A CURRENT SURVEY ON APPROVED FIRE PERFORMANCE MATERIALS IN JAPAN

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1. ABSTRACT

In Japan, since 1969 to 1991, 2701 cases of the fire performance materials are approved, but among of them, 818 cases are cancelled because of their selling situations. These materials are classified into four classes, non-combusitible, semi-noncombustible, fire retardant and flame retardant, by Japan Building Standard Law. In this survey, at first, the materials are classified in detail. As for the non-cancelled materials, two-thirds of them are occupied by non-combustible, and one-fifth are semi-noncombustible. Then we discuss the relationship among test results, i.e. temperature in the test furnace (heat release rate), deformation, smoke generation, melting, crack and after-flame, mainly concerning non-combustible and semi-noncombustible materials. Finally, we disuss the current Japan test methods.

keywords:survey, fire performance material, component, material design, Japan Building Law

2. INTRODUCTION

The important function of interior materials are to prevent fire spread, to help fire fighting and evacuations.

In Japan, there are some fire related laws, e.g. Japan Building Standard Law, Fire Service Law an and so on.
According to these laws, the requirements of fire performance on building elements, i.e. wall, floor, ceiling, roof and opening are different with occpancy, scale and location of the building. Then these elements have to be constructed by the fire performance of materials, which have approved by the same laws.

Now, there are many kinds of fire performance materials, whose shapes and components are complicated. Up till now, there are few knowledges about the behaviours at high temperature of various materials and the relationship between their components and fire perfermance. In order to develop further fire perfomance design, we believe the necessity of investigating and studying a present status on approved fire performance materials.

3. SURVEY RESULTS AND DISCUSSIONS

(1) Characteristics of various materials and their components

At first, we classified the fire performance materials (Fig. 1). Fig. 2 shows the approved share about the non-combustible, semi-noncombustible, fire retardant and flame retardant materials. This figure indicates that 52.8 percent of fire performance materials are approved as non-combustible. The most of them are mainly composed of cement. In addition to them, there are much amount of other innovative materials made from gypsum and calcium silicate, following various dressed metallic materials. (Fig. 3)

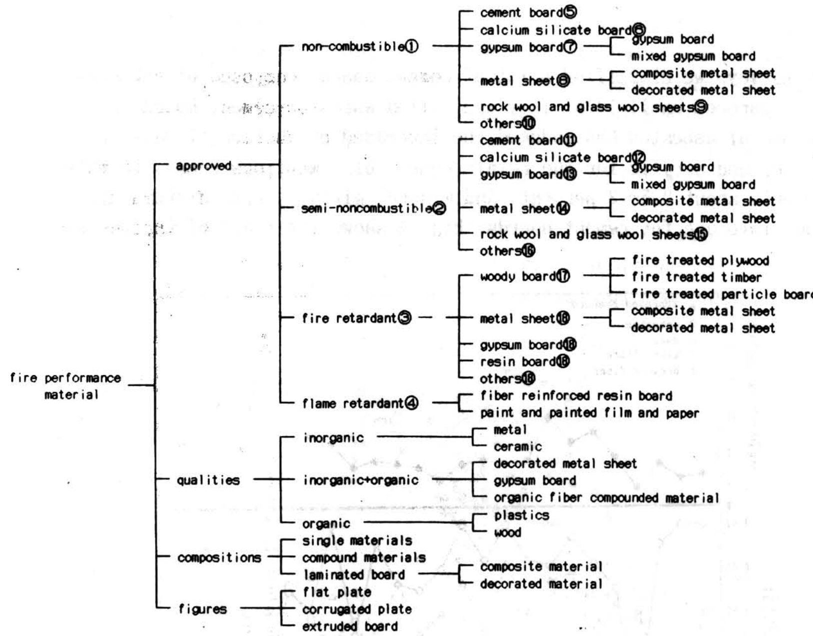


Fig.1 Classification of fire performance materials

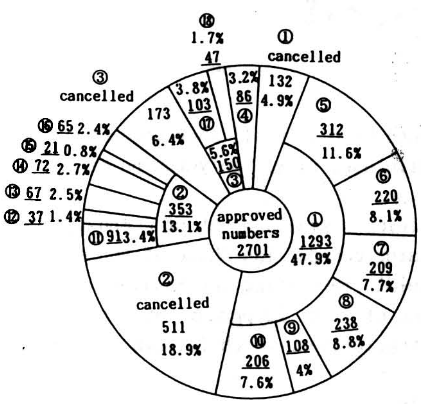


Fig.2 Approved share about fire performance materials
The number with underline indicates the approved cases.
The number in circle corresponds to the material number in Fig.1.

