Fire Performance of Drywall Partition with Plastic Receptacle Box

MITSUHIRO MORI*[1], SHINICHI SUGAHARA*[1], KENICHI NAKAMURA*[2], HIDEAKI MASUDA*[3], MASAMICHI TAMURA*[1] and AKIHIKO IIDA*[1]

*[1]: Dept. of Architecture, Graduate School of Engineering, Univ. of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

*[2]: Better Living, 1 Tachihara, Tsukuba City, Ibaraki 300-0802, Japan

*[3]: Building Research Institute, 1 Tachihara, Tsukuba City, Ibaraki 300-0802, Japan

ABSTRACT

According to the notification by Ministry of Construction, noncombustible materials should be applied at the plumbing or wiring part of fire wall. However, in case another material is applied at that part, its fire performance has not been clear yet, and almost partitions have been authorized only to solid core ones with noncombustible materials, causing fire protective performances of these partitions are one-hour rating for wood frame and two-hour for steel frame according to the bench scale test. Therefore, several drywall partitions with plastic receptacles are served to this experimental research.. Several fire protective structures could be standardized by this research through fire performance analysis on two layers of temper-edge gypsum board with plastic receptacle box on one side.

Key Words ; *void drywall, fire performance, plastic receptacle, fire test*

INTRODUCTION

Almost partitions with plastic receptacle have been rated through fire evaluation test by using solid core type partitions, although the fire rating of void core drywall system might have some differences[1],[2],[3]. Plastic receptacle could be soften, fall, and ignite during a fire, which causes fire resistivity of void drywall would be subject to decrease. This experimental research is aimed at finding some sorts of representative methods on installation of plastic receptacle in drywall systems.

EXPERIMENTALS

Test specimen

Test specimens are framed by 2×4 timbers and covered by two layers of 12.5mm gypsum board on both sides with plastic receptacle box on one side (Figure 1,2). The size of each specimen is 550mm in height and 560mm in width. The opening area of an electric receptacle is 58cm^2(60×96mm). Plastic conduit tube for electric wiring is streched out to the upper side of test specimen and pulled outside there. The receptacle is covered by mineral wool blanket and intumescent sealing materials[4].

Test condition

Town gas is used for the fuel of test furnace. 20 burner nozzles are installed for heating. The distance is 100mm from heating surface to exposed specimen surface and 30mm to 3 thermo-couples. Furnace temperature(T) is controlled along with ISO 834 standard curve described below[5]. The pressure of inside furnace is measured at the center of specimen. Furnace temperature(T) is in the following.

$$T=345\log(8t+1)+20$$

where, T: standard furnace temperature (℃) , t: time (minute)

Measuring points of temperature are shown in the cross section of the test specimen(Figure 1).

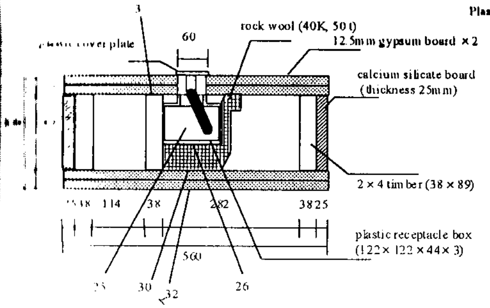

Figure 1: Horizontal cross section of test specimen 3
representative measuring points of temperature 3,25,26,30,32

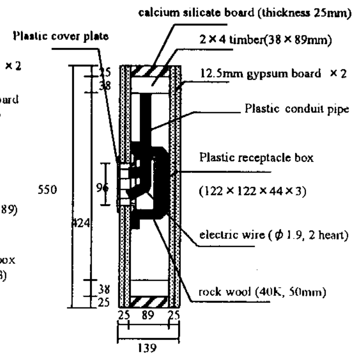

Figure 2: Vertical cross section

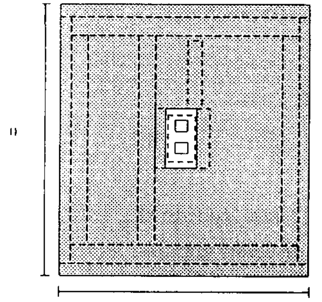

Figure 3: Vertical plan of drywall (exposed side)

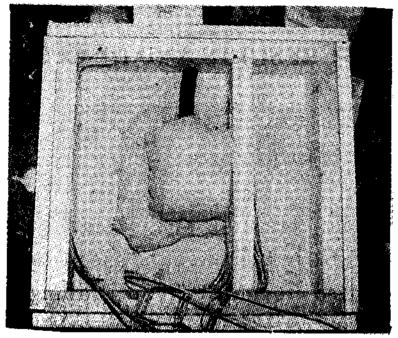

Photo 1: Test specimen 3 before heating (before test)

Specimen of experiment II is covered by 15mm gypsum board. Plastic receptacle is installed at the center of the test specimen. Two layers of 21mm gypsum board are covered on both sides for steel frame drywall at experiment Ⅲ[6].

