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Survey Results of Combustible Contents and Floor Areas in Canadian Multi-Family Dwellings

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Abstract

This paper presents the results of a survey of floor areas and combustible contents in multi-family dwellings such as semi-detached houses, town houses and low-rise apartments. The survey was primarily based on measurements and photographic information obtained from real-estate websites. This is a novel method, which reduces the effort required to conduct fire load surveys in residential buildings. In addition to quantifying combustible contents, an important objective of the survey was to determine the similarities in combustible contents and configurations of these dwellings, which could be used in designing fire experiments. The survey provided an insight into the types and quantity of combustible contents found in the dwellings, as well as the types of floor configurations and other information that are pertinent to fire issues. Typical furnishings that constituted a significant portion of the movable fire load were identified and possible values of fire load densities were calculated for rooms such as: kitchens, dining rooms, living rooms and bedrooms.

The average fire load densities in various rooms were estimated to be: kitchens – 807 MJ/m^2; dining rooms – 393 MJ/m^2; living rooms – 412 MJ/m^2; basement living rooms – 288 MJ/m^2; primary bedrooms – 534 MJ/m^2; and, secondary bedrooms – 594 MJ/m^2. Although kitchens had the highest fire load densities the actual fire load (heat content) was found to be lower than bedrooms, which have a higher fire load due to the presence of mattresses, clothing and carpeting.

Keywords: Fire load density, Fire load survey, multi-family dwellings, combustible contents, fire experiments

1 Introduction

This paper presents the results of a survey of floor areas and combustible contents in multi-family dwellings such as semi-detached houses, town houses and low-rise apartments, as part of the Characterization of Fires in Multi-Suite Residential Dwellings (CFMRD) project, which seeks to characterize fires in these buildings and ultimately develop methods for use in fire safety engineering analysis and design. There are three distinct dwellings of interest in the CFMRD project, namely multi-family residential dwellings, residential care dwellings and secondary residential suites. This paper only discusses results for semi-detached houses, town houses and low-rise apartments. Detailed results of the survey in all of these dwellings have been published elsewhere [1]. For the purpose of the project, the term "multi-suite" reflects the fact that the three types of residential dwellings share a common attribute in that they all consist of multiple suites. Therefore, in addition to quantifying combustible contents an important objective of the survey was to determine the similarities in combustible contents and configurations of these dwellings, with a view to designing an optimized experimental program with generally applicable results.

Information on the configuration of rooms in a building and their combustible furnishings is an essential requirement in any effort to characterize a fire. Therefore, the surveys focused on combustible furnishings in key rooms, such as the kitchen, living room and bedroom, in which fires are more likely to originate.

The survey was conducted over a period of six months using information collected from a real estate web site, which lists homes for sale. Various websites around the country were considered in the survey. However, many did not have the information structured in the form required for the survey. Therefore, the survey was primarily based on information from the Grapevine website [2] in Ottawa, which had all the required information, such as room dimensions, floor plans and photographs of room furnishings.

2 Literature Review

Many published fire load surveys have shown that fire loads in houses vary greatly, even within the same geographical location. Up-to-date information on fire loads in residential buildings is scarce and much of the available data often lack detailed information about attributes such as floor area, window sizes and material composition, which is important in characterizing fires. The scarcity of fire load data is largely because fire load surveys are laborious and difficult to organize. For example, in the USA, a survey conducted in 1980 [3] reported that the previous survey was conducted in the 1930s, almost 50 years ago from that date! The survey conducted in 1980 covered 359 housing units and was carried out by 62 students.

A comprehensive list of fire load data was published by CIB W14 [4] for a wide range of occupancies, from which the values in Table 1 are extracted.

Table 1. Fire Load Energy Densities [4]

Occupancy type	**Fire load per unit floor area (MJ/m^2)**
Basement, dwellings	900
Homes	500
Hospital	300
Hotel	300

Buchanan [5] reported that the New Zealand Building Code recommends design fire loads of 400, 800 and 1200 MJ/m^2 of floor area for residential, office and retail occupancies, respectively with a requirement that storage areas be assessed separately. Some fire load densities found in the literature are given in Table 2.

Table 2. Published fire load densities for residential occupancies

Country	**Fire load density (MJ/m^2)**	**Year and References**	**Notes**
US	450	1980 [6]	Survey of basement recreation rooms in 200 single family detached homes
US	500	1980 [6]	Survey of 70 residential recreation rooms
Sweden	600	1983 [7]	-
New Zealand	724 (SD[1] 107)	2000 [8]	Four bedrooms in flats (apartments) with mean floor area of 9.3 m^2
Japan	670	1965-1988 [9]	Survey of 214 homes
Canada	410 (SD 230); 360 (SD 210)	2004 [10]	NRC Canada, values for main floor and basement living rooms

[1] SD: Standard deviation.

