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SOME STATISTICS OF DAMAGE TO BUILDINGS IN FIRES

by

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SUMMARY

Statistics of damage to industrial and storage buildings in Hertfordshire are analysed. It is found that the probability of structural damage is about 14 per cent, and the chance of failure of a structural element is about 0.5 per cent. About half the fires have damage less than 10 m^2, about three-quarters less than 100 m^2. The extent of damage appears to be associated with the size of fire as represented by the probability of spread beyond the room of origin.

KEY WORDS: Building, Damage, Fire, Statistics.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
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INTRODUCTION

This report presents some statistics on the extent of structural damage to buildings by fires, drawn from fire reports submitted by the brigades. The analysis was carried out largely to examine the feasibility of incorporating measures of damage in studies of fire loss and for this it was sufficient to look at the fires of one brigade only. In this pilot survey fires occurring in Hertfordshire in the years 1965-1968 inclusive in industrial and storage buildings were chosen. Structural damage in this paper includes damage by heat to the walls, ceiling, roof or floor, but does not include damage to the contents, or damage by smoke or water.

The information given in the fire report usually includes:

(a) area of damage;

(b) location (i.e. wall, ceiling) and nature of damaged structural element;

(c) limited comment on the seriousness of the damage, e.g. plaster only, serious damage, structural collapse (failure of walls, ceiling etc. due to action of the fire).

This information has been coded and analysed and the results are presented below.

CHANCE OF STRUCTURAL DAMAGE AND COLLAPSE

In the years covered by the survey there were 840 fires in industrial and storage buildings in Hertfordshire, and of these 108 were reported as having structural damage, 4 involved structural collapse, and in 13 the extent of damage was unknown. This information is summarized in Table 1.

Table 1

Statistics of structural damage

Fires in industrial and storage buildings	
Fires involving structural damage	108
Fires involving structural collapse	4
Unknown structural damage	13
Fires with no structural damage	715
TOTAL	840

Unknowns tend to be in the larger fires, where the extent of internal damage to the building is difficult to determine, and thus there may be more fires involving structural collapse than given in the table.

The chance of structural damage and collapse are thus

(a) probability of structural damage = 0.14;

(b) probability of structural collapse = 0.005;

(c) probability of a structural collapse <u>given</u> that there is some structural damage = 0.04.

Only a small proportion of fires involve structural damage, as might be expected since most fires are small and only a very small fraction involve some degree of structural collapse, defined here as failure of any structural element in a fire. Thus the chance of fire spreading because of structural failure appears to be very small. One form of damage which is not apparently reported by the brigades is the failure of a door. Since this is likely to be an important factor in the spread of fire, allowing fire to pass through a fire resisting construction, this is a serious omission.

LOCATION OF DAMAGE

The location of structural damage, whether the roof, ceiling, walls or floors are involved, is tabulated in Table 2. Of the fires involving structural damage, 59 per cent involve damage to the ceiling or roof alone, although about 9 per cent start in and are confined to the roof space. This is only to be expected since flames and/or hot gases will always rise to the ceiling or roof, whereas in rooms of large superficial area, the walls stand a relatively small chance of being involved, depending on the location of the fire. Floors are damaged comparatively rarely because the heat transfer downwards is comparatively small (unless the floor is above a ceiling).

Table 2

Location of damage

Location of damage	Proportion of fires involving damage
Roof only	38%
Ceiling only	21%
Wall only	16%
Floor only	8%
Combination	17%

Of the 4 fires involving structural collapse, 3 involved walls, the other the roof. However these figures may be distorted by the comparatively large number of unknowns.

AREA OF DAMAGE

The frequency distribution of the area of structural damage in fires is shown in Fig.1. Most fires have damage less than 100 m^2 and a more detailed frequency diagram for these fires is given in Fig.2. This shows that about one half of the fires have damage less than 10 m^2.

The distribution function of the area damage (fires with damage greater than A) is plotted on log-linear paper in Fig.3, with $\sqrt{\text{area}}$ on the x-axis. The observed data lie approximately on a straight line and the distribution function can be represented approximately by the equation

$$P\left[\text{Damage} > A\right] = e^{-0.17\sqrt{A}} \quad (A \text{ in } m^2)$$

for fires with $A > 0$ (i.e. exluding fires with no structural damage).