Table 1 : Specification of test specimens

	test specimen	receptacle box	covering plate	back up material
Experiment Ⅰ	1	non	non	non
	2	plastic	plastic	non
	3	plastic	plastic	*rock wool
	4	plastic	plastic	*thermal tumescent sealing
	5	plastic	aluminium alloy	non
Experiment Ⅱ	6	non	non	non
	7	plastic	aluminium alloy	non
	8	plastic	aluminium alloy	*rock wool
	9	plastic	aluminium alloy	*thermal tumescent sealing
Experiment Ⅲ	10	non	non	non
	11	plastic	aluminium alloy	non
	12	plastic	aluminium alloy	*rock wool
	13	plastic	aluminium alloy	*thermal tumescent sealing

*rock wool(density 40kg/m^3、 thickness 50mm)

* thermal tumescent sealing(M.P.P by 3M)

TEST RESULTS AND DISCUSSIONS

・Furnace pressure

Furnace pressure was measured around 0.1～ 0.2 mmH$_2$O during initial 5 minutes, which might be adequate for this test. A division member should be secured around 10±2 Pa, according to DIN 4102 : Part 2 after five minutes.

・Temperature-rise of 2×4 timber and receptacle

The receptacle box of experiment Ⅰ ignited at 1 minute and average temperature at the rear of exposed side gypsum board (for example, 1 and 3 by the Figure 4) reached to 260 ℃ at 55 minutes, which indicates that if mineral blanket covered around plastic receptacle, fire could not develop into the void space of drywall. The void area exceeded 260 ℃, because of the accumulation of heat in the plastic receptacle. The rate of temperature rise is similar among test specimen 3,4,and 5. During 75 minutes, the temperature rise of specimen 7 is about 100 ℃ higher than that of specimen 6 and 9,which indicates the progress of the carbonization of the 2×4 timber could be restrained by covering the back of plastic receptacles. Intumescent sealing material is effective for preventing temperature rise, because of its commencement of swelling around 180 ℃[7].

・Carbonization of 2×4 timber frame

Timber frames of experiment Ⅰ began to carbonize at 50 minutes when the temperature exceeded up to 350 ℃, and developed to intensive charring around plastic receptacles(Photo 2). Maximum char-depth was observed at experiment Ⅱ which has no mineral or intumescent covering. The same charring figure was formed in test specimen 6 and 9, despite of the difference of charred depth, which indicates the charring behavior develops in a similar way[8].

Table 2 : Rear temperature at the end of test

	heating time(min)	test specimen	unexposed side temperature(℃)
Experiment Ⅰ	60	1	63.3
		2	70.9
		3	57.5
		4	62.9
		5	70.8
Experiment Ⅱ	75	6	61.0
		7	66.0
		8	52.0
		9	53.0
Experiment Ⅲ	120	10	61.7
		11	66.6
		12	69.7
		13	67.2

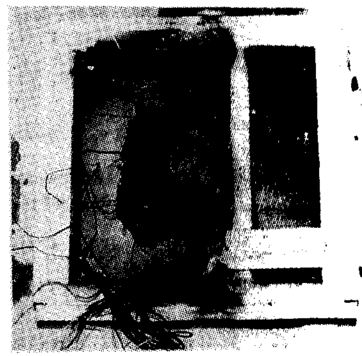

Photo 2: Charred figure of test specimen 3(after 60 minute test)

