Fire Research Note

No. 727

FIRES IN OLD AND NEW NON-RESIDENTIAL BUILDINGS

by

P. H. THOMAS

FIRE
RESEARCH
STATION

Fire Research Station,
Borehamwood,
Herts.
Tel. 01-953-6177

F.R. Note No. 727
September 1968.

FIRES IN OLD AND NEW NON-RESIDENTIAL BUILDINGS

by

P. H. Thomas

SUMMARY

A new method of examining the fire brigade reports shows that for 1963 there were differences between the extent of fire spread in buildings built since 1950 and older buildings. There is a reduced tendency for fires to spread upward in such new buildings.

Key words: Age, building, fire spread, probability, statistics.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

F.R. Note No. 727
September 1968.

FIRES IN OLD AND NEW NON-RESIDENTIAL BUILDINGS

by

P. H. Thomas

INTRODUCTION

The use of the statistics on fire spread has been discussed in a previous note[1]. Essentially the procedure is to assess the frequency with which fires of a given class (occupancy, attendance time, etc.) spread beyond the room or floor of origin etc. It is possible to obtain these probabilities for fires of various duration (measured by the interval between the arrival of the fire brigade and their declared stop time). Fig. 1 is typical of the data. There are fewer fires lasting a long time so most of the data points tend to cluster near the origin and in addition one has the distribution in time of fires confined to the room of origin and those spreading beyond the room of origin but the presentation in the form shown in Fig. 1 is to a first approximation independent of the distribution of sizes of building. For this first examination all non-residential fires have been pooled together, separated only into single and multi-storey buildings. Because for buildings having only one compartment, one cannot strictly categorize fires into those confined to or spreading beyond the room of origin, fires in such buildings have been omitted from this discussion though these are large in number and the loss in such buildings may contribute greatly to the total fire loss. The fire brigade reports refer to rooms and compartments and there is some ambiguity in the meanings to be attached to these.

The data have been grouped into intervals of five minutes. This was an arbitrary choice to give sufficient numbers of fires in each interval; there is some chance variation in the stop time itself. Initially there was some uncertainty as to whether fires reported as being out on arrival should be included or excluded but as we shall see the data suggest that they should be included with the first interval. This means one is dealing with fires attended by the fire brigade. However, one is not sure that all such fires have been fought by the fire brigade: a control time of say one minute may not indicate that one minutes fire fighting has taken place - only that the stop time was not given immediately on arrival of the brigade. If one were to take the opposite course and exclude these data one would still not be sure that the data refer only to fires fought by the fire brigade. There is therefore some ambiguity for these small fires as to the precise criteria by which the fire brigade were called.

Single-storey buildings

Table 1 lists the numbers of fires of various duration in non-residential single-storey buildings. All the data in this table and in the rest of the report are for 1963 only. So far this is the only year for which data on spread and duration have been fully recorded. P_R is the fraction of fires spreading beyond the room of origin. Given the totals of fires in new buildings of various durations the value of P_R is used to give an estimate of the numbers expected to have spread beyond the room of origin in new buildings based on the fraction spreading beyond the room of origin in all ages of buildings.

In addition, the distribution of these totals can also be estimated from the distribution of totals for all buildings so that a comparison can be made between the distribution of fire duration in old and new buildings. These distributions differ somewhat. There are for example 56 fires of 25-29 minute duration instead of the expected 39, and 59 long lasting fires instead of 44, and somewhat fewer very small fires than expected. However, given the distribution, there is no significant change in the proportions spreading beyond the room of origin. The changes in the distribution of the numbers in each time interval may, of course, be a reflection of a change in the size distribution of new buildings for which we do not have any data. While such a change is very relevant to total fire costs it is less relevant to this comparison of risk.