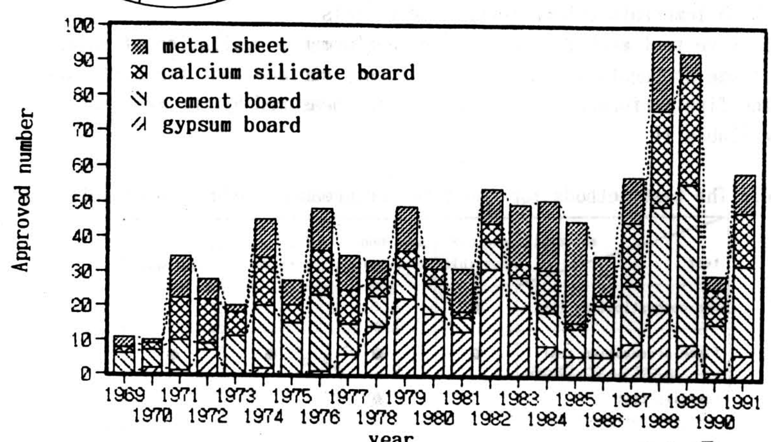


Fig.3 Main approved non-combustible materials per year

Moreover, in this survey, we classified a lot of cement boards composed of asbestos and pulp before which had been approved until 1978. They are called Asbestos-cement board and pulp-cement board. Recently, the ban of asbestos has induced the increased production of many organic fibers, e.g. vinylon, cellulose, and acrylic for the reinforcement of cementious composite materials. The weight percentage is only about 0.5~3 percent. And mineral mixture, e.g. diatomaceous earth, vermiculite and mica come into use for cement boards. Fig. 4 shows the trend of various fibers for reinforcement.

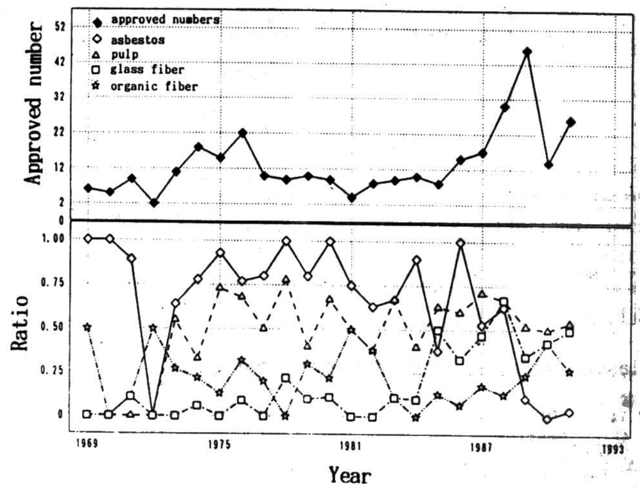


Fig.4 Ratio of the numbers of fiber reinforced boards to all approved materials (Organic fibers are mainly classified to cellulose, vynyl, polyethrene etc.)

There are 31 percent semi-noncombustible materials containing a small amount of combustible ingredients. Many of them are some kinds of cementious excelisior boards. The share of approved gypsum boards and metalic plates backed by isocyanuric foam now rapidly increasing for insulating materials.

There are about 12 percent fire retardant materials. Among of them, 70 percent are treated woody materials. However, the usage of them is rather limited by regulations, which follows only about 3.2 percent flame retardant materials.

(2) Test Methods and High Temperature Behaviours of Materials

In Japan, there are five test methods for the fire performance evaluation of materials, i.e. non-combustibility test, flame propagation test, toxicity test, surface test for perforated specimens and model-box test. The fire performances of materials are measured by the test authorized by Japan Building Standard law.(Table.1)

Table.1 The test methods for the fire performance evaluation of materials

test \ material	non-combustible	semi-non-combustible	fire retardant	flame retardant
non-combustibility test	●			
flame propagation test	●	●	●	●
toxicity test		●		
surface test for perfated specimens		●	●	
model-box test		●		

Fig. 5 shows the non-combustibility test results on the temperature difference and the ratio of weight loss/density. The data of cement or calcium silicate board scatter within the same range. Generally, the density of calcium silicate boards is half of cement board, so the weight loss is about 50 percent less than cement board. It may be mainly because of the difference of crystal water contents. There might exist, however the difference of decomposition at high temperature according to autocraving levels. The temperature differences of gypsum boards were lower, but the weight losses are greater than the others. Gypsum board contains about 20 percent of crystal water as $CaSO_4 \cdot 2H_2O$, so that it is possible to consider that the separation of crystal water by heating mainly makes the weight loss. The density and weight loss of rock or glass wools are very small. However, the temperature differences were higher, because of their containment of some organic materials.

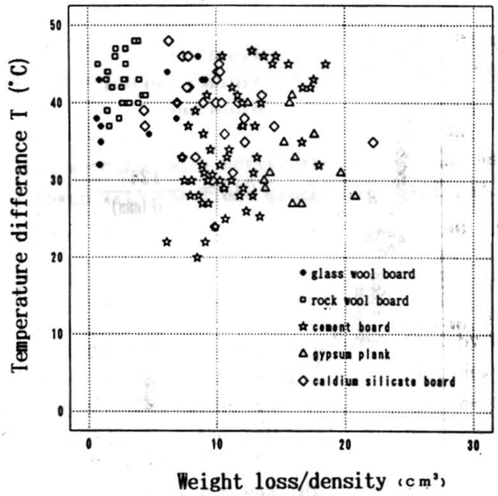


Fig.5 The non-combustible test results of the temperature difference and the ratio of weight loss/density

As shown in Table.1, four tests are needed for the evaluation of semi-noncombustibity. Here we discuss the test results by model-box test for isocyanuric foam-gypsum boards and isocyanuric foam-metallic plates. Fig. 6 shows the relationship between the total heat release rate and the maximum temperature within model box. It may indicate that temperatures in the center of the floor at the 3/4 height of ceiling height is almost equal to average temperature in the box.

