Resources of heat, water and carbon fluxs for an induced urban fire in 1945 Hiroshima based on field research of Japanese traditional houses

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Abstract

The amount of flammable materials in traditional Japanese houses in the Hiroshima region in the 1940s is estimated to calculate heat, water and carbon fluxes during the induced urban fire by the Hiroshima A-bomb in 1945. Traditional houses remaining in the Fukuyama region were examined to estimate the total amount of flammable resources in each house classified into three categories based on number of stories and size of the houses. Our research revealed that the kind of flammable resources is mostly pine and the density of wood was estimated to be 112 kg m^{-2} for one-story houses while it was 72 kg m^{-2} for two-story houses.

Introduction

Heat, water, carbon dioxide and black carbon fluxs during the induced fire by the Hiroshima A-bomb are important to accurate simulation of the clouds and precipitation due to the Hiroshima A-bomb. Therefore, we estimate the amounts of flammable materials such as structural wood, tatami-mats and wooden doors in traditional Japanese houses in the Hiroshima region based on field research on 10 houses.

In this paper we present 1) the kind of wood mainly used as frames of houese, 2) the total ampunt of flammable materials in each house and 3) the estimated density of flammable materials in three types of houses.

1. Methods

We measured the amount of flammable materials such as wood framing, tatami-mats and wooden doors in traditional Japanese houses in the Hiroshima region based on field research on 10 houses. The 10 houses consisted of traditional urban Japanese houses (house #s 1,2,3), farmer's houses (house #s 9, 10), big traditional residences in the countryside (house #s 5,6,7,8) and a Japanese style store house (house # 4). Six of the 10 houses were built 60 to 145 years ago. Although there were not clear data on the year of construction for 4 of the 10 houses, nevertheless, these houses are very old.

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Japanese traditional wooden house consist of a basement, floor, wallss and a roof structure as shown in Figure 1. Japanese traditional houses also universally contain straw tatami-mats and wooden doors which are also flammable materials. Therefore we measured every wooden part and integrated them to get total volumes of flammable materials in terms of m^3 for each house.

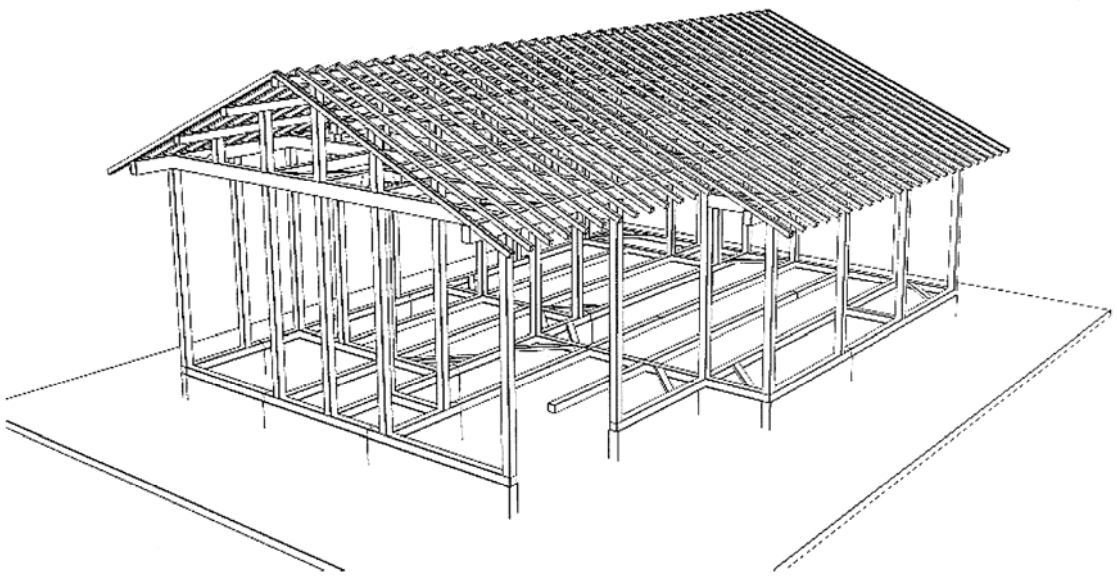

Figure 1 A structure of a typical traditional Japanese wooden house.

2. Results and discussions

Results of measurements for 10 houses are shown in Table 1 and Figure2. We also estimate the density of flammable materials for one story houses based on the measured data for houses #1 and #2 because we could not find a good example to get the density of flammable materials for one story houses that can be assumed to be like the burned houses in Hiroshima.

In the case of the house as shown in Figure 1, 1 m^3 wood was used for the basement, 2 m^3 for floor, 4 m^3 for the walls and 2 m^3 for a roof structure, respectively. We also measured straw tatami-mats and wooden doors and obtained 0.6 m^3 for tatami-mats and 0.26 m^3 for wooden doors, too. The total amount of flammable materials was estimated to be 12.75 m^3 for this house. The two results are also shown in Table 1 as house # s 11 and 12.

