Field Survey Considering Distribution of Fire Location

Part 1 Survey Summary and Results

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1. INTRODUCTION

The revised Building Standards Law in Japan (2002) introduced four performance verification protocols. One of the verifications for fire resistance performance was standardized by anticipating "uniformly distributed fire" and "localized fire" in terms of the design fire source. To date, much research has been conducted with respect to the flammable materials in order to incorporate this aspect into the fire safety design, but most of the research was mainly focused on the weight of the flammable material (e.g. fire load). The weight of the flammable material is a very important factor for calculating the burning duration under the assumption of a "uniformly-distributed fire". On the other hand, for the assumption used for the "localized fire" that does not induce flashover, it is necessary to understand the layout of the flammable materials in addition to the weight and to identify the fire source whose burning area is locally confinable in the design.

With this background, and taking into account a past survey on fire load, a survey was conducted in order to determine the actual layout condition of the flammable materials in a room that could be presumed in the context of a "localized fire" that does not induce flashover.

2. SURVEY SUMMARY

This survey was conducted with 6 different rooms, 5 of which were office buildings and 1 a school. Each room was categorized by the use of the room per building such as lobby, hallway and meeting room, and the layout conditions of the fire load were assessed. *Figure 1* illustrates one of the examples used in the survey.

Sheet for flammable material survey				Completed by: Ueta		Date: 09/15/2004	
Survey No	A - 1	Name of building	Building A			Name of room	Lobby
Use	School	Use of room	Lobby			Activities	Magazine, Internet
Structure	RC	Scale	4 stories	Floor area	182.3 m ²	Building area	Unknown m ²
List of Flammable Materials							
No.	Name	Type	Qty	Size (mm) Width × Depth × Height		Calorific value of the compartment Parts Material Heat rate	
A-1-1	Desk		1	1000 * 900 * 600		Top board Particle board 1000 * 900 * 20 11.7kg 135.7 MJ	
Type	Storage		Storage coefficient	Mobility	Remarks		
	Yes (L, M, S) or No			Movable		Other Steel * * 0.0 kg 0.0 MJ
Exposed wood	* * 0.0 kg 0.0 MJ	
					1.88 m ²		
					Exposed plastic	* * 0.0 kg 0.0 MJ	
					0.00 m ²		
					Exposed contents	* * 0.0 kg 0.0 MJ	
					0.00 m ²	Cal. rate of wood 135.7 MJ	
					Valid exposed area	Cal. rate of plastic 0.0 MJ	
					1.88 m ²	Valid cal. value (per furniture) 135.7 MJ	

Figure 1 Example of the flammable material survey sheet

3. DEFINITION OF SURVEY DATA (CALORIFIC VALUE AND EXPOSED AREA OF THE FLAMMABLE MATERIAL)

3.1 Definition of calorific value of the flammable material

a) Calorific value

In order to organize the data obtained from this survey, the flammable materials were described by calorific index rather than by the traditional weight index. Additionally, since most of the flammable materials are made of various materials such as wood and plastic, each material was measured per part in detail and each calorific value was calculated.

i) Calorific value of wood

The characteristic value of several wooden materials (particle board, paper, etc.) was specified and calculated in order to determine the calorific value of the cellulosic materials.

ii) Calorific value of plastic

The characteristic value of several plastic materials (polyethylene, polyester, etc.) was specified and calculated in order to determine the calorific value of the cellulosic materials.

b) Valid heat release rate

The valid heat release rate is the heat release rate calculated by taking into account the condition of the flammable materials in terms of the shape and size of the flammable materials, materials of the storage furniture, and the condition of the stored flammable materials.

3.2 Definition of the exposed surface area

a) Exposed surface area

By taking into account that the heat release rate per exposed surface area (1m^2) varies depending on the exposed surface of the flammable materials of the furniture, the exposed surface of the plastic material was calculated as 3 times greater than that of the wooden material.

Additionally, based on the idea that if flammable materials were stored in furniture whose outer material is made of flammable material, then the burning would start from the outer material of the furniture, and therefore, the exposed surface area of the outer material was determined as the maximum burnable area, which is the exposed area of the furniture.

On the other hand, if the flammable materials were stored inside the furniture whose outer material is non-flammable material (e.g. a steel-made locker), no flammable material is exposed; however, it is possible that they may burn. Therefore, by assuming that the stored flammable materials would burn by a ventilation-induced fire, the exposed surface area of the stored materials was calculated as the apparent exposed surface area.

b) Valid exposed surface area

In the calculation of the exposed surface area, by considering the traditional survey method, the area facing other flammable materials or walls was subtracted from the exposed surface area of the flammable material.