Fig. 1, shows P_R against duration showing an approximately linear relation. This type of variation has been observed before: it can reflect either or both of two self-evident tendencies. Fires which are large when the brigade arrives take longer to control. On the other hand if, for any reason, the brigade takes longer to deal with a fire than is expected for that size of fire, the more likely it is to spread further in the course of fire fighting. No doubt some element of both tendencies is present. A higher slope for a different type of fire means a shorter time scale; either the fire brigade is more effective or the fire spreads faster per unit of fire fighting time.

MULTI-STOREY BUILDINGS

For multi-storey buildings we could proceed in the same way, but a simple distinction is possible between sideways and upward spread. If 'a' is the number confined to the room, 'b' is the number confined to the floor and 'c' the number confined to the building and we neglect the few others then:-

$\frac{b + c}{a + b + c}$ is the fraction spreading beyond the room of origin P_R.

$\frac{c}{a + b + c}$ is the fraction spreading upward p_u.

$\frac{b}{a + b}$ is the fraction spreading sideways but not upwards p_s.

The relationship between these parameters is given by

$$1 - P_R = (1 - p_u)(1 - p_s)$$

$$P_R = p_u + p_s - p_u p_s$$

Before examining upward and sideways spread in multi-storey buildings, we shall make some comparison between single and multi-storey buildings.

COMPARISON OF SINGLE AND MULTI-STOREY BUILDINGS

Comparative data are given in Table 2 where it is seen that in multi-storey buildings there are more long lasting fires than expected from single storey data, i.e. the mean duration of multi-storey fires is longer than that of single storey fires. Allowing for this there is only a slight tendency for increased spread in multi-storey buildings, on average about 10 per cent. There is some reason to believe that this is not uniformly so for every occupancy, and that in some multi-storey building this tendency is better and in others worse than in single storey buildings.

OLD AND NEW MULTI-SOTREY BUILDING FIRES

The data are shown in Table 3. The pooling of the fires normally out on arrival and those lasting 1 to 4 minutes improves the agreement and it is this that suggests that these data should be pooled rather than treated separately. The calculated P_R and the expected values for new buildings have been obtained in the same way as in Table 1. The similarity of the P_R in the two tables up to 20 minutes reflects the similarity found in Table 2. The data will now be examined in more detail distinguishing between upward and sideways spread.

Sideways spread is shown in Table 4 where again it is seen that pooling the zero time data and the data for 1 - 4 minutes improves the agreement. The data do not show much difference between sideways spread in old and new buildings. Table 5 shows the data for upwards spread and here there is a statistically significant difference between the expected and the recorded numbers of fires spreading upwards, the major part of the difference being that there are fewer small fires then expected. This is perhaps not surprising in view of the improved control exercised on the floors in modern buildings by modern building regulations. However, here we have some measure of the improvement: the expected totals of fires spreading beyond the room of origin in post 1950 buildings are 82 and 166 in Tables 4 and 5, respectively. That these figures do not equal the total in Table 3, viz. 242, is due to rounding each expected value to the nearest whole number.

We do not have as yet a relationship between fire duration and financial loss, but there is some reason to believe that these two quantities for any one occupancy are in rough proportionality. However, it is impracticable to use these data for costs largely because the greater part of the cost is the result of the long lasting fires for which there are few data available. The number of fires is twice the number of actual data sampled - the actual number of independent data is therefore half of those listed. The presence of odd numbers in certain Tables arises because of a correction ($<$10 per cent) to allow for the fires where the number of storeys is unknown.

