SURVEY AND ANALYSIS ON SURFACE AREA OF FIRE LOAD

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ABSTRACT

Fire spread upper floor is mostly incurred by external window flames, which depends on the generation rate of fuel volatile from combustible products in the room. The generation rate of the volatile is thought to be strongly influenced by the area of the combustible exposed to the fire environment. In order to assess the risk of the fire spread to upper floor in high-rise buildings, it is important to know the surface area of combustibles contained in building spaces in actual use. Therefore, the fire load and surface areas of the combustibles in office, hotel room, and apartment, which are considered to be dominant use of high-rise buildings, are investigated. The correlation between the fire load density and the surface area factor, of live fire load in actual use, was obtained for each of the occupancies.

Keywords : Fire Risk, Fire Load, Surface Area, and Investigation

1. INTRODUCTION

In High-rise buildings, in order to estimate risk of fire spread to upper floor incurred by external flames, it is necessary to develop the model of predication for fire behavior that can estimate the generation rate of gas of heat decomposition in the fire room. The combustible in the fire room is the one of input conditions that have an effect on the estimate results

and be a indefinite factor.

The length of external window flames in the fire room is related to the rate of heat decomposition of the combustibles. This rate depends on the total surface area of combustibles exposed to the heat transfer on the gas in the fire room.

On the fire loads, it has been proposed recommendation by the past survey¹⁾, but it can expect that the

quantity and quality of combustibles changed at the present as compared with the past as for the building uses. Harmathy has showed the calculate method of the surface area of combustible²⁾. The method holds goods the relation between weight and surface areas of furniture and so on, but it is indistinct about the propriety on the surface exposed the flames when it thinks the condition of combustibles in actual use, which furniture are put by the wall, the documents are heaped up.

Therefore, in office, hotel room, and apartment, which are considered to be dominant use of high-rise buildings, we investigate with the object of assessing the fire load and surface areas of the combustibles in actual use, and analysis the distributed condition and surface areas of combustibles.

2. CALCULATE METHOD OF COMBUSTIBLES

As adjusting the result of investigation, on this study, the fire load, the conversion value of it and the surface area factor Φ defines the following on the basis of the past method¹⁾.

2.1 Calculate Method of Fire Load

On this study, the fire load of a member per unit floor area (a value of survey) which have no regard for the kind and condition of combustibles defines the fire load density and is calculated as Eq. (1).

$$q = \frac{\sum G_i}{A} \quad (1)$$

The weight of combustible is converted the weight of timber that has equal calorific value, so each quality of combustible has its own calorific value. This is defined the equivalent fire load and the fire load is the equivalent fire load of a member per unit floor area¹⁾. On this study, the fire load defines the equivalent fire load density and is calculated as Eq.

(2).

$$q_o = \frac{\sum (G_i \cdot H_i)}{H_o \cdot A} = \frac{\sum Q_i}{H_o \cdot A} \quad (2)$$

On this study, unit calorific value of synthesis high molecule is twice as much as timber, the others, which is documents, books, wooden furniture is equal to timber¹⁾.

Moreover, on actual fire, each not only quality but also form, condition has its own calorific behavior of combustible. The fire load densities considered this behavior is defined conversion fire load density and is calculated as Eq. (3) on this study.

$$q_o' = \frac{\sum (a_i \cdot G_i \cdot H_i)}{H_o \cdot A} \quad (3)$$

On this study, the factor a_i is defined the following on the basis of the past method.

- Put away in steel furniture(attached steel door) : 0.4
- Put away in steel furniture(attached glass door) : 0.5
- Put away in steel furniture(no door) : 0.6

2.2 Calculate Method of Combustible Surface Area

The relation the weight and the surface area of usual combustibles has been proposed as Eq. (4) according to Harmathy²⁾.

$$A_f = \Phi \cdot G \quad (4)$$

According to Harmathy, the surface area factor Φ of usual combustible is defined $0.12 < \Phi < 0.18$.

3. SURVEY ON COMBUSTIBLE IN OFFICE

In consideration of the influence to fire behavior of the fire load and surface (exposure) area of combustibles, two office buildings are investigated to put emphasis on the following head.