PROBABILITY OF SPREAD BEYOND THE ROOM OF ORIGIN

Structural damage can be caused by relatively small fires strategically placed by chance, but the extent of structural damage is probably related to the fire size. The only measure of the size of fire available at the present (other than some measure of the volume of fire brigade activity necessary to bring the fire under control) is the extent of spread of the fire, as measured by whether or not the fire was confined to the room, floor or building of origin. In Fig.4 the probability of spread beyond the room of origin for this class of fire with damage $\leq$ A is plotted against A, the area of damage. This shows an almost linear relationship between the two variables, indicating that the area of damage is associated quite strongly with the size of the fire. More data is necessary to confirm this.

CONCLUSIONS

An analysis of structural damage in industrial and storage buildings in Hertfordshire has shown that for these buildings

1. The chance of structural damage is 14 per cent, and the chance of failure of a structural element is 0.5 per cent.

2. In more than one half of the fires (59 per cent) the damage is to the roof or ceiling only, and in 16 per cent the damage is confined to the walls.

3. About one half of the fires have damage less than 10 m^2, and about three-quarters have damage less than 100 m^2. The distribution function of the area of damage is approximately.

$$P\left[\text{Damage} \geqslant A\right] = e^{-0.17\sqrt{A}} \quad (A \text{ in } m^2)$$

4. The extent of damage in a class of fires is associated with the size of fire in that class as represented by the probability of spread beyond the room of origin.

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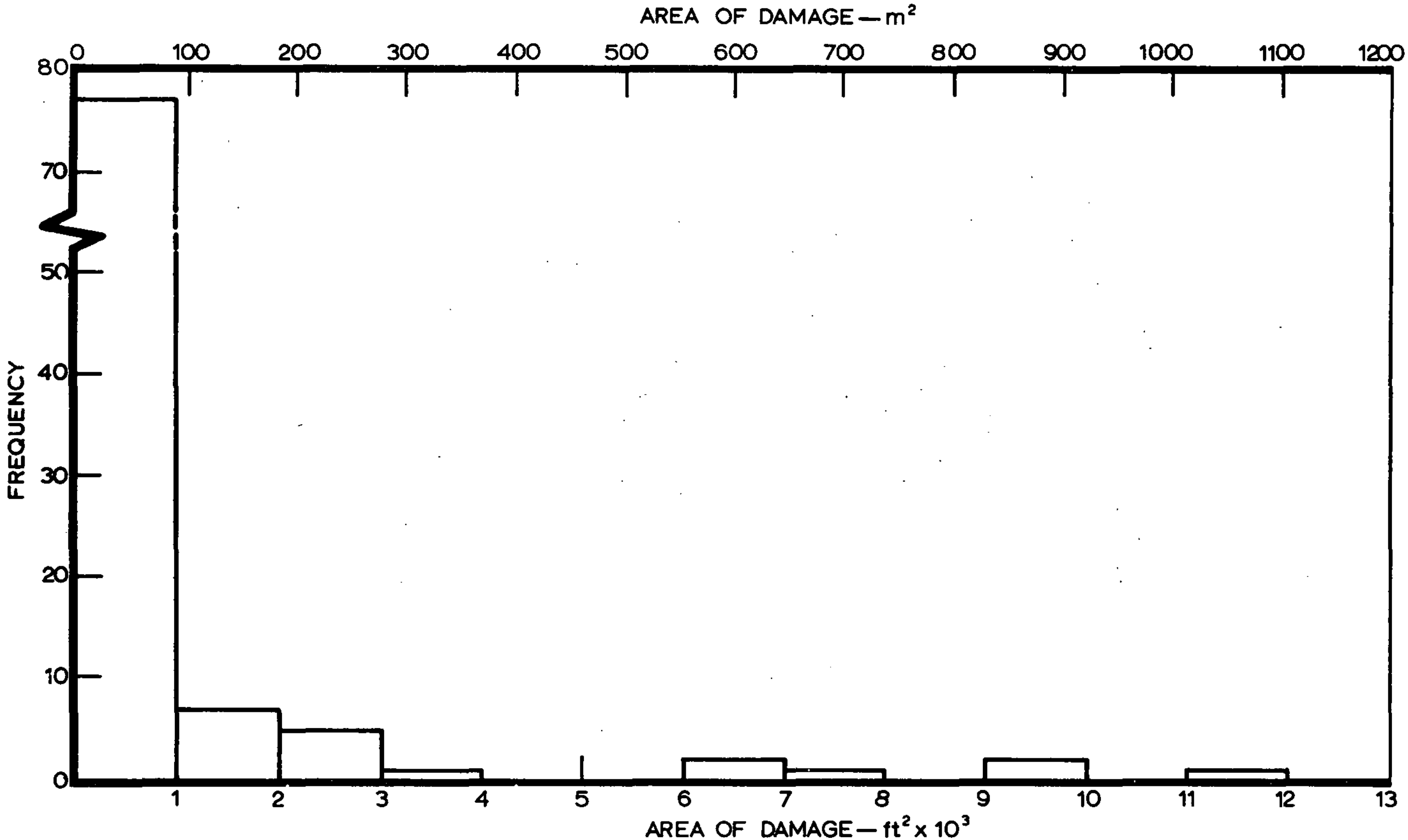