DISCUSSION AND CONCLUSIONS

In the above discussions no attempt has been made to distinguish between one type of occupancy and another. The numbers of data available for new buildings are too few to make this profitable but data for years after 1963 will be available shortly, and such sub-divisions will then become practicable. The results suggest that new buildings differ somewhat from old buildings. There is some suggestion that fires in new buildings spread sideways somewhat more frequently than expected, but spread upwards somewhat less frequently, and the two effects tend to counteract each other. It is not however possible to say that this means that the cost of fires is no different because upward spreading fires may well be more damaging than sideways spreading fires. It is noticeable that the chance of fire spreading beyond the room of origin in single and multi-storey buildings is little different and this suggests that fire may as readily spread through the building from floor to floor as through the roof of a single storey building but such a conclusion is clearly only a tentative one pending further studies. Furthermore the graphs of P_K against fire duration show only relatively small discontinuities at, or near, 30 minutes and 60 minutes, the two lowest standards of fire resistance grading. This implies that perhaps the variations in the fire resistance of the various elements of structure, in the chance of doors being open, and in the behaviour of fires, are enough to almost obscure these standardized values. Fig. 1 shows such a small "kink" around 20-30 minutes, and Mr. Baldwin has found similar "kinks" in other distribution curves. They are exposed by taking running averages over 5 minutes. However, they may be affected by a preference for reporting times such as 15 and 30 minutes over, say, 14 or 29 minutes. Either way the "kinks" correspond to a 'delay' of about 5 minutes.

It is an aim of future work on these lines to try to assess the economic value of such fire resistance and consider whether recognition should be extended to fire resistance gradings intermediate between 30 and 60 minutes, or even less than 30 minutes. The value of this method of analysis is that it provides sub-classes in time to any class fire. The comparisons are accordingly more sensitive than those based on total numbers alone. Indeed, there is a remarkable consistency in the data even though we are sampling in effect about $^1/_{10}$th of the total of all fires in 1963. The consistency of the distribution and the numbers in the various time intervals suggests the technique is a useful one especially, as will be shown elsewhere, in that the tendency to spread varies little from year to year - unlike the numbers of fires - so that as more data become available for analysis one should be able to make more searching comparisons. It will also become possible to perform these comparisons for the separate occupancy types that appear in Building Regulations.

ACKNOWLEDGEMENT

I should like to thank my colleagues, Mrs. Day and Mr. North, for extracting and computing the data and Mr. Baldwin and Mr. Fry for several helpful discussions.

REFERENCES

1. Spread of Fire in Buildings: A Statistical Approach. P. H. Thomas. Ministry of Technology and Fire Offices' Committee Joint Fire Research Organization Fire Research Note No. 694.

TABLE 1

Fires in non-residential single-storey (multi-compartment) buildings in 1963

	All ages				Post 1950				
Arrival to stop time - min -	Confined to room of origin	Spread beyond room of origin	Total	P_R	Confined to room of origin	Spread beyond room of origin		Total	
						Actual	Expected	Actual	Expected
0	509	6	515	0.01	168	0	2	168	127
1 - 4	1160	142	1302	0.11	246	24	30	270	322
5 - 9	1211	276	1487	0.18	294	64	67	358	369
10 - 14	542	208	750	0.28	122	58	50	180	186
15 - 19	258	146	404	0.36	61	36	35	97	100
20 - 24	92	94	186	0.51	22	20	21	42	46
25 - 29	84	72	156	0.46	30	26	26	56	39
30 - 34	28	34	62	0.54	11	8	10	19	15
35 - 39	27	40	67	0.60	8	10	11	18	17
40 - 44	14	32	46	0.69					
45 - 49	7	16	23	0.70	9	50	44	59	44
50 & over	24	86	110	0.77					
Total	3,956	1,152	5,108		971	296	296	1,267	

TABLE 2

Comparison between fires in non-residential single storey (multi-compartment) and multi-storey buildings in 1963

Single storey			Multi-storey			
Arrival to stop time - min -	Spread beyond room of origin	Total	Total		Spread beyond room of origin	
			Actual	Expected	Actual	Rxpected
0	6	515	855	1055	36	10
1 - 4	142	1302	3006	2670	368	328
5 - 9	276	1487	3015	3050	570	560
10 - 14	208	750	1254	1535	350	345
15 - 19	146	404	616	830	224	222
20 - 24	94	186	416	381	222	211
25 - 29	72	156	322	320	212	148
30 - 34	34	62	204	127	134	112
35 - 39	40	67	155	137	108	93
40 - 44	32	46	138	95	98	96
45 - 49	16	23	93	47	76	64
50 & over	86	110	392	226	334	305
Total	1,152	5,108	10,466		2,732	2,494