- (1) Use and Size of the room
- (2) Quality, Size, Weight and Arrangement of furniture
- (3) Quality, Size and Weight of combustibles in furniture
- (4) Quality, Size and Weight of things on furniture or floor
- (5) Exposure condition of combustibles

3.1 Subject of Investigation

On office building, some past investigations¹⁾ exist, but at the present, the change of combustibles in office room is expected for the addition of OA and use of partitions. Then, office rooms, council rooms and so on, which are considered to be representative use, are selected and the part adjusted Table.1 are investigated. A corp.'s fifth floor plan is shown in

Table.1 Part of survey (Office)

Building	Floor	Part of Investigation	Building	Floor	Part of Investigation
A Corp.	3F	Big Hall	B Corp.	8F	Office Room
	4F	Small Council Room Mideum Council Room			Library
	5F	Office Room Reception Room Library		12F	Small Council Room A Mideum Council Room A
	11F	Dining Room		13F	Mideum Council Room B Big Council Room
	13F	OA Room		14F	Lounge(Dining Room)

Figure.1 The layout plan of investigate part (Example)

Figure.1 to give the example of layout.

On office building, some past investigations¹⁾ exist, but at the present, the change of combustibles in office room is expected for the addition of OA and use of partitions. Then, office rooms, council rooms and so on, which are considered to be representative use, are selected and the part adjusted Table.1 are investigated. A corp.'s fifth floor plan is shown in Figure.1 to give the example of layout.

3.1.1 Method of Measurement

On the weight of furniture, objects and so on, it was surveyed by the use of personal platform scale (limit: 150kg, sensitivity: 50g) or bathroom scale (limit: 100kg, sensitivity: 500g). And on the measure of those it was surveyed by the use of steel tape measure. However, in the difficult case of measurement it was conducted supplementary survey by the use of the catalog from maker and form of furniture.

3.1.2 Method of Computation

In office room, it was divided roughly from part of desk, partition and bookshelf (cf.Figure.1) and investigated each parts.

① Part of Desk

In the part of desk, it was surveyed measure, weight, quality of a few administrative positions' seat and one block (ten seats) of regular seat that is opposite type. By the way, arrangement of documents and OA apparatuses on the desk and objects on the floor around the desk draws up the layout plan (Figure.2) and investigative sheet (Table.2). It was calculated surfaces on the basis of scales written down this layout and sheet. By the above, the average value of fire loads and surface areas of a member per unit desk was computed, and total fire loads and surface areas are computed at which this value multiplied by all number of desk in sphere of survey.

Figure.2 The layout plan do desk in office (Example)

Table.2 Investigate sheet of desk in office (Example)

No.	Subject	Quality of The Lumber	Length[cm]	Width[cm]	Height[cm]	Weight[kg]
1	Document (A4size)	Paper	30	21	5	4.3
2	Document (A4size)	Paper	30	21	3	3.2
3	Document (B5size)	Paper	26	18	6	4.0
4	Filebox	Paper	30	10	21	2.5
5	Filebox	Paper	30	10	21	3.0
6	Filebox	Paper	30	10	21	1.6
7	Filebox	Paper	30	10	21	0.5
8	Filebox	Paper	30	10	21	4.5
9	Stampbox	Timber	14	10	8	0.4
10	Telephon	Plastics	23	17	4	0.4

② Part of Partition

In the part of partition, it was investigated on the part differed from its characteristic, kind of computer, copy machine, steel rack and so on. In the same way as the part of desk, it draws up the layout plan and investigative sheet, and the fire loads and surface area of a member per unit length was computed on the basis on those. On the part of similar characteristic, total fire loads and surface areas are computed at which it multiplied those values by the length of its part. But on oversize apparatus that is impossible to measure, the weight is computed at which it multiplied specific gravity of small apparatus that is possible to measure by its volume.

③ Part of Bookshelf

In the part of bookshelf, the capacity and of a member per unit bookshelf and the weight of objects was surveyed and total fire loads were computed at which it multiplied by the number of bookshelf with reference to pictures. In the surface areas, a part of exposure was surveyed and computed except the objects that store in steel furniture.

In the others (library, reception room, council room dining room), on the representative furniture, total fire loads and surface areas are computed by the same way.

3.2 Result of Investigation

3.2.1 Fire Load Density

In the office, the fire load density, equivalent fire load density, and conversion fire load density of each use of room are shown in Table.3.

① Office Room

The fire load density of office room is A Corp.: 32.1kg/m², B corp.: 28.9 kg/m². Both values are a little smaller than 34.6 kg/m² that is value of past technique type office room, and are thought that it is equal. As office desk and chair are combustible of synthesis high molecule, equivalent fire load density amplifies a little. But as almost combustibles are stored in steel cabinet and bookshelf, conversion fire load density is fairly reduced, A Corp.: 20.9kg/m², B corp.: 16.5 kg/m².