FIG. 1. FREQUENCY DISTRIBUTION OF AREA OF BUILDING DAMAGE

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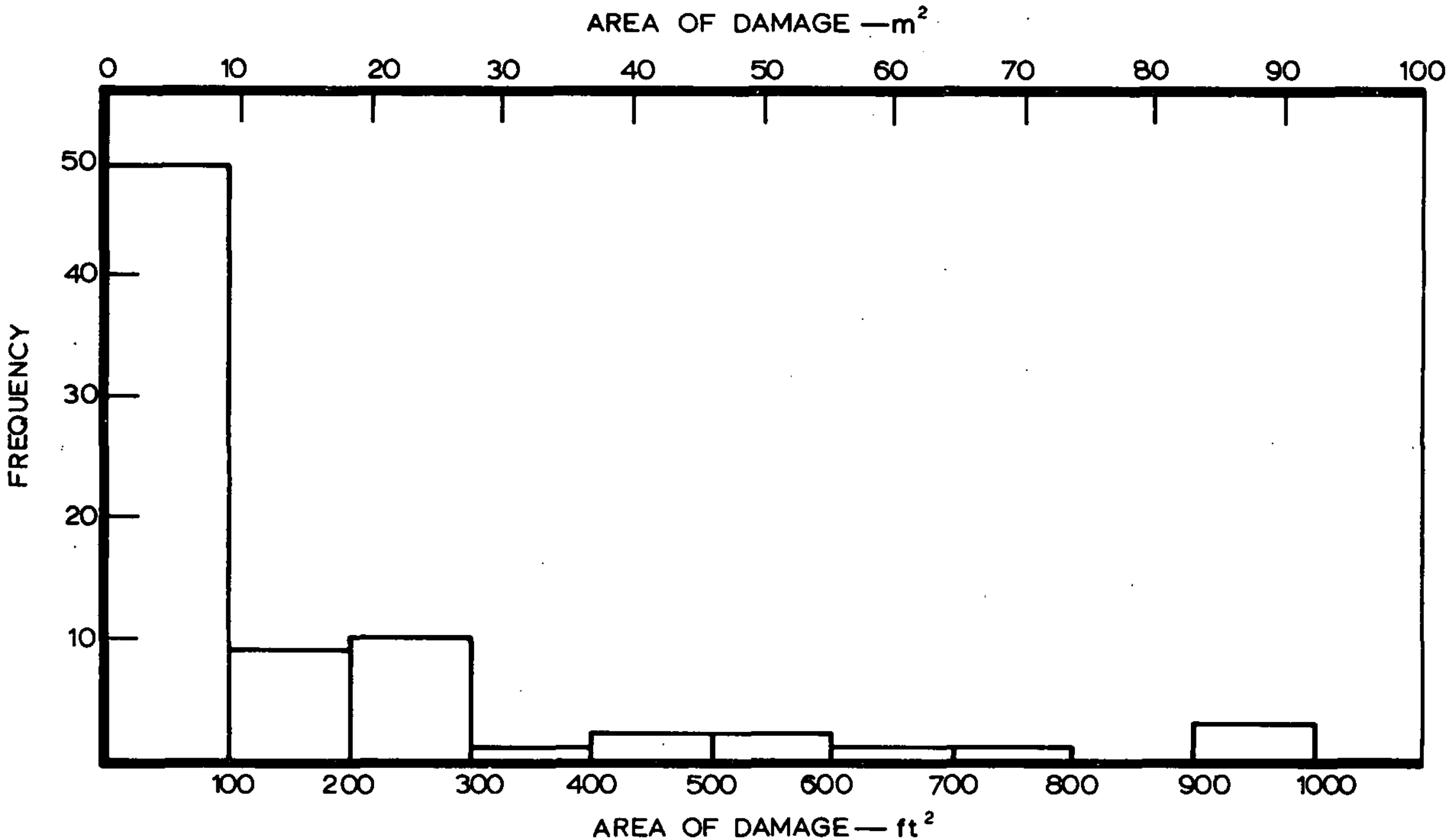