Figure 2 illustrates the relation of exposed area of the flammable material, exposed area of the furniture's outer material, exposed surface area of the stored materials, and valid exposed surface area.

Figure 2 Definition of the exposed surface area

4. SURVEY RESULTS

Table 1 shows the survey data and illustrates the relation of calorific value of the flammable materials, exposed surface area and occupancy of the flammable materials with respect to the use of space and floor area. The occupancy of the flammable materials is defined as a percentage (m^2/m^2) that is occupied by the flammable materials against the floor area in planar view. The mean occupancy values of the lounge, meeting room, hallway and lobby are approximately 0.26 (m^2/m^2), 0.335 (m^2/m^2), 0.032 (m^2/m^2) and 0.075 (m^2/m^2), respectively. The occupancy of the flammable materials is lower in the hallway and lobby than in the lounge and meeting room. In Part 2 of this report, a discussion will focus on "walkway areas" (e.g. hallway and lobby areas) and "room areas" (e.g. lounge and meeting room areas).

Table 1 Survey results of the flammable materials

Bldg name	Use	Category	Room use	Use category	Floor area (m ²)	No. of furniture items	Total HRR (MJ)	Valid HHR (MJ)	Exposed surface (m ²)	Valid exposed surface (m ²)	Flam. material conc. (MJ/m ²)	Valid flam. material conc. (MJ/m ²)	Surface coefficient (m ² /MJ)	Valid surface coefficient (m ² /MJ)	Mean offset (mm)	Occupancy
Bldg A	School	Walkway	Lobby	Lobby	182	49	5007.8	5007.8	59.45	59.45	27.5	27.5	0.012	0.012	320	0.078
			1F Hallway	Hallway	233	87	16049	23273.4	33.29	104.2	68.9	99.9	0.002	0.004	39	0.061
			2F Hallway	Hallway	272	81	3678.8	4997.2	31.95	39.69	13.5	18.4	0.009	0.008	0	0.079
			3F Hallway	Hallway	272	54	4014.6	5351.84	28.35	35.25	14.8	19.7	0.007	0.007	0	0.044
			4F Hallway	Hallway	218	54	22680.3	23572.3	132.42	150.89	104.0	108.1	0.006	0.006	27	0.078
		Room	Media Center	Lounge	75	19	2750.9	2750.9	30	30	36.7	36.7	0.011	0.011	1351	0.174
			Student Hall	Lounge	113	37	4201	4201	66.6	66.6	37.2	37.2	0.016	0.016	878	0.125
			Computer Room	Computer Room	90	127	1757101	17608.7	287.44	313.56	195.2	165.7	0.016	0.018	1534	0.356
			Refresh Room	Lounge	27	25	2378.8	2845.8	37.72	41.34	88.1	105.4	0.016	0.015	578	0.393
			Library	Lounge	66.5	50	7634.1	23915.1	183.35	294.3	114.8	359.6	0.024	0.012	1110	0.332
			Study Room	Lounge	136	74	12205.6	12205.6	184.28	184.28	89.7	89.7	0.015	0.015	2027	0.283
			Gym	Arena	Gym	1540	12	23090.2	23090.2	264.52	264.52	15.0	15.0	0.011	0.011	618
Bldg B	Office	Walkway	Lobby	Lobby	86.4	15	1675.2	1949.82	14.42	17.48	19.4	22.6	0.009	0.009	95	0.021
			2F Hallway	Hallway	28.8	1	7	7	0.79	0.70	0.2	0.2	0.113	0.113	0	0.003
			4F Hallway	Hallway	28.8	5	350.1	350.1	7.35	7.35	12.2	12.2	0.021	0.021	0	0.022
			5F Hallway	Hallway	28.8	5	373	373	6.62	6.62	13.0	13.0	0.018	0.018	0	0.025
			Meeting Room 1	Meeting Room	168	106	9595	39986.7	277.91	286.6	57.2	238.6	0.029	0.007	1090	0.227
	Room	Meeting Room 8	Meeting Room	51.2	34	6621.1	6888.46	109.98	114.54	129.31	134.5	0.017	0.017	1309	0.333	
		Meeting Room 11	Meeting Room	31.7	35	4015.9	19788.99	65.27	103.22	126.7	624.3	0.016	0.005	691	0.429	
		Forum	Meeting Room	65.6	57	16610.6	17127.89	206.92	227.98	253.2	261.1	0.012	0.013	480	0.326	
		Parking	Parking	Parking	269	12	2680	2680	31.47	31.47	10.0	10.0	0.012	0.012	277	0.016
		Bldg C	Office	Walkway	Lobby	Lobby	427	57	26626.3	2662.3	396.12	396.12	62.4	62.4	0.015	0.015
1F Hallway	Hallway				169	20	4085.3	4085.3	42.08	42.08	24.2	24.2	0.010	0.010	438	0.028
Room	Foyer			Lounge	68.8	48	3786.2	3786.2	75.15	75.15	55.0	55.0	0.020	0.020	1236	0.121
Bldg D	Office	Walkway	Lobby	Lobby	420	210	20187.8	20187.8	352.15	352.15	48.0	48.0	0.017	0.017	995	0.032
		Room	Forum	Lounge	107	54	13991.35	16326.35	225.66	243.8	130.9	152.7	0.016	0.015	380	0.144
Bldg E	Office	Walkway	Lobby	Lobby	167	46	8741.29	8741.29	128.68	128.68	52.2	52.2	0.01	0.015	427	0.097
			1F Hallway	Hallway	70.3	7	1831.3	1831.3	14.8	14.8	26.0	26.0	0.008	0.008	0	0.002
			2F Hallway	Hallway	121	10	5612.9	5612.9	109.76	109.76	46.5	46.5	0.020	0.020	0	0.013
			3F Hallway	Hallway	107	27	7628.52	7765.26	117.18	124.2	71.3	72.6	0.015	0.016	23	0.070
			4F Hallway	Hallway	79	4	1588.2	1588.2	27.51	27.51	20.1	20.1	0.017	0.017	100	0.000
			5F Hallway	Hallway	53.2	7	535.2	535.2	5.73	5.73	10.1	10.1	0.011	0.011	100	0.006
			6F Hallway	Hallway	50.6	8	465	465	44.03	11.03	9.2	9.2	0.024	0.024	50	0.028
			7F Hallway	Hallway	93.9	22	8648.6	8648.6	51.76	51.76	92.1	92.1	0.006	0.006	37	0.042
		Room	Service Room	Service Room	6.72	7	1089.6	1665.42	9.58	45.68	162.1	247.8	0.009	0.027	0	0.261
			Lounge	Lounge	85	57	5349	5974.96	194.31	198.14	62.9	70.3	0.036	0.033	715	0.235
Bldg F	Office	Walkway	Lobby	Lobby	114	2	95	95	3.28	3.28	0.8	0.8	0.035	0.035	145	0.000
			1F Hallway	Hallway	27.2	11	1538.09	2511.69	13.56	22.24	56.5	92.3	0.009	0.009	45	0.074
			Exterior Stairs	Stairs	8.9	38	926.6	1255.88	11.17	72.77	104.1	141.1	0.012	0.058	180	0.253
			3F Hallway	Hallway	23.8	11	2033.8	2033.8	7.52	7.52	85.5	85.5	0.004	0.004	8	0.037
			4F Hallway	Hallway	41.4	6	1107.1	1107.1	22.65	22.65	26.7	26.7	0.020	0.020	31	0.017
		Room	3F Lounge	Lounge	13.2	59	6355.2	7224.78	73.61	78.31	481.5	547.3	0.012	0.011	60	0.354
			4F Lounge	Lounge	13.2	91	4916.1	5406.58	63.22	76.67	372.4	409.6	0.013	0.014	28	0.368
		Bath Room	Bathroom	10.2	6	186.7	186.7	2.57	2.57	18.3	18.3	0.014	0.014	30	0.007	