② Council Room, Reception Room

In the council room and reception room, as combustibles are sofa, table and chair, and are limited volume except a part of woody furniture, the fire load density is small, A Corp.: 6.6kg/m², B corp.: 7.5 kg/m² (both the average value). There is about the same as the past investigation.

③ Library

The fire load density of library is fairly bigger than other use of room, A Corp.: 226.0kg/m², B corp.:

Table.3 The fire load density and surface area factor Φ in office

Use of Room		Object	Fire Load Density [kg/m ²]	Equivalent Fire Load Density [kg/m ²]	Converted Fire Load Density [kg/m ²]	Φ [m ² /kg]
Office Room	Business Type	A Corp.	32.1	35.8	20.9	0.04
		B Corp.	28.9	32.9	16.5	0.03
	Technique Type	Value of Past	34.6	35.6	22.3	
Council Room Reception Room		A Corp.	6.6	6.9	6.9	0.18
		B Corp.	6.8	7.5	7.5	0.17
		Value of Past	6.9	7.8	7.0	
Library		A Corp.	226.0	226.0	226.0	0.02
		B Corp.	157.3	157.3	157.3	0.02
		Value of Past	114.4	115.5	83.1	
Dining Room		A Corp.	3.1	3.6	3.6	0.22
		B Corp.	3.0	3.5	3.5	0.23
OA Room		A Corp.	7.4	11.8	11.8	0.12

Table.4 Fire load density and surface area of each part in office

Object		Fire Load Density [kg/m ²]	Converted Fire Load Density [kg/m ²]	Surface Area [m ²]
Per Unit of Business Desk	A Corp.	50.8	49.6	2.1
	B Corp.	67.9	31.6	2.3
	Average	59.4	40.6	2.2
Per Unit Length of Partition (Average of A and B Corp.)	Part of OA	53.9	82.1	4.2
	Copy Machine	65.0	91.1	4.3
Per Unit Area of Shelf	A Corp.	95.0	38.0	1.3
	B Corp.	45.4	18.2	1.0
	Average	55.0	22.0	1.1
Per Unit Area of Library	B Corp.	65.5		1.5

157.3kg/m², for it is fully loaded with the documents over the room. There is no difference between the fire load density and the equivalent fire load density, since the documents are stored in the steel-lack that is full-open type. But the value is one and half time or two times as large as the past value.

④ Dining Room

In the dining room, the fire load density is fairly

smaller than other use of room, A Corp.: 3.1kg/m², B corp.: 3.0kg/m², for almost combustibles are limited to table and chair that is a steel leg.

⑤ OA Room

The fire load density of OA room is comparatively small, 7.4kg/m². For the most of combustibles is synthesis high molecule, the equivalent fire load density slightly grow large, 11.8

kg/m².

The fire load density, the equivalent fire loads density and the surface areas classified by furniture in sphere of survey are shown in Table.4. As office room is defined a number of furniture by the number of persons to be admitted, the case which fire loads are computed by the number of persons to be admitted not floor areas is set up the standard.

3.2.2 Surface Area

In the office room, the surface area factor Φ of fire load showed in the Table.3 is nearly equal, A Corp.: 0.04, B Corp.: 0.03. If the fire load density in both companies was the average value in the office, Φ in this survey can be thought to a standard. The value

of office room and library is fairly smaller, or the value of council room and dining room is 0.18~0.23, bigger than Harmathy's one.

It has a tendency that generally the more fire load density is large, the more value of surface area factor Φ is small. In the council room and dining room the fire load density is small but area of exposure is large, in the office room and library the fire load density is large but area of exposure is small for almost fire load is stored in the steel furniture. And the relation of the surface area factor Φ to the fire load density is showed in Figure.3, more the regression line is Eq.(5).

$$\Phi = 0.54 \times q^{-0.65} \quad (5)$$

Figure.3 The surface area factor Φ (Office)

4. SURVEY ON COMBUSTIBLE IN HOTEL

4.1 Subject of Investigation

On the hotel, for a kind or number of furniture

stored in buildings is limited, it thinks that there is little change. So with reference to the data of fire load in the past survey³⁾, the part adjusted in Table.5 was surveyed on records.