The residential survey conducted in the USA in 1980 included information on the composition of the fire load and percent of floor area covered. The composition of the fire load was approximately: Wood and paper (70%), Plastics (21%), fabrics (9%) and other materials (1%). The averaged covered floor area was around 30%. Floor areas for various rooms were reported as follows: kitchen (10.5 m^2), dining room (11.2 m^2), living room (20.6 m^2), family room (17.6 m^2) and bedroom (11.8 m^2).

3 Survey Methodology

Surveys are traditionally conducted by physically entering a building and listing the contents and their pertinent characteristics. However, this method is laborious, time consuming and for residential dwellings, in particular, progress can be hampered by privacy concerns, and hence the need for alternative approaches. Surveys conducted at NRC [10, 11] in living rooms demonstrated that using a questionnaire produced reasonable results. However, one of the main disadvantages of a questionnaire is that the results are largely qualitative since the accuracy and consistency of the information provided by respondents cannot be verified.

In this work, an internet-based survey was utilized in order to circumvent the drawbacks associated with the traditional and questionnaire surveys. In the context of this survey, the term ‘living room’ includes family rooms that may be located on the basement level.

4 Internet-Based Survey

Homes for sale are commonly listed on well-organized real estate websites, which are managed by realty firms. The listings were usually complete with the dimensions (likely taken from original floor plans) of all major rooms in the house and in some cases floor plans are also provided. In addition, and most importantly for the purpose of conducting a fire load survey, homeowners wishing to sell their property usually provide digital photographs of various rooms, which show furnishings and their layouts. Figures 1 and 2 show examples of photographs provided with such real estate listings.

Figure 1. Photograph of a 12.3 m^2 basement recreation room obtained from a real estate website

Figure 2. Photograph of a 11 m^2 secondary bedroom obtained from a real estate website

However, this method also has some limitations, such as:

1) The photographs often show a single view and all of the furnishings and some relevant details may not always be visible. This was particularly so for the bedrooms, where typical furnishings and contents such as dressers, drawer chests and clothing were not always visible in some photographs.
2) Many photographs show tidy room settings in an obvious effort by the seller to portray a positive image, whereas in reality some degree of clutter would be expected to occur (at times) in some areas of a house.
3) Calculation of fire load density is based on estimated weights and calorific values of representative furniture items, since physical weighing of the furnishings is not possible.

Despite these limitations, this approach is expected to provide a good insight into the typical furnishings and likely fire load densities in residential dwellings given that these dwellings are otherwise inaccessible for the purpose of fire load surveys.

The rooms covered in the survey were: 1) kitchen; 2) dining room; 3) main living room (main floor); 4) basement living room; 5) master bedroom; 6) second bedroom; 7) third bedroom. In this report, the master bedroom will be referred to as the primary bedroom, whereas the second and third bedrooms will be termed secondary bedrooms. Secondary bedrooms are normally occupied by children or used for other purposes such as a home office.

5 Calculation of Fire Load Density

The quantity of movable combustibles in a compartment is commonly expressed as the total heat energy (units in MJ) that can be released through complete combustion, and will be referred in this work as fire load (FL), which is essentially the potential heat energy that can be liberated during the combustion process. The FL is commonly expressed as an energy density (fire load per unit floor area in MJ/m^2) and referred to as the fire load density (FLD). The fire load is also sometimes referred to as the fuel load. At times, the contribution of the combustible parts of the building structure (the fixed fire load) is included in the total fire load. However, this survey was only concerned with the movable fire load, which consists of any contents that are not part of the building structure, such as furnishings and other personal belongings.

Where possible, published data on heat of combustion [12 - 14] were used in the calculation of the fire loads. Weights, dimensions and the composition of representative furniture items, flooring finishing materials and other assumptions used in survey calculations are presented in a separate publication [1]. The sub-floor material was not included in the calculation since this is considered to be part of the building structure and is therefore, a fixed component of the total building fire load. A computer algorithm was used to calculate the fire load density for each room. The input files for the program contained room dimensions, combustible contents (noted from the photographs) and weights and heat of combustion values for furnishings.

