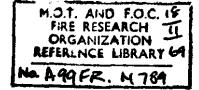
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THE SPREAD OF FIRE IN BUILDINGS - THE EFFECT OF VARYING STANDARDS OF FIRE COVER

by

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SUMMARY

The statistics of fires attended by the fire brigades are used to examine the effect of different standards of fire cover and attendance time on the chance of a fire spreading beyond the room of its origin. The analysis has been performed for several different occupancies and reveals no significant trend for fires to spread in multi-storey buildings as the attendance time gets longer.

As a result of comparing different risks it appears that in most occupancies, the system of varying standards of cover compensates for different risks of spread, so that high risks have the same chance of confinement as low risks. However, there are one or two exceptions notably in the Manufacturing Industries, where some classes of building have a much higher chance than average of fires spreading beyond the room of origin, and data for these buildings require further examination.

KEY WORDS: Fire spread, Fire Statistics, Fire Cover, Brigade, Attendance.

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INTRODUCTION

The fire cover given by the fire brigade to a building or to an area of urban buildings is determined by the brigade on the basis of experience and the estimated risk of fire spread. Buildings are classified into four main risk categories, taking into account whether the area is industrial or residential and the density of building. These risk categories are labelled A, B, C and D, with A as the highest risk; in addition there is a special risk category in which special or high risks are placed, and for which the cover is individually determined. The standard of fire cover varies with the risk category as shown in Table 1, so that high risks are attended earlier and with more men. The figures in Table 1 are minimum requirements and in practice most fire brigades provide better cover.

This note uses fire statistics to assess the effect of this system on the spread of fire in buildings. The technique used is one described in earlier papers 1,2,3, in which the chance of fire spreading beyond the room of origin, estimated from the statistics, is linked with the various circumstances surrounding the fire in order to assess their effect on fire spread. In addition to revealing any significant trends, this technique has the advantage of providing numerical estimates of any benefits due to the system.

CALCULATION OF FIRE SPREAD

Tables 2, 3, 4, 5 and 6 show the proportion, or chance, p, of fire spreading beyond the room of origin. These have been calculated from the statistics of fires attended by the fire brigades in 1963, ignoring fires occurring in single compartment buildings for which no measure of spread is available, and fires confined to common service spaces, exterior components, etc. Also excluded are those fires involving a single item, thus ignoring the risk of spread from the item first ignited. This is admittedly relevant to assessing the risk of a given building or urban area, but they have been excluded here because they do not affect the integrity of the structure, and in most cases it is not clear in which type of building the fires occurred.

The chance of fire spread is known to vary from one occupancy to another, and between multi and single storey buildings so a separate analysis will be undertaken for each. The chance of spread has then been tabulated according to risk and attendance time. The attendance times specified in Table 1 are defined as the period between call and arrival of the brigade, but a more complete measure of the effect of delay is the period between discovery and arrival.

These attendance times (discovery to arrival) have been grouped into 3 intervals for convenience of analysis, namely 0 - 5 mins, 6 and 7 mins, and 8 mins and above. It can be seen from the Tables 2 - 6 that this results in about one-third of the fires falling within each category, but within each risk category this distribution is very much distorted so that, for example, very few fires are attended within 5 mins in D risk fires.

STATISTICAL ANALYSIS

The data in Tables 2 - 6 form 3 x 5 tables, which are amenable to statistical analysis. This has been performed on a computer using a program described by Lewis⁵. The analysis is undertaken with a transformed variable, Z, defined as $z = \frac{1}{2} \log_e (p/q)$ where p is the observed proportion in any cell and q = 1 - p

This transformation is expected to give approximately additive effects for many conditions so that in this case we assume a model

$$z_{ij} = \mu + \kappa_{i} + \beta_{j} + e_{ij}$$

 $z_{ij} = \mu + \kappa_i + \beta_j + e_{ij}$ where z_{ij} is the logit of the proportion in cell (i, j)

is the mean value of Z

is the attendance time effect

is the risk category effect

is the error term

The statistical analysis is performed using the logits of the data, and the constants of the model with their standard errors are estimated by maximum likelihood.