Table.5 Part of survey (Hotel)

Floor	Part of Investigation	Floor	Part of Investigation
2F	Banquet Room A (No.201)	13F	Guest Room H (No.1361)
	Banquet Room B (No.202,203)	16F	Guest Room B (No.1622)
	Banquet Room C (No.302~305)	20F	Guest Room I (No.2010)
3F	Lobby		Guest Room F (No.2017)
12F	Guest Room A (No.1204)	21F	Guest Room G (No.2120)
	Guest Room C (No.1220)	22F	Guest Room K (No.2203,2204)
	Guest Room D (No.1227)		Guest Room J (No.2226)
	Guest Room E (No.1231)		

4.1.1 Method of Measurement

In the past investigation, the weight of furniture measure by a few bathroom scale (limit: 150kg, sensitivity: 50g), the size measure by steel tape. The weight of fixed or oversize furniture is competed to multiply each volume by specific gravity.

4.1.2 Method of Computation

The fire load density was used the past survey

data³⁾. For no data on surface area was included in this data, the surface area was computed at which it is considered the plan of each room (Figure.4) and investigative sheet corresponded its plan (Table.6), the pictures, and the arrangement of furniture. Besides the measurement of furniture was used the value listed investigative sheet, and wasn't computed by the estimation except the detailed part.

Figure.4 The plan of guestroom A in hotel example³⁾

Table.6 Investigate sheet of guestroom A in hotel (example)³⁾

No.	Subject	Quality of The Lumber	Length[m]	Width[m]	Height[m]	Weight[kg]
1	Desk	Timber	0.55	0.55	0.50	13.0
2	Chair	Timber,Cloth	0.65	0.65	0.75	13.0
3	Televition	Steel,Timber	0.38	0.57	0.90	17.0
4	Side Table	Steel,Timber	0.45	0.45	0.60	16.0
5	Side Table	Timber	0.45	0.45	0.60	12.0
6	Bed		2.00	1.54	0.55	10.5
7	Bedboad	Timber	0.80	1.60	0.04	9.0
8	Floor Lamp	Steel,Timber	0.50 (Across)		1.70	4.5
9	Chair	Timber,Cloth	0.40	0.50	0.80	4.5
10	Dustbin	Steel	0.17	0.30	0.30	1.0
11	Desk	Timber	0.18	1.80	0.70	13.5
12	Refrigerator	Steel	0.44	0.48	0.70	32.0
13	Frame (Picture)	Glass,Timber	0.51	0.42	0.02	1.5
14	Wardrobe	Timber	0.71	1.49	2.10	36.0
15	Frame (Mirror)	Timber	0.03	0.63	1.40	5.0

4.2 Result of Investigation

4.2.1 Fire Load Density

According to the past investigation³⁾, in the guest room woody furniture account for about 85~95 percent of all combustibles, synthesis high molecule combustible is mainly vinyl leather and curtains, carpets that uses a sort of chair. Except the banquet rooms and lobby that chair account for almost furniture, the ratio of synthesis high molecule combustible to all fire load is less than 5 percent in almost guest room and there is no furniture that is

only steel.

In table.7, the fire load density, equivalent fire load density and conversion fire load density of each use of room is shown.

① Guestroom

The fire load density of guest room is 7.8~13.3kg/m²(the average value: 10.4 kg/m²). For a number and size of furniture differ by the size of room, the value is merely dispersed. In the distribution of fire load in guestroom shown in Figure.5, the fire

Table.7 The fire load density and surface area factor Φ in hotel

Use of Room	Fire Load Density [kg/m ²]			Equivalent Fire Load Density	Converted Fire Load Density	Φ [m ² /kg]
	Limit	Average	Standard Deviation	[kg/m ²]	[kg/m ²]	(Average)
Guest Room	7.8~13.3	10.4	1.5	10.6	10.6	0.09
Banquet Room	2.2~6.9	3.9	1.5	4.6	4.6	0.21
Lobby		2.7		1.1	1.1	0.16

load has a tendency to be in almost proportion to floor area. For there is little combustible except woody furniture in the guestroom, the equivalent fire load density is 10.6kg/m^2 and there is no difference between the survey value.