TABLE 3

Fires in non-residential multi-storey buildings in 1963

All ages					Post 1950				
Arrival to stop time - min -	Confined to room of origin	Confined to floor and building	Total	P_R	Confined to room of	Spread beyond room of origin		Total	
						Actual	Expected	Actual	Expected
0	819	36	855	0.04	138	12	6	150	82
1 – 4	2638	368	3006	0.123	222	20	30	242	286
5 – 9	2445	570	3015	0.189	250	52	57	302	287
10 – 14	904	350	1254	0.278	72	30	28	102	120
15 – 19	392	224	616	0.365	42	16	21	58	59
20 – 24	194	222	416	0.535	18	16	18	34	40
25 – 29	110	212	322	0.66	6	14	13	20	31
30 – 34	70	134	204	0.66	2	10	8	12	19
35 – 39	47	108	155	0.70	4	8	8	12	15
40 – 44	40	98	138	0.71	6	10	11	16	13
45 – 49	17	76	93	0.82	12	38	42	50	46
50 & over	58	334	392	0.85					
Total	7,734	2,732	10466		772	226	242	998	

TABLE 4

Sideways spread in non-residential multi-storey buildings in 1963

All ages					Post 1950				
Arrival to stop time – min –	Confined to room of origin	Confined to floor	Total	P_R	Confined to room of origin	Confined to floor		Total	
						Actual	Expected	Actual	Expected
0	819	26	845	0.031	138	8	3	146	87
1 – 4	2638	194	2832	0.069	222	16	16	238	290
5 – 9	2445	258	2703	0.095	250	38	27	288	278
10 – 14	904	100	1004	0.10	72	10	8	82	103
15 – 19	392	64	456	0.14	42	10	7	52	47
20 – 24	194	56	250	0.224	18	4	5	22	26
25 – 29	110	44	154	0.29	6	6	3	12	16
30 – 34	70	24	94	0.26	2	4	2	6	10
35 – 39	47	20	67	0.30	4	2	2	6	7
40 – 44	40	18	58	0.31	6	4	3	10	6
45 – 49	17	4	21	} 0.29	12	8	6	20	11
50 & over	58	26	84						
Total	7,734	834	8,568		772	110	82	88	

TABLE 5

Upward spread in non-residential multi-storey buildings in 1963

All ages					Post 1950				
Arrival to stop time - min -	Confined to room of origin	Confined to building	Total*	P_R	Confined to room of origin	Confined to building		Total*	
						Actual	Expected	Actual	Expected
0	819	10	855	0.012	138	4	2	150	82
1 – 4	2638	174	3006	0.058	222	4	14	242	286
5 – 9	2445	312	3015	0.103	250	14	31	302	287
10 – 14	904	250	1254	0.20	72	20	20	102	120
15 – 19	392	160	616	0.26	42	6	15	58	59
20 – 24	194	166	416	0.40	18	12	13	34	40
25 – 29	110	168	322	0.525	6	8	10	20	31
30 – 34	70	110	204	0.54	2	6	6	12	19
35 – 39	47	88	155	0.57	4	6	7	12	15
40 – 44	40	80	138	0.58	6	6	9	16	13
45 – 49	17	72	93	0.78	12	30	39	50	46
50 & over	58	308	392	0.79					
Total	7,734	1,898	10,466		772	116	166	998	

* These totals include those fires confined to floor of origin .