5.1 The Method

The data collected was processed using a computer algorithm. Separate spreadsheet data files containing the following information from the survey were created: 1) Room dimensions; 2) Combustible contents; and 3) List of 165 reference combustible items. The procedure is illustrated for the living room shown in Figure 3, which was found in sample no. 13.

Table 3 shows the structure of the spreadsheet which contained the list of reference combustible furnishings. The list contained information about the mass of the combustibles and calorific values used in the calculations. The type of house and dimensions of rooms for each sample were entered as shown in Table

4. In the case of combustible contents, ten of the most significant items were entered into the spreadsheet for each room, as shown in Table 5. Three rows in the spreadsheet were used to record the combustible contents, their quantities and size attributes.

Figure 3. Photograph of a living.

Table 3. Structure of input file with weight and heat of combustion values for the living room shown in Figure 3.

Item #	**Furniture Type**	**Relative Size**			**Calorific Value**
		1 - Small	2- Medium	3- Large	Medium Value
3	27 inch CRT TV	35.0	35.0	35.0	25
10	Area rug	5.0	15.0	30.0	20
25	Chair - wooden no padding	8.0	10.0	12.0	18
28	Chair leather	12.0	26.8	37.1	20
44	Drawer chest	66.3	74.5	82.6	18
47	Entertainment unit	37.5	61.5	85.5	18
48	Fabric folding chairs	5.0	5.0	5.0	20
86	Side table	15.5	22.9	33.8	20
90	Sofa (3 seat)	52.5	57.2	65.5	20
110	Hard wood flooring	2.1	2.1	2.1	18
147	Assorted plastic decorations	2.0	2.0	2.0	20

Table 4. Structure of input file with room dimensions.

			1-Living Room		**2-Dining Room**	
Sample #	**ID[1]**	**Type[2]**	**L**	**W**	**L**	**W**
13	10347	5	4.4	3.5	2.3	3.0
14	10394	1	5.6	3.4	3.4	2.8
15	10455	2	5.2	3.8	3.2	2.8

[1] Listing identification number provided on the website; [2] Type of house (1 – Townhouse; 2 – Semi-detached; 3 – High rise apartment; 4 – Duplex; 5 – Condominium low-rise apartment)

Table 5. Structure of input file with combustible contents from the survey.

	1-Living Room										2-Dining Room, etc.
	1	2	3	4	5	6	7	8	9	10	
13[1]	90	3	47	10	28	43	25	110	147	86	
OTY	1	1	1	1	1	1	1	1	12	1	
Size	3		3	2	2	2	2	2		2	
14											
OTY											
Size											

[1] Sample #

To process the data, the computer algorithm read the structured input files and calculated the necessary output.

5.2 Uncertainties

All surveys regardless of the methodology have a degree of uncertainty due to the many assumptions and approximations made in the measurements and calculations since in many cases it is not practical to directly weigh every combustible item in a building. In physical surveys using an inventory technique, measurement errors have been reported to be about 10% [3], whereas the errors between different surveyors were of the order of 15% to 20%.

It is the authors' opinion that reasonableness (of assumptions) plays an important role in the interpretation and use of information from fire load surveys such as this one. Therefore, the focus of this survey was not to assign specific levels of accuracy to numerical values, but rather to provide reasonable estimates of the likely magnitude of fire load densities and typical combustible contents in various areas, given that residential dwellings are otherwise inaccessible for fire load surveys. However, many of the typical furniture items used in calculating fire load densities were weighed accurately to better than +/- 0.1 kg during actual surveys of furniture stores [1].

6 Results

The number of homes surveyed from the Grapevine website was 515. A breakdown of the types of homes found in the survey is shown in Figure 4.

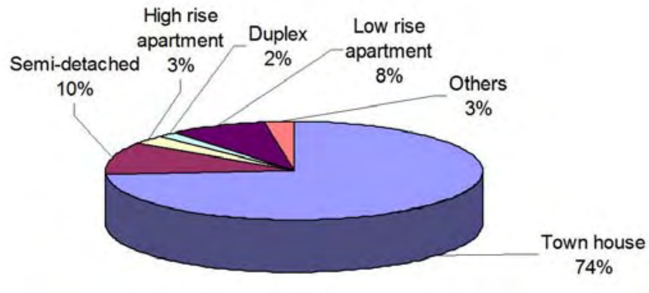

Figure 4. Types of homes found in the Grapevine survey

The largest proportion (74 %) of the homes was town houses. The average age of a random sample of 201 homes in the survey was 16 years with a standard deviation of 13 years. The ages of the homes ranged from 83 years (built in 1925) to 1 year (built in 2007).