② Banquet Room

The fire load density of banquet room is small, $2.2 \sim 5.9\text{kg/m}^2$ (the average value: 3.9kg/m^2). The form of banquet and a number of users change this value, in the case of special use, the exhibition, it expects that the value fairly become large. But except the case, the combustible is limited a kind of table, chair, and it thinks that the fire load density externally be not over the sphere of the above on the contents of banquet. The equivalent fire load density become large, 4.6kg/m^2 , for it is due to the synthesis high molecule, vinyl leather that use a kind of chair.

③ Lobby

In the lobby the survey is only an example, and the fire load density is small, 2.7kg/m^2 . The equivalent fire load density cut down 1.1kg/m^2 , for the combustible is table and chair that has steel leg.

4.2.2 Surface Area

The surface area factor Φ that is shown in Table.7 are small in the guestroom and large in the banquet room as compared with Harmathy. In the same way as office, it has a tendency that the more fire load density is large, the more value of surface area factor Φ is small, and in the reverse Φ is become large. And the relation of the surface area factor Φ to the fire load density is showed in Figure.6, more the regression line is Eq.(6).

$$\Phi = 0.39 \times q^{-0.62} \quad (6)$$

Figure.5 Distribution of fire load in guestroom

Figure.6 The surface area factor Φ (hotel)

5. SURVEY ON COMBUSTIBLE IN APARTMENT

In the apartment, the fire load density and surface area were computed by the past survey data⁴⁾ based on the form of questionnaire that the quality and size of furniture and objects in the room is observed by dwellers.

5.1 Subject of Investigation

In this survey, the condition of delivery and recovery of questionnaire to dwelling intended to investigation is shown in Table.8.

Table.8 Survey object (apartment)

Subject of Investigation	Distribution	Recovery
Company House	283	275
Corporation Apartmen	1685	287
Total	1983	562

5.1.1 Method of Measurement

In the survey data, the wide, depth and height are measured in 10 centimeter by dweller on the size and shape of furniture and objects that is based on the questionnaire.

5.1.2 Method of Computation

At the questionnaire data, use of room was reclassified kitchen, dining, living (Foreign style·Japanese style), bedroom (Foreign style·Japanese style), closet, and hobby room (Foreign style·Japanese style). The data was extracted at non-restoration, and computed at each fire load by the simple method (Table.9)⁴⁾.

Further on the basis of this calculated result the dwelling units that have the average fire load were extracted ten and a few examples in the whole of survey objects, the arrangement of furniture and objects were estimated from the plan and the surface area was computed at their size that wrote down the questionnaire by dwellers.

Table.9 The simple method of fire load in dwelling

Subject	Fire Load[kg]	Fire Load[kg]
Wardrobe	$M*(V*57.87+4.27)$	$K*V*39$
Bureau	$M*(V*93.8-2.97) (V \geq 1)$	
Another	$M*(V*89.7) (V < 1)$	
Booksheif	$M*(V*93.85-5.87) (V \geq 0.125)$ $M*(V*76.6) (V < 0.125)$	$K*V*316$
Cupboard		$V*56.4$
Sideboard		
Boot Cupboard		
Knee-hole Desk	57.4	20.0
Reception Table	13.8	
Side Table		
Dining Table	$N*5.8$	
Chair	5.5	
Bed (Single Size)	$M*(52.9-11.7)+11.7$	
Bed (Dowble Size)	$M*(89.8-22.6)+22.6$	
Carpet	$N*2.85$	
Buddhist Aitar	$V*128.34-10.11 (V \geq 0.15)$ $V*111.1 (V < 0.15)$	
Piano	163.0	

V: Volume [m³]

K: Degree of Store

K=1.0; Full, Ignorance

K=0.75; 3/4

K=0.5; Under 1/2

M: Quality

M=1.0; Woody, and Other, Ignorance

M=0.0; Steel

5.2 Result of Investigation

5.2.1 Fire Load Density

In this investigation, for each room was classified, the fire load density and surface area was computed on the basis of the questionnaire data⁴⁾. For the questionnaire greatly depends on the subjectivity of writer, the consistency of data is open to question. But there is large number of data, so it thinks that the whole tendency generally can be known.

According to Table.10 shown in the fire load density in each room of use, in the apartment, the fire load density sees to disperse covering a wide area. The average of fire load density is 44.1~58.0kg/m² in bedroom, hobby room and closet, and fairly is large compared with the value of kitchen, dining, living(23.0~34.9kg/m²). Still more in Figure .7 shown

on living (foreign style) for example of distribution of fire load, the fire load necessarily be proportional relation to floor area. And in living, bedroom, hobby room, both Japanese and foreign style rooms closely resemble, so they specially be always to distinguish. But in hobby room, as classification in the room of use, the purpose of use isn't clear and is similar to the value of closet, so hobby room is no problem to think the same term to closet. Since the use of room in apartment divide roughly into five types, kitchen, dining, living, bedroom and closet.