5. CONCLUSION

This report summarized the procedure and results of a survey that was conducted to obtain knowledge about flammable materials that is vital to assessing a "local fire". In further research, more surveys will be conducted with respect to the use space where a "local fire" can be anticipated and more knowledge will be accumulated with respect to the actual conditions.

REFERENCES

1. Edited by Japan Association for Fire Science and Engineering, "Fire and Architecture 2.1 Concept of Performance Based Code of Building Standards Law", Kyoritsu Shuppan, pp.11-15, 2002 (in Japanese)
2. Harada K., Ohmiya Y., Takeichi N., Wakamatsu T., Matsuyama K. and Kakae N., "A Proposal for a Set of Databases for use in Fire Resistance Design of Structure against Localized Fires", Summaries of technical papers of Annual Meeting Architectural Institute of Japan. A-2, Fire safety, off-shore engineering and architecture, information systems technology, pp.229-232, 2003 (in Japanese)
3. Kitahori J., Ohmiya Y., Harada K. and Kakae N., "Investigation into the Actual Conditions of Fire Load Location", Summaries of technical papers of Annual Meeting Architectural Institute of Japan. A-2, Fire safety, off-shore engineering and architecture, information systems technology, pp.101-104, 2004 (in Japanese)
4. Working Group of Fire Resistance Design of Structure against Localized Fires, "Symposium of Thinking over Fire Resistance Design of Structure against Localized Fires -Toward Attractive a Fire Resistance Design", Architectural Institute of Japan, 2005 (in Japanese)