and the opening or shutting of windows will influence the direction of natural air currents through the building and these too, may effect performance. Where doors are

3. (cont'd)

Fire Check doors (cont'd)

of the double-swing variety without rebated frames, their performance must be even more suspect. Nevertheless, there can be little doubt that in most fire situations closed fire check doors have proved to be of the greatest value to escapees and countless people owe their lives to them. However, in very high buildings where rescue by ladder is impossible, too much reliance should not be placed upon the efficiency of the door as a smoke stop if it is used in conjunction with a form of natural ventilation as severe localised wind conditions may affect its performance. In such cases, a system of mechanical pressurisation of staircase and/or lobbies is likely to give greater certainty that the pressure differential will always be in the required direction.

Travel Distance:

Any designer of an escape route who relies solely upon doors to prevent smoke penetration to the route must consider the possible consequences if a door is left open or otherwise fails. The production of smoke and hot gases from a developing fire is very considerable and, since in almost any building sub-divided into rooms it is possible for a fire to develop unseen, the sudden opening of a door may mean that the escape route is smoke-logged very rapidly indeed. At this point, it matters little to the occupants of other rooms that an escape corridor may lead in either direction to a staircase because they are effectively trapped. The question of travel distance then becomes irrelevant as no travel in the corridor is possible at all. Even if smoke-logging is not complete, any attempt to negotiate a badly affected route could be extremely hazardous because the actual position of the fire may not be known and an escaper may be moving towards it rather than away from it: furthermore, he may not be aware of conditions on the rest of the route.

Ventilation of Escape Routes:

In very tall buildings localised wind conditions are such that reliance upon natural ventilation methods for escape routes is questionable and various forms of pressurisation of staircases and/or lobbies appear to offer greater reliability. One of the disadvantages

3. (cont'd)

Ventilation of Escape Routes (cont'd)

of a ventilated staircase could be that the staircase enclosure may act as a flue. Thus, although smoke may be dispelled through the openings, more and more smoke will be drawn towards the very area one is trying to protect.

In lower buildings, when natural ventilation is to be used for smoke clearance, permanent openings giving cross-ventilation have much to recommend them. Unfortunately, openings large enough to serve their fire function can also cause extremely unpleasant conditions at other times. The alternative of openable windows has the objection that if the build-up of smoke on the escape route is very rapid (and experience shows that this is often the case), then complete smoke-logging may ensue before there is an opportunity to open them. Thus, the windows may be of little use for escape purposes - however useful they may become at a later stage of the fire for smoke clearance of the building.

4. New trends in Means of Escape thinking and possibilities for the future

Changing ideas on the need to escape:

Ideas on escape and the need to escape are changing. Originally it was considered that the entire building should be evacuated as soon as a fire was discovered and that this operation would be carried out within two or three minutes. Undoubtedly there are many buildings today in which this is the only safe course to adopt, but if the building has been suitably designed and constructed it may now be sufficient to evacuate only the floor at risk and, perhaps, the floor above. Indeed, in blocks of flats, where each flat is a separate fire compartment, the occupants of all flats except the one on fire may well be far safer if they stay behind their own closed front door. In any case, very large and high buildings cannot be evacuated in a short space of time; the minimum for total evacuation of such buildings may be half-an-hour or more - and that only under favourable conditions. Thus the concept of partial evacuation or evacuation to safe areas within the building is being developed. This concept has important implications

4. (cont'd)

when it is remembered that last resource rescue by ladder is not possible from high buildings. If occupants are to be encouraged to stay within a building on fire then we have to be very certain that whatever arrangements are made for their safety are virtually foolproof in operation and that scientifically it can be proved that they are feasible.

Future developments for the safety of escape routes:

At this stage it is obviously not possible to be too specific about the future form that escape route requirements might take but one can "read the omens". However, before doing so it must be pointed out that means of escape is but one factor in overall fire protection to buildings and strictly speaking it cannot be considered in isolation. For the purpose of this Symposium on 'Smoke Movement on Escape Routes' however, the future possibilities in this direction are best considered by dividing buildings into two very broad categories:-

(a) Very large buildings, building complexes such as central area developments and very high buildings.

Buildings in this category will normally have either a full air conditioning system or at least a very sophisticated ventilating system: in most cases the windows on the external wall will be sealed or alternatively, in very deep buildings they may be too far from the seat of a fire to be of much use for fire ventilating purposes. From the point of view of smoke these buildings will raise three major problems:

(i) to prevent circulation of smoke and hot gas via the air ducting systems.

(ii) to prevent smoke penetrating the escape route and safe areas.

(iii) to dispel smoke and heat to the outside of the building.