Still more analysis including factor, a number of dweller, a term of dwelling, user of room and so on is thought the effective data that estimates the fire load density.

Table.10 The fire load density and surface area factor Φ in apartment

Use of Room		Fire Load Density [kg/m ²]			Φ [m ² /kg] (Average)
		Limit	Average	Standard Deviation	
Kitchen (K)		0~113.1	23.0	17.5	0.04
Dining (DK,LDK)		0.9~149.4	28.0	19.5	0.10
Living Room	Japanese Style	7.5~121.1	34.9	25.1	0.12
	Foreign Style	1.5~82.6	30.8	16.1	
	Total	1.5~121.1	32.3	19.9	
Bed Room	Japanese Style	10.5~97.7	44.1	18.6	0.07
	Foreign Style	16.5~101.2	46.4	22.7	
	Total	10.5~101.2	44.6	19.7	
Hobby Room	Japanese Style	1.0~218.9	55.0	38.3	0.05
	Foreign Style	4.0~277.3	58.0	32.4	
	Total	1.0~277.3	56.2	34.8	
Closet		1.0~211.1	55.5	32.6	0.05

Figure.7 Distribution of living room (foreign style)

5.2.2 Surface Area

The surface area factor Φ shown in Table.10 is 0.04~0.12, the whole use of room in apartment is smaller than the value of Harmathy. The relation between the fire load density and Φ has a tendency

as good as office, hotel. As a result of revolution, living is Eq.(7), bedroom is Eq.(8), and the case of unification on the whole use of room is Eq.(9).

$$\text{Living Room} : \Phi_{\text{Living}} = 6.19 \times q^{-1.11} \quad (7)$$

Figure.8

$$\text{Bed Room} : \Phi_{Bed} = 0.77 \times q^{-0.73} \quad (8)$$

$$\Phi_o = 0.54 \times q^{-0.65} \quad (5)$$

$$\text{Whole} : \Phi_{Whole} = 0.61 \times q^{-0.64} \quad (9)$$

6. SUMMARY

If the fire load density by way of the input term to the model of fire prediction for fire behavior that is the purpose of this investigation is used, it is effective that the fire load are computed at the value of Table.3, 7, 10. And the surface area factor of combustible in three uses of building is 0.02~0.23, is the wider area than the value of Harmathy, $0.12 < \Phi < 0.18$.

As a result of this investigation, the relation between the fire load density q and the surface area factor Φ has a inverse proportional tendency that the more q is large, the more Φ is small, the other way, the more q is small, the more Φ is large, and is shown in Figure.9.

In the office, there is a difference in the fire load density at each use of room, but it is Eq.(5) that the relation between q and Φ is revolved.

And in the hotel, the fire load is in proportion to the floor area, and the relation between q and Φ is shown in Eq.(6).

$$\Phi_H = 0.39 \times q^{-0.62} \quad (6)$$

Still more, in the apartment, the fire load isn't in proportion to the floor area as hotel, the relation between q and Φ is shown in Eq.(9).

$$\Phi_A = 0.61 \times q^{-0.64} \quad (9)$$

But, in each use of room, a number of sample is biased and there is a difference in the fire load density, but the relation between the fire load density and the surface area factor Φ resembles. So, in future, it needs to investigate, increase a number of data and estimate with. Then it thinks that generally the surface area factor can be computed at the fire load density.

Figure.9 The surface area (classified by use)

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NOMENCLATURE

A	Floor Area of Fire Room (m^2)
A_f	Surface Area of Combustibles (m^2)
a_i	Coefficient defined by Form of Combustibles
G	Total Weight of Combustibles (kg)
G_i	Weight of Combustibles (kg)
H_i	Unit Calorific Value of Combustibles (kJ/kg)
H_o	Unit Calorific Value of Timber (kJ/kg)
q	Fire Load Density (kg/m^2)
q_o	Equivalent Fire Load Density (kg/m^2)
q'_o	Conversion Fire Load Density (kg/m^2)
ΣQ_i	Total Calorific Value of Combustibles in

Fire Room (kJ)

 Φ Surface Area Factor (m^2/kg)

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