House #4, which is the largest one, is not built to be used as a residential house but for a store. Therefore we can assume that a density of 0.084 m^3 m^{-2} as estimated for this large one marked L in Table 1 is suitable estimate for the density of wooden schools, inns and temples in this region.

We also observed the kinds of wood used in the traditional Japanese houses and found that pine was used for the main frames of the houses in general, i.e., soft rather than hardwoods.

We can get total weights of flammable materials using a density of 0.52 x 10^3 kg m-3 for dry pine (ref's #1,#2). We obtained 112 kg m^{-2} for one story houses, 72 kg m^{-2} for two stories houses and 44 kg m^{-2} for large wooden buildings as shown in Table 2. We used the reference

density of the wood in houses times the average total volume of wood in a vertical column of one m^2 plan (horizontal) area to get estimates of areal density of wood as kg per m^2 within the floor plans of houses. To estimate total amounts of wood per unit land area for areal inventories of combustible material as input to fire fields, it will be necessary to either determine the average ratio of the area of the floor plan of a house or other building to the total land area of the lot (parcel of land) associated with that house or building, or else count the individual houses and buildings and use the per house or per building volumes in Table 1.

Table 1 Results of measurements for 10 houses and estimated results for 2 houses.

No.	Built # of years ago	# of stories	Density of wood $m^3\ m^{-2}$	Area of floor plan m^2	Total amount of wood m^3
1	60	2	0.149	112	16.7
2	unclear	2	0.127	218	27.73
3	unclear	1	0.273	116	31.7
4	unclear	L	0.084	389	32.53
5	80	2	0.168	302	50.7
6	65	1	0.142	331	46.9
7	unclear	2	0.122	287	35
8	110	2	0.220	210	46.3
9	145	1	0.181	258	46.7
10	75	1	0.067	156	10.5
11*	60	1	0.229	55.7	12.75
12*	unclear	1	0.200	119	23.82

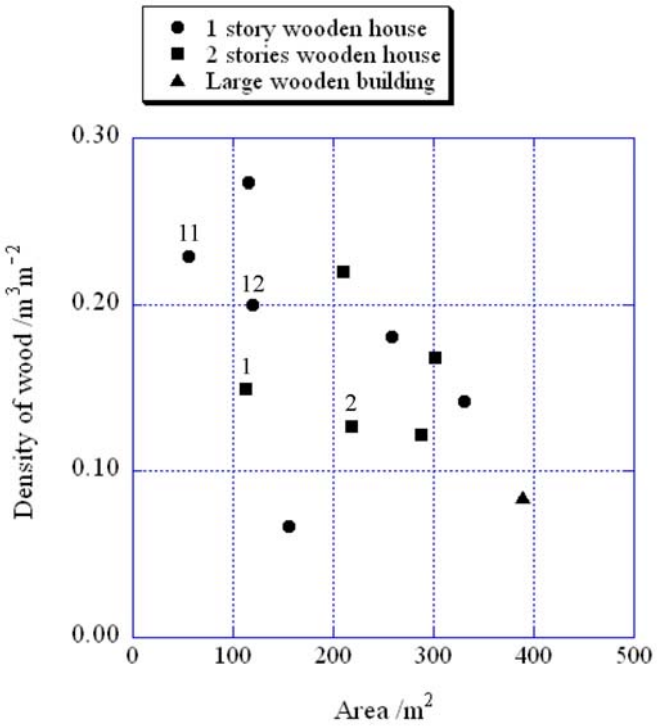

Figure 2 Area vs. Density of wood for several kind of houses/buildings

Table 2 Summary of amount of flammable materials per unit floor area in traditional Japanese houses in Hiroshima area

Type of the house	mass density kg m^{-2}	volume density m^3 m^{-2}	data source
One-story house	112	0.215	house # 11 and # 12
Two-story house	72	0.138	house # 1 and # 2
school /inn/temples	44	0.084	house # 4
previous study	45		see note *
previous study	100		see note **

*: in "Genshibakudan saigai chousa houkokusho" (1953) p136

**: in "Kuroiame ni kansuru sennmonka kaigi houkokusho" (1991)

3.Conclusions

The amount of flammable materials in traditional Japanese houses in the Hiroshima region in the 1940s has been estimated for use in calculating heat, water and carbon fluxes during the induced urban fire by the Hiroshima A-bomb in 1945. Traditional houses remaining in the Fukuyama region were examined to estimate total amounts of flammable resources in each house classified into three categories based on number of stories and size of the houses. Our research revealed that the kind of flammable materials is mostly pine and densities of flammable

materials per unit floor area are estimated to be 112 kg m^{-2} for one-story houses vs.72 kg m^{-2} for two-story houses. For the larger wooden buildings such as schools, inns and temples, the areal density of wood is estimated to be 44 kg m^{-2}. These numbers will be used to estimate boundary conditions at the ground when model simulation is done in the near future.

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