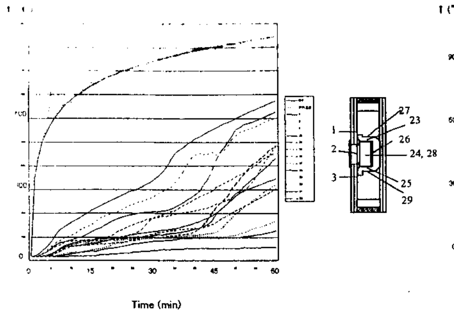

Figure 4: Temperature rise of test specimen 3

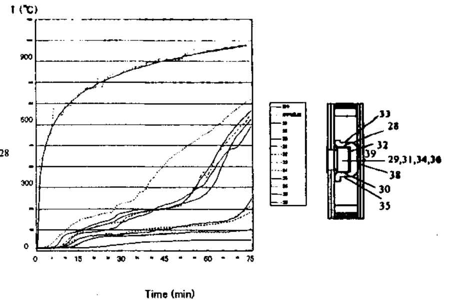

Figure 5: Temperature rise of test specimen 8

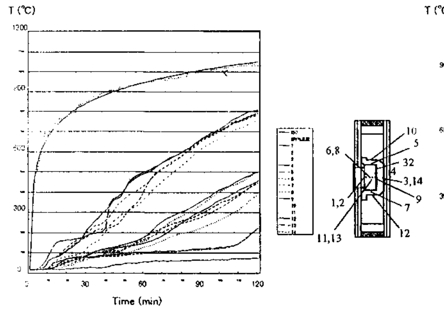

Figure 6: Temperature rise of test specimen 12

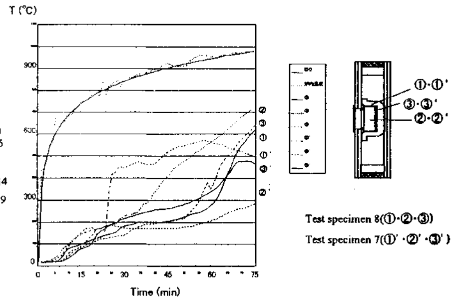

Figure 7: Compared temperature rise between with and without fire covering

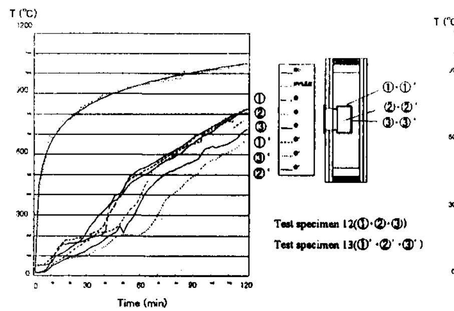

Figure 8: Temperature rise around receptacle

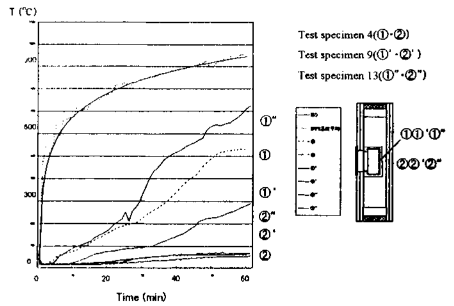

Figure 9: Difference of temperature rise by thickness of drywall layer

Table 3 : Surface temperature of studs in 120-minute heating

test specimen	stud temperature (℃)		stud average temperature (℃)	unexposed side temperature (℃)
10	257.5	230.6	244	61.7
11	286.8	285.3	286	66.6
12	223.1	221.5	222	69.7
13	279.7	267.5	274	67.2

CONCLUSION

Experiment I shows that carbonization around void area at the rear of plastic receptacle without covering develops deeper than with covering, which means fire covering is effective for elongating its load bearing duration. However, as for the test specimen with no gypsum board covering on the unexposed side, there was few differences in the effectiveness of fire covering, in comparison with no covering case. Intumescent covering is effective to prevent temperature rise around void area, in spite of rather quicker charring propagation in its covered area. This experimental research was carried out by using bench scale furnace, which needs to promote further studies by more large scale tests. Fire stopping technology might be quite important for wood structure, especially for platform construction with void wall or ceiling partition. In the future, we would like to develop some evaluation systems with the opening ratio of receptacle and standardizing method for its fire coverings.

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Morphological Research on Gypsum Board Exposed to Fire Based on SEM and XRD Analysis

SHINICHI SUGAHARA, AKIHIKO IIDA and MASAMICHI TAMURA
Department of Architecture, Graduate School of Engineering
University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

ABSTRACT

Gypsum board is used, in general, as interior finish material in building, aimed at functional efficiency, i.e.: fire resistance, insulation, sound barrier and so on. However, there is little research on substantial transformation of gypsum board under fire exposure necessary to settle thermal properties such as coefficient of thermal conductivity, heat transfer expansion, and specific heat [1]. In this study, fire-tested specimens were analyzed by using scanning electron microscope (SEM) and X-ray diffraction (XRD) in order to grasp the relationship between these substance transformation and fire performance test. Test data obtained from DTA and TG test, XRD and SEM observation showed the transformation of bassanite or anhydrite around 135 ℃ could be effective for surpressing temperature-rise in drywall.

KEYWORDS - *gypsum board, XRD, SEM, fire-resistance test, interior finishing materials, bassanite, anhydrite*