FIG. 2. DETAILED FREQUENCY DISTRIBUTION OF DAMAGE LESS THAN 1000 ft^2

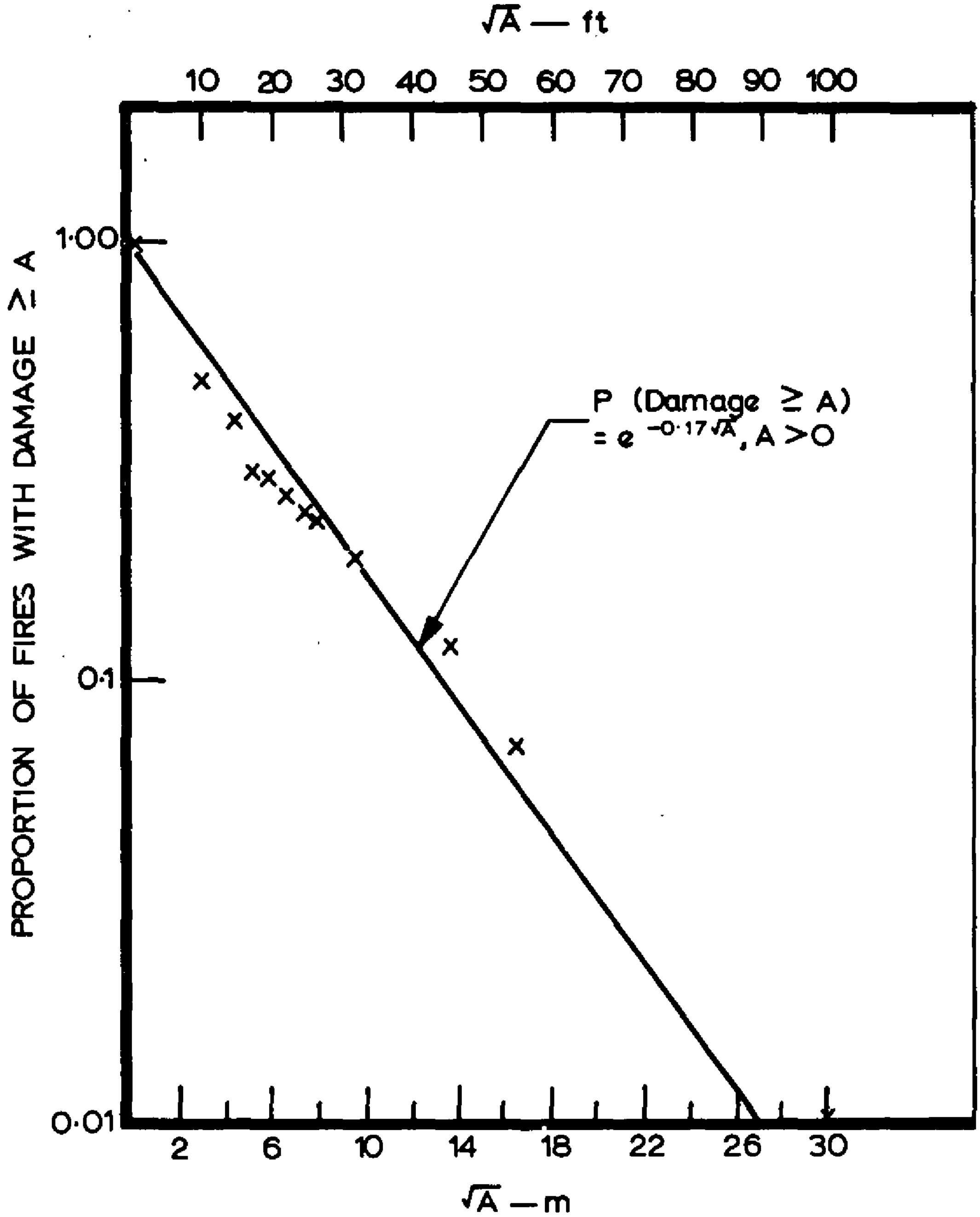

FIG. 3. DISTRIBUTION FUNCTION OF STRUCTURAL DAMAGE (EXCLUDING FIRES IN WHICH THERE IS NO DAMAGE)