RESULTS OF THE ANALYSIS

Table 7 gives the residual χ^2 resulting from estimating the constants of the model, together with the appropriate degrees of freedom. None of these are significantly different from their expected values and such differences as are present are likely to arise through statistical fluctuation. We are thus able to accept the additive model as an adequate representation of the data.

The analysis also estimates the values of the risk and attendance time constants, together with their standard errors and the standard errors of differences. These values are all in terms of logits, and since in the present paper their only use will be in testing the significance of any differences, and the volume of results is rather large, this information will not be included. Of greater interest is Table 8, the expected marginal proportions of spread beyond the room of origin to be associated with each risk and attendance time group. These are the weighted percentage for fires falling into a particular risk or attendance time allowing for the distortion due to different frequencies in each cell.

DISCUSSION OF RESULTS

The results of the analysis are summarised in Table 8, giving the expected marginal proportions spreading beyond the room of origin. The significant feature of this analysis is that there is no measurable effect of attendance time on the chance of fires spreading. The differences that do occur in the Table are not significant and could well occur by chance statistical fluctuation.

The absence of any strong attendance time effects, at first seems rather surprising. However, this could occur in several different ways and at the present there is no means of assessing which is correct. Three possible explanations are as follows:-

- (1) Within each risk category, the attendance time has been so adjusted by the fire brigades that potentially hazardous fires have the same chance of confinement as less hazardous fires.
- (2) The effects of attendance time are real but small and indistinguishable from the random and systematic inaccuracies arising from ambiguities in definition and errors in measurement of attendance time.
- (3) The period of time is small compared with the variation occurring in other time periods, such as time from ignition to discovery, reflected in the size of fire on arrival of the brigade, about which little is known at present.
- (4) The ambiguities associated with the word "room" may mean that "confined (or not confined) to room of origin" are inadequate measures of fire size.

So far as the effect of risk categories is concerned, the significant features are indicated in Table 8. In the Manufacturing Industries, in single

storey buildings the chance of spread in D risks is significantly higher than in the other risks, and in multi-storey buildings the chance of spread in special orhigh risk category is very much higher than in other risks. In the Distributive Trades, there are no significant differences in the chance of spread between the risks, although there appears to be a trend, with the higher risks having a higher risk of spread. However, the differences between risks that do occur could well occur by chance statistical fluctuations. The only feature of the analysis of residential buildings is that the chance of spread in C risks is significantly lower than other risks.

In summary, it seems that there is evidence that the system of varying standards of cover is sufficient to compensate for different risks of spread, as measured by the chance of a fire spreading beyond the room of origin, so that high risks have the same chance of confinement as low risks. However, there are some classes of buildings in which the chance of fire spread is higher, and these classes may require further examination. Most important of these is the "special" risk in multi-storey Manufacturing Industry buildings with a very high risk of spread, and D risk Manufacturing Industry buildings. These are especially important economically, since more than half of the large fires that occur are in the Manufacturing Industries.

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Table 1. Minimum standards of fire cover

			endance Time (mincal)	ns)
Risk Category	First Attendance (Pumps)	1st Appliance	2nd Appliance	3rd Appliance
Special or High risk	Indiv	idual	Asses	s m e n t
A	3	5	5	8
В	2	, 5	8	-
С	1	8–10	-	- .
מ	1	20	-	- .
_	,			

Table 2

MANUFACTURING INDUSTRIES - SINGLE-STOREY BUILDINGS

Number of fires

			Risk Ca	ategory	
		A	В	С	D
Discovery	0 - 5	63	107	52	12
Arrival	6 + 7	77	140	70	15
(mins)	8 + above	4 9	121	120	66

Proportion of above fires spreading beyond room of origin

			Risk (Category	
		A	В	С	D
Discovery	0 5	0.21	0.14	0.23	0.42
Arrival	6 + 7	0.13	0.15	0.21	0.27
(mins)	8 + above	0.14	0.17	0.19	0.23