6.1 General Layout (Analysis of floor plans)

Analysis of photographs and 53 floor plans collected from the Grapevine website revealed that the predominant layout of the main floor was of the so-called 'open-concept' design, which means that the kitchen, dining room and living room on the main floor are mainly interconnected spaces without full-height (floor to ceiling) wall separations. The second floor is typically partitioned into bedrooms each having a doorway that leads to a common corridor. A portion of the floor area on the second floor accommodates a bathroom, closets and the staircase leading to the lower floor. The configuration of the basement level was the most varied among all of the floors. Typical layouts included a single recreation area or compartmented areas for various uses.

6.2 Floor Areas

Table 6 gives the statistical results of the distribution of floor areas of various rooms. The results show that: 1) basement living rooms are typically larger than all other rooms in a dwelling; 2) living rooms on the main floor and the master bedroom are of comparable intermediate size; and 3) secondary bedrooms, the kitchen and dining room are of a comparable small size. The average aspect ratio (length divided by width) was found to be about 1.1. As the main-floor in dwellings was of open-concept design, the mean and standard deviation of complete main floor areas (kitchen, dining and living room) was 34.8 m^2 and 7.6 m^2, respectively. The areas ranged from 22.0 m^2 to 62.0 m^2. The results for

Ottawa were found to be comparable with those for other cities in other Canadian provinces [1].

Table 6. Statistical results for floor areas of rooms in a multi-family dwelling in Ottawa.

Room	Average Area (m^2)	Standard Deviation (m^2)	Minimum (m^2)	Maximum (m^2)	Sample Size
Kitchen	9.8	3.6	3.6	28.2	515
Dining room	9.7	2.3	4.2	21.2	415
Main living room	17.6	4.3	6.1	33.2	494
Basement living room	23.2	9.0	6.7	64.7	295
Primary bedroom	16.6	3.7	7.2	27.3	521
Secondary bedroom 1	10.5	2.0	6.1	26.5	514
Secondary bedroom 2	9.5	2.2	6.0	21.7	402

6.3 Fire Load Densities

Table 7 shows the calculated fire load densities for four rooms. The results show that kitchens have a significantly higher fire load density (mean of 807 MJ/m^2) than any other area in a home due to a combination of the heavy wooden cabinets and a small floor area. This result is in good agreement with the results of a survey of single-family dwellings conducted in the USA [3], in which the highest fire load densities were found in kitchens and storage areas, although the values were reported to be higher than 1,000 MJ/m^2.

After kitchens, bedrooms, and in particularly secondary bedrooms (mean of 594MJ/m^2 compared to 534 MJ/m^2 in primary bedrooms), had the next highest fire load density. The higher mean fire load density obtained in secondary bedrooms is due to their smaller mean floor area (10.5 m^2) compared to primary bedrooms (16.7 m^2), yet both rooms contain similar furnishings albeit of different configurations, sizes and quantities. Basement living rooms had the lowest mean fire load density (288 MJ/m^2) among all the rooms, which can be attributed to their higher mean floor area (23.2 m^2) compared to main floor living rooms (17.6 m^2) and primary bedrooms (16.7 m^2). This is consistent with observations from the photographs that basement living rooms were generally more spacious, less crowded with furniture and had more floor area that was unoccupied by furniture compared to all other rooms.

Table 7. Fire load densities for various rooms

Room	Mean FLD (MJ/m^2)	Standard Deviation (MJ/m^2)	95^{th} Percentile	Sample Size	Mean FL (MJ)
Kitchen	**807**	**123**	**940**	**515**	**7,908 (2)***
Secondary bedroom	**594**	**146**	**846**	**129**	**6,237 (5)**
Primary Bedroom	**534**	**125**	**753**	**347**	**8,864 (1)**
Living Room	**412**	**127**	**610**	**397**	**7,251 (3)**
Dining Room	**393**	**132**	**576**	**292**	**3,812 (6)**
Basement Living Room	**288**	**96**	**450**	**130**	**6,682 (4)**

* () FL ranking FLD: Fire load density; FL: Total fire load

Since the area of different rooms differs greatly, the fire load density alone may not be a particularly good indicator of the likely impact of a fire given that a large room with lower fire load density may contain a greater overall quantity of combustible materials (greater fire load) than much smaller rooms having high fire load densities, as shown by the comparison of rankings based on mean fire load density (FLD) and fire load (FL), which is given in Table 8.

Table 8. Ranking of rooms based on the mean FLD and FL.