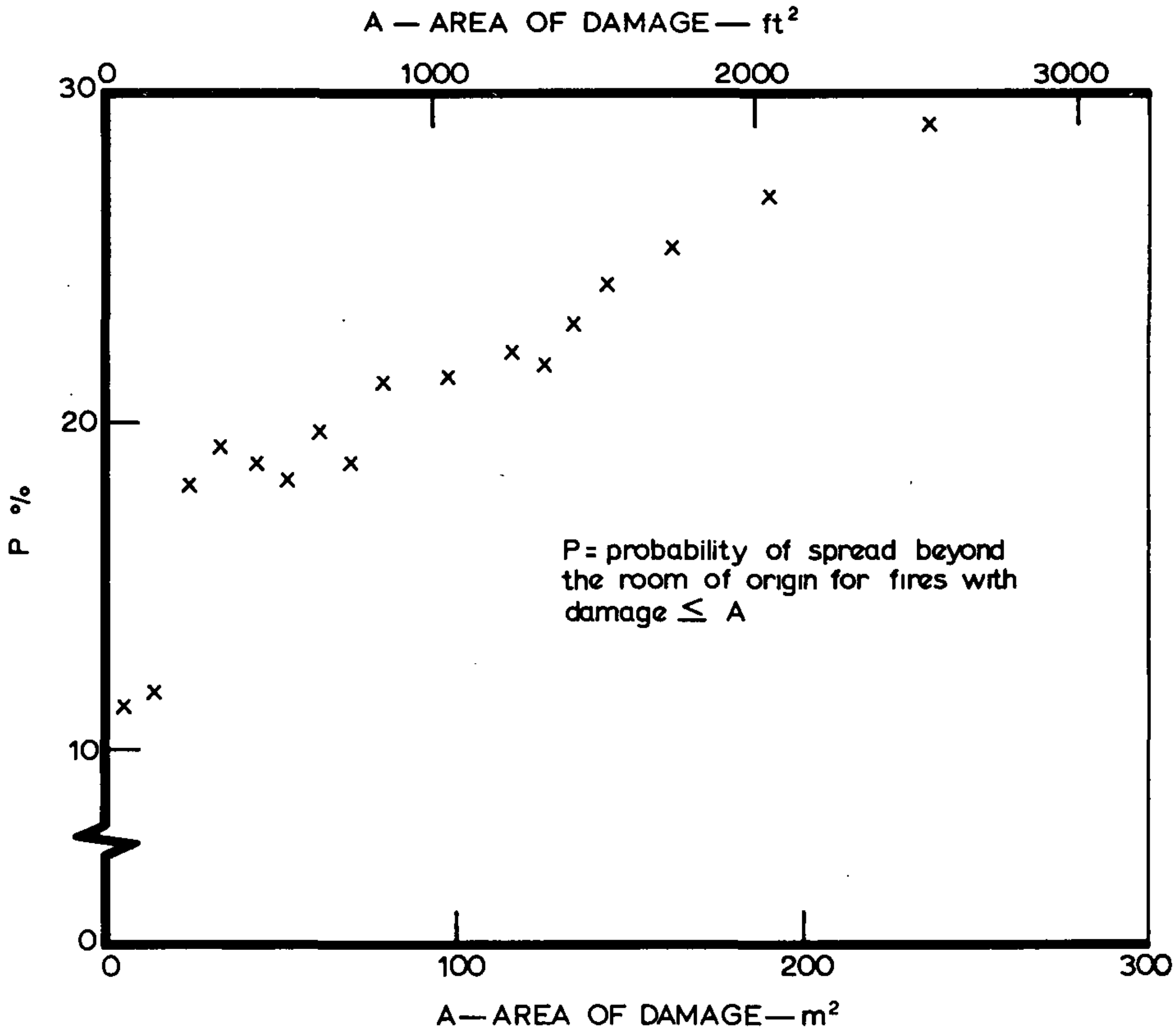

FIG. 4. CORRELATION BETWEEN THE AREA OF STRUCTURAL DAMAGE AND THE PROBABILITY OF SPREAD BEYOND THE ROOM OF ORIGIN