Too few fires in Special or High Risk for inclusion

Table 3

MANUFACTURING INDUSTRIES - MULTI-STOREY BUILDINGS

Number of fires

			Risk (Category		
		Special or High	A	В	С	D
Discovery	0 - 5	14	172	124	45	4
to Arrival	6 + 7	6	114	130	63	10
(mins)	8 + above	2	73	136	84	46

Proportion of above fires spreading beyond room of origin

			Ris	k Categor	у	
		Special or High	A	В	С	D
Discovery	0 - 5	0.50	0.34	0.26	0.18	0.50
Arrival	6 + 7	0.67	0.31	0.29	0.30	0.40
(mins)	8 + above	0.50	0.26	0.34	0.39	0.35

Table 4

DISTRIBUTIVE TRADES - SINGLE-STOREY BUILDINGS

Number of fires

			Risk Ca	ategory	
		A	В	С	D
Discovery	0 - 5	12	30	24	0
Arrival	6 + 7	17	20	25	2
(mins)	8 + above	9	22	35	18

Proportion of fires spreading beyond room of origin

	!		Risk Ca	ategory.	
	· · · ·	A	В	С	D
Discovery	0 - 5	0.25	0.40	0.13	
Arrival	6 + 7	0.18 .	0.25	0.32	0 .
(mins)	8 + above	0.44	0.32	0.26	· 0.28

Too few fires in Special or High Risk for inclusion.

<u>Table 5</u>

DISTRIBUTIVE TRADES ~ MULTI-STOREY BUILDINGS

Number of fires

	•	Risk Category				
		Special or High	A	В	С	D
Discovery	0 - 5	10	167	207	77	6
to Arrival	6 + 7	11	74	120	109	8
(mins)	8 + above	4	38	76	106	40

Proportion of fires spreading beyond room of origin

			Risk	Category		
,		Special or High	A	В	С	D
Discovery	0 - 5	0.20	0.27	0.25	0.19	0
to Arrival	6 + 7	0.09	0.23	0.22	0.15	0.38
(mins)	8 + above	0.25	0.24	0.24	0.18	0.30

Table 6

RESIDENTIAL HOUSES - MULTI-STOREY BUILDINGS

Number of fires

	·			Risk Ca	ategory	- ''
			Α .	В	С	D
	Discovery	0 - 5	94	294	321	20
	Arrival	6 + 7	87	343	523	63
:	(mins)	8 + above	60	223	798	465

Proportion of fires spreading beyond room of origin

	;				<u> </u>	1	97.
·			Risk Ca	ategory			
		A	В	С	D		
Discovery	0 - 5	0.09	0.13	0.08	0.15		
Arrival	6 + 7	0.14	0.12	0.10	0.14	., ,	
(mins)	8 + above	0.10	0.13	0.10	0.16	. ,	i.ī

Too few fires in Special or High Risk for inclusion.

Table 7

Residual Chi-squared after fitting constants

0ccupancy	Storeys	Residual Chi-squared	Degrees Freedom
Manufacturing	Single	3.33	6
Industries	Multi	9•45	8
Distributive	Single	6.47	5
Trades	Multi	5•51	8
Residential Buildings	Multi	2.06	6

Values of X^2 are not significant at 1 per cent level

Table 8 Expected Marginal Proportions of spread

Occupancy	Storeys	Risk Category					Attendance Times (mins)		
		Special	A	В	С	D	0 - 5	6 + 7.	8 and above
Manufacturing Industries	Single	-	0.16	0.15	0.21	0.27 ⁽¹⁾	0.20	0.17	0.17
	Multi	0.56 ⁽²⁾	0.32	0.30	0.31	0.35	0.30	0.31	0.34
Distributive Trades	Single	- -	0.27	0.34	0.24	0.23	0.26	0.25	0.31
	Multi	0.16	0.25	0.24	0.17	0.28	0.24	0.20	0.23
Residential Houses	Multi	_	0.11	0.13	0.10 ⁽³⁾	0.15	0.11	0.12	0.12

⁽¹⁾ Significantly higher than A or B risks
(2) Significantly higher than A, B or C risks
(3) Significantly lower than B or D risks