Room	Ranking based on: Mean FLD (MJ/m^2)	Mean FL (MJ)
Kitchen	1	2
Secondary bedroom	2	5
Primary Bedroom	3	1
Living Room	4	3
Dining Room	5	6
Basement Living Room	6	4

FLD: Fire load density; FL: Fire load

Whereas the primary bedroom ranks third in terms of fire load density, it ends up in first position in terms of fire load. Another interesting case is the secondary bedroom, which drops from second position (FLD ranking) to fifth position in the FL ranking order. Under comparable fire growth and ventilation conditions, rooms with a greater fire load are likely to result in fires having a longer duration and a more severe impact.

The frequency distribution of fire load density in all the rooms is shown in Figures 5-10. All of the rooms have lightly positively skewed (median close the mean) distributions with the exception of the kitchen, which has a prominently negatively skewed distribution. A positively skewed distribution has more observations of low frequencies above the median than below it, whereas a negatively skewed distribution is the opposite.

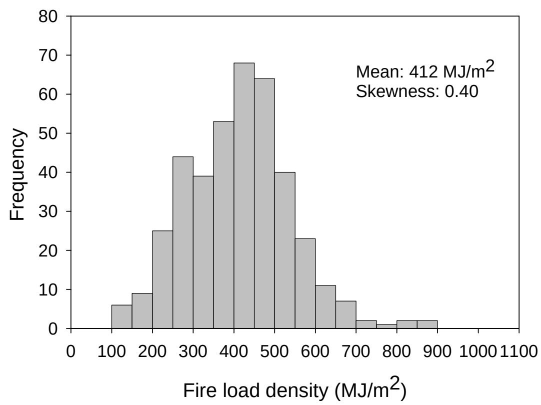

Figure 5. Distribution of fire load density in living rooms (SD = 127 MJ/m^2)

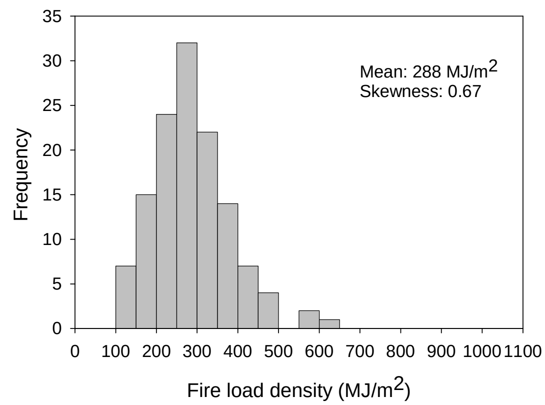

Figure 6. Distribution of fire load density in basement living rooms (SD = 96 MJ/m^2)

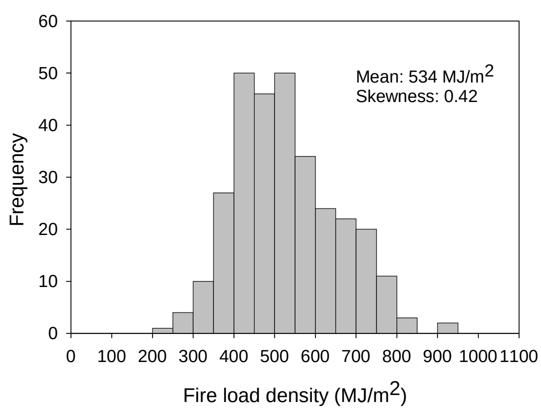

Figure 7. Distribution of fire load density in primary bedrooms (SD = 125 MJ/m^2).

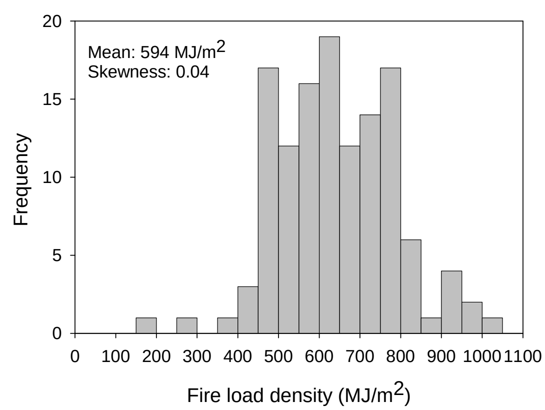

Figure 8. Distribution of fire load density in secondary bedrooms (SD = 146 MJ/m^2).