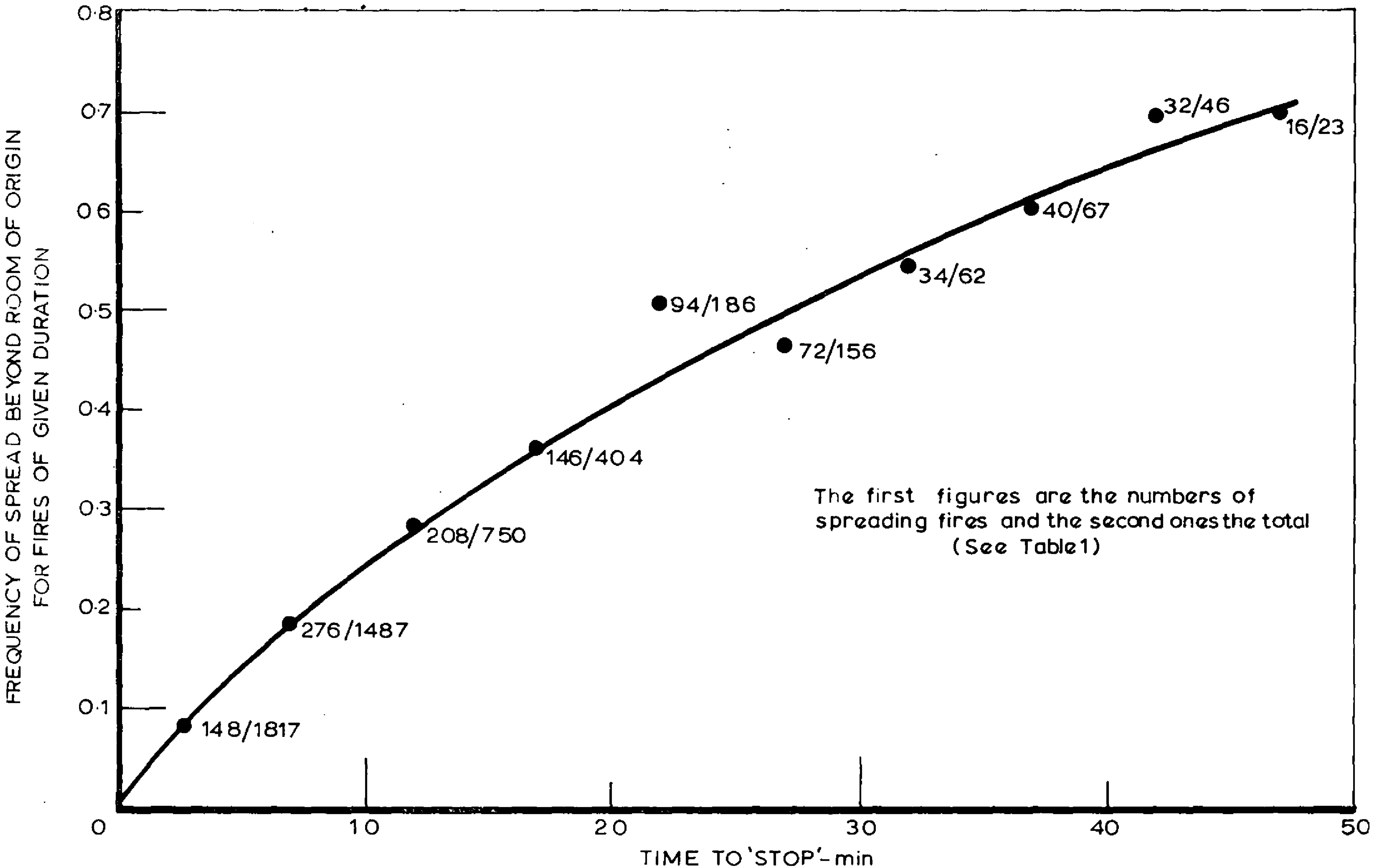

FIG.1. FREQUENCY OF SPREAD BEYOND THE ROOM OF ORIGIN
(Non-residential, single storey, 1963)