With regard to (iii) it must be appreciated that a developing fire is virtually unapproachable by firemen unless some of the heat and smoke can be dispelled.

Since most buildings in this category cannot be evacuated en masse in a short space of time the provisions for life safety must be guaranteed . This suggests less reliance upon the human element and more reliance upon automatically operating mechanical systems including detectors, door closing and air handling devices. Problems will arise regarding the extent of the reliance which can be placed upon such methods and their cost/effectiveness; but unless such problems are tackled on a scientific basis we shall be reduced to over-providing to allow for our uncertainty and this could prove to be very expensive.

4. (cont'd)

(b) <u>Smaller and comparatively low rise buildings of traditional well established plan form</u>

The slab block with a staircase at or near each end, some department stores and blocks of flats are typical of this category. Such buildings are not normally provided with air conditioning or complicated ventilating systems and for this reason natural ventilation schemes for lobbies and staircases will be preferred.

Although the complete fire protection scheme for buildings in this category will be less sophisticated than for category (a) there is no reason why it cannot be tailormade to suit the individual building in much the same way. To accomplish this two main factors must be studied:-

(i) The efficiency of various means of natural ventilation and the effect upon them of external weather conditions.

(ii) The suitability of door furniture for fire purposes[4].

The closed door is certainly the greatest single factor affecting the safety of the occupants of a building from smoke and, if in a building the appropriate fire doors are in the closed position, a low standard of fire resistance to the structure appears to be of less importance. In many cases it has proved far safer to stay in an unaffected room of a building and await either rescue or the extinguishing of the fire rather than attempt to escape - despite the fact that some of the buildings concerned had comparatively poor fire resistance to their structures. Thus if the efficiency of doors in performing their fire function could be improved and more was known about the usage and limitations of natural ventilation then we might be in a position to consider the fire protection requirements for a building from the following viewpoints:-

(i) The need to evacuate the whole or part of the building at all.

(ii) The standard of efficiency to be expected from the door and ventilation system proposed.

(iii) The travel distance.

(iv) Structural fire protection - as an overall value for the structure or protection stratigically placed in accordance with the risk at various parts of the building.

(v) Internal linings.

(vi) The efficiency of any fire fighting equipment to be provided.

When these factors and the relationship between them are more clearly understood then it should be possible to suit the fire protection of the building to the requirements of a particular project.

4. (cont'd)

Thus greater freedom in planning or choice and protection of structure might be admissible provided there was an appropriate compensation in one or more of the other factors: similar principles could be applied to category (a) buildings. Thus fire protection would be adapted to suit the design rather than the design to suit the fire protection as so often happens today.

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(4) The Ministry of Public Building and Works have contracted the Royal College of Arts. School of Industrial Design (Engineering) Research Unit to study the specification and design of self closing devices for doors for fire purposes.

	1	2	3	4
	Totals for 26 fires	Total where personal hazard was due primarily to:-		
		Door failure	Omission of a door(s)	Both omission and failure of a door
Number of fires	26	10(38%)	10(38%)	19*(73%)
Number of escapees	157	47(30%)	108(69%)	155(99%)
Number rescued	182	95(52%)	44(24%)	135*(74%)
Number killed	17	8(47%	6(35%)	14(82%)
Number injured	40	18(45%	6(15%)	24(60%)

TABLE 1. THE EFFECT OF DOORS UPON PERSONAL HAZARD
Figures in brackets are percentages of Col.1. to nearest whole number. *The figures in Col.4. are not the addition of Cols 2 and 3 because one incident contained both features

Type of door failure	No.of fires in which type of failure occurred
Wedged or left open (including no closer or closer disconnected)	5
Locked	1
Faulty letterbox	1
Missuse (glazed panel broken)	1
Warped	1
Insufficient fire resistance	2
Insufficient resistance to smoke penetration	1

TABLE 2. TYPES OF DOOR FAILURE

THE EFFECT OF DOORS UPON PERSONAL HAZARD
An analysis of 26 fires in which a personal hazard occurred

For the purpose of this analysis the following definitions have been adopted

EVACUATION - The unaided egress from a building by normal means as a reasonable precaution. The persons involved not being subject to immediate danger nor to serious conditions of smoke or fire.

ESCAPE - The unaided agress from a building by normal or abnormal means. The persons involved being subject to immediate danger and subject to some degree of smoke or fire.

RESCUE - The aided agress from a building by normal or abnormal means. The person involved being subject to immediate danger and subject to some degree of smoke or fire.

OMISSION OF A DOOR - When in a building it can be deduced that a door might reasonably have been provided for fire purposes (e.g. to enclose an open staircase) and that had such a door or doors been provided it can also be reasonably deduced that it would have materially assisted the occupants of the building during the fire in question.

FIGURE 1