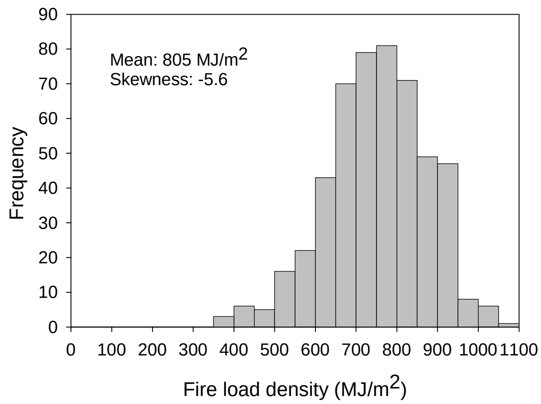

Figure 9. Distribution of fire load density in kitchens (SD = 123 MJ/m^2).

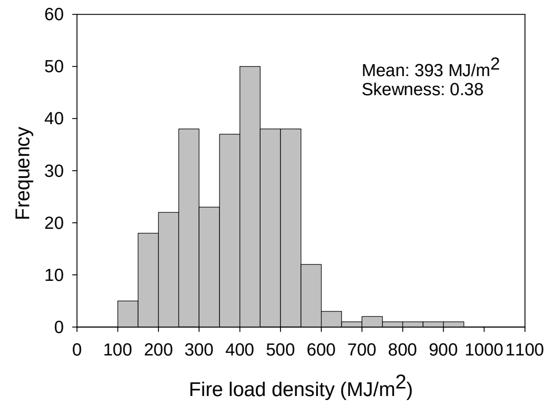

Figure 10. Distribution of fire load density in dining rooms (SD = 96 MJ/m^2).

6.4 Variation of Fire Load Density with Floor Area

Figures 11-14 show graphs of fire load density against the floor area. The graphs show a considerable amount of scatter with a distinct trend that higher values of fire load density are found at small floor areas. The scatter also indicates that the variation of fire load density is somewhat random, since vastly different values can be found for the same floor area.

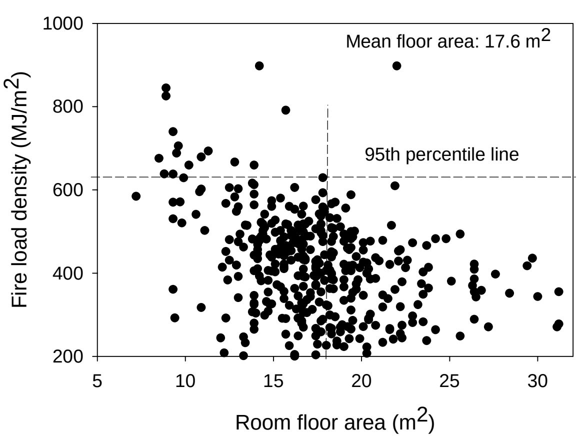

Figure 11. Variation of fire load density with floor area in main floor living rooms