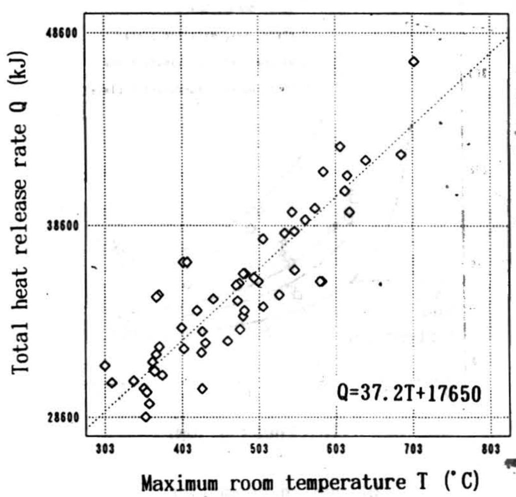
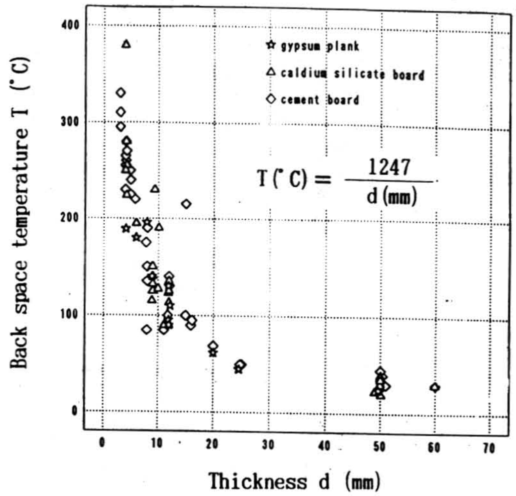
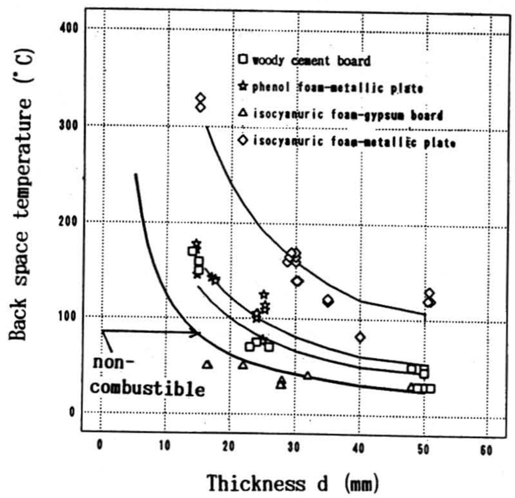


Fig.6 Total heat release rate by model-box test

Fig. 7(a) and (b) show the relationship between the thickness and the temperature of the unexposed space of specimens with the non-combustible and the semi-noncombustible. In spite of the quality of material, the unexposed side temperature are in an inverse proportion to the thinckness in Fig. 7(a) Fig. 7(b) shows the relationship between thickness and back up temperature of semi-noncombustible materials. the curresobtained by semi-noncombustible materials are located in lower positions than that of non-combustible materials, which may indicate the difference of each combustion heat.



a) non-combustible



b) semi-noncombustible

Fig.7 The relationship between the thickness and the temperature of unexposed space

(3) Discussion Points on the Current Test Methods

On the non-combustibility test, the flame propagation test and the surface test for perforated specimens:

A. the weight loss and droped-off weight should be measured at some relevant time intervals.

B. the conditions of air supply should be varied, for the consideration of actual fire behaviours.

C. the three holes by the surface test for perforated specimens might be doubtful recognized as a representative of the jointseam of specimens.

D. the data might be difficult for applying to fire simulation models.

E. the furnace temperature should be changable for evaluating the effect of crystal water separation.

On the model-box test:

A. the dimension of the cribs might not be appropriate as an initial heatsource.

B. the dimensions of opening should be varied for the applilcation to a real fire situation.

On the toxicity test:

A. the gas data should be compared with the mice activities recorded by an electromagnetic method.

B. the toxicity test should be linked with the flame propagation test and simplified to one test method.

4. CONCLUSIONS

As the result of this survey, we got some valuable data classified by each fire performance, which might be useful for developing other innovative fire materials. However, there found a few descrepancies among test results obtained from the same sorts of specimens, so that it seems to be unable to get quantitative characteristics of fire materials and/or components. Some solutions might exist in the modification of test methods, the applications of other adequate methods for analyzing high temperature behaviours and the establishment of a fire simulation model.