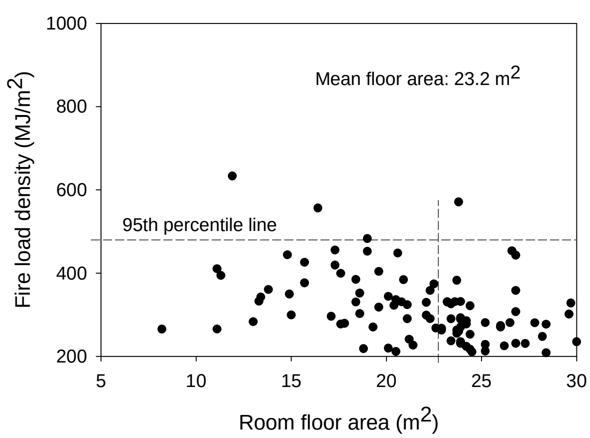

Figure 12. Distribution of fire load density in basement rooms

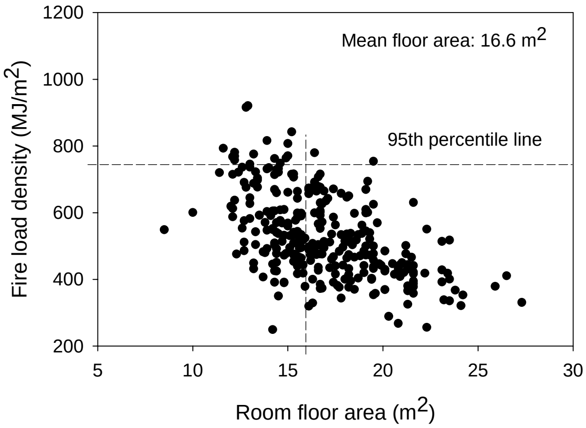

Figure 13. Variation of fire load density with floor area in primary bedrooms

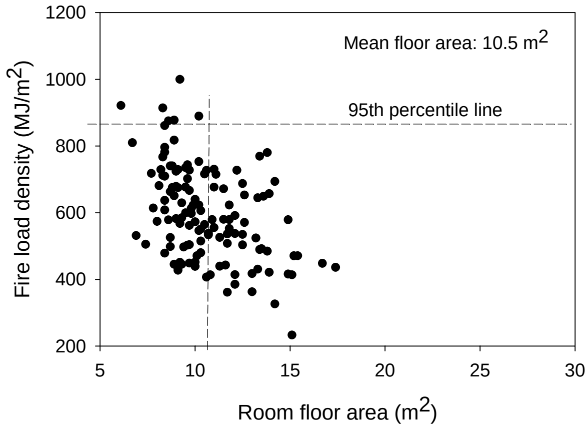

Figure 14. Distribution of fire load density in secondary bedrooms

6.5 Composition of Fire Load

Table 9 gives the composition of the combustible contents in all of the rooms broken down into three main material groups: wood and paper (cellulose-based), synthetic plastics and textiles (or fabrics). It is evident from these results that wood-based materials form a significant proportion of the total combustible mass in every room, particularly in kitchens (86.5%), dining rooms (72.6%) and living rooms (65.8%).

Table 9. Composition of the fire load

Room	Percent Weight		
	W	**P**	**T**
Kitchen	86.5	13.5	<<1%
Living Room	65.8	32.9	1.4
Dining Room	72.6	26.6	0.8
Primary Bedroom	42.3	26.4	31.4
Secondary bedroom	39.8	29.8	30.3
Basement Living Room	61.0	39.0	0.2

W: Wood and paper; P: Plastic materials (including PUF);
T: Textiles (including clothing); <<1%: much lower than 1%

The higher percentage of wood in kitchens and dining rooms is due to the presence of large wooden furnishings and fittings – kitchen cabinets and dining sets (table, display unit and hutch). In dining rooms, a considerable portion of the combustible plastic mass comes from carpeting given that dining chairs only have a small amount of polyurethane foam on the seat and backrest sections. The percentage of wood in living room appears to be high relative to plastics largely due to the popularity of hardwood flooring (Table 10). The sub-floor material (typically an engineered wood board) was not taken into account.

As for bedrooms, the weight distribution is markedly different from all other rooms because textiles (clothing) constitute a significant portion (about 30%) of the combustible mass. However, wood still claims the largest proportion (about 40%) of the combustible mass. The overall percentage of wood-based (cellulose) materials may actually be greater if clothing were to be divided up into synthetic and cotton materials – it is estimated that 50% of clothing will be cotton, a cellulose material. In all cases, Table 9 shows that the percentage contribution of the plastics to the total fire load (MJ) increases proportionately since plastics have higher calorific values than wood-based materials.

The survey revealed considerable variations in the types and arrangements of furnishings found in residential dwellings, which reflects the unique nature of every occupant. While all of the rooms contain a group of furnishings that characterize the use of the room, secondary bedrooms and basement living rooms were found to contain a greater variety of furnishings than other rooms. The detailed listing of the contents of the rooms surveyed is presented elsewhere [1].

6.6 Floor Coverings

The distribution of floor covering materials in various rooms is given in Table 10. Hardwood and laminate flooring are popular in living rooms (63%) whereas carpeting is the most commonly used floor covering in bedrooms (67% and 77%) and basement living rooms (88%). Vinyl flooring was very common (75%) in kitchens. The percent reported as unknown in kitchens is most likely ceramic flooring since the non-combustible flooring materials were not documented. In most cases, dining rooms were observed to have the same floor finishing material as living rooms since these are interconnected areas on the same floor. The results for living rooms are in good agreement with a previous survey [11] in which it was found that usage of hardwood and carpeting floor finishing was 49% and 41% , respectively.

Table 10. Distribution of floor covering materials in various rooms

Floor covering	Kitchen	Living room	Primary Bedroom	Secondary Bedroom	Basement living room
Carpet	0%	33%	77%	67%	88%
Hardwood	7%	63%	17%	18%	11%
Vinyl	75%	4%	0%	1%	1%
Unknown	18%	-	6%	14%	-
Sample size	241	396	347	143	129

6.7 Combustible Wall or Ceiling Finishes

There were very few cases (about 1% - only six cases) where combustible wall or ceiling finishing materials was found and 60% of these cases were basement living rooms. Figures 15 and 16 show two such cases, one with a combustible ceiling finish and the other a combustible wall finish consisting of wood panels. Combustible wall and ceiling finishes were included in the calculation of fire load densities for these cases.

Figure 15. Combustible (wood) ceiling finish

Figure 16. Combustible (wood) wall finish

6.8 Validation of the Survey Method

The method was partially validated by using data from a room set up for a fire experiment conduct in the “Characterization of Fires in Multi-Suite Residential Dwellings” project [14]. A test room with a floor area of 16 m^2 was furnished to simulate a medium-sized residential primary bedroom. All the furnishings in the test room were weighed and the fire load density was calculated to be about 790 MJ/m^2. The known mass of combustibles was compared with the estimated fire load density obtained by “blindly” entering the contents and their attributes into the computer algorithm that was developed to process the data collected from the real estate websites. The input data for the fire load calculation are given in Tables 11 and 12.

Table 11. Combustible contents entry data for the validation exercise.

Test Bedroom										
	1	2	3	4	5	6	7	8	9	10
526	81	19	16	105	44	43	134	21	80	66
OTY	1	1	20	1	1	1	1	100	1	1
Size	2	2	2	2	2	2	2	2	1	1

Table 12. Reference weight and heat of combustion values for the test case.

Item #	Furniture Type	Relative Size			Calorific Value
		1 - Small	2- Medium	3- Large	(MJ/kg)
16	Book	0.5	1.0	2.0	18
19	Carpet and under-pad (kg/m^2)	3.1	3.9	4.3	26
21	CD case	0.3	0.3	0.3	20
43	Drawer chest	47.9	54.8	60.0	18
44	Dresser	66.3	74.5	82.6	18
66	Night table	17.2	26.0	49.0	20
80	Printer	5.0	8.0	10.0	20
81	Queen bed	44.3	57.6	134.9	20
105	Wardrobe/ armoire	41.8	46.6	51.5	18
134	Book case	30.0	50.0	70.0	18

The original input files for the weight and heat of combustion values were not modified. The fire load density was estimated to be 700 MJ/m^2, which is about 10% less than the actual measured value of 790 MJ/m2.

7 Conclusions

This survey method provided a substantial insight into the types and quantity of combustible contents found in residential dwellings, as well as the types of floor configurations and other information that are pertinent to fire issues. The results of the survey provided the basis for designing a test facility and fire experiments for the CFMRD project. Typical furnishings that constituted a significant portion of the movable fire load were identified and possible values of fire load densities were calculated.

The fire load densities calculated using this method are within the range of values found in the published literature, although most of this data is scarce and out of date. The method was partially validated by conducting a calculation using data from an actual room setup. However, further work is needed to fully validate the method using other real cases.

Some of the main findings from this survey are that:

1) The main floor in a residential dwelling is of the open-concept design (not compartmented), whereas the upper floor(s) containing bedrooms are highly compartmented. Basements have a combination of an open-concept layout with some degree of compartmentation depending on their usage.

2) Primary bedrooms and main-floor living rooms have a mean floor area of about 16 m^2, whereas basement living rooms have larger floor areas with a mean of around 23 m^2. Kitchens, dining rooms and primary bedrooms have comparable floor areas of about 10 m^2.

3) The fire load density and composition of combustible contents varies according to the type of room. The kitchen, dining room and living room have a higher composition of wood compared to bedrooms due to the popularity of hardwood flooring in living and dining rooms, and the presence of heavy wooden cabinets in kitchens.

4) Bedrooms have fire loads consisting of a significant amount of textiles compared to other rooms.

5) The average fire load densities in various rooms were estimated to be (95th percentile values in brackets): Kitchens – 807 (940) MJ/m^2; dining rooms – 393 (576) MJ/m^2; living rooms – 412 (610) MJ/m^2; basement living rooms – 288 (450) MJ/m^2; primary bedrooms – 534 (753) MJ/m^2; secondary bedrooms – 594 (846) MJ/m^2. Although kitchens have the highest fire load densities the actual fire load (heat content) is lower than bedrooms, which have the highest fire load due to the presence of contents with a high calorific value such as mattresses and carpeting.

6) The fire load density alone does not provide a complete picture of the associated fire hazard since parameters such as floor area and composition of the fire load can affect the total heat energy content and its rate of release during a fire, assuming that other parameters remain identical.

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