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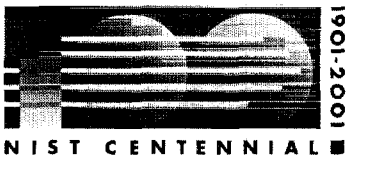
VOLUME 1

Sheilda L. Bryner, Editor



National Institute of Standards and Technology
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U. S. Department of Commerce
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Technology Administration
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Japanese Progress and Overview of Building Material Performance and Testing

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ABSTRACT
In the field of fire safety research, the change of building regulation system from specification expressions to performance requirements is present worldwide trend. The author found that most of the available data are based on results of fundamental research. From the view on risk communication, research on the combustion of building material is insufficient. There has been a stronger demand for research on combustion of building materials. More research activities on this subject are most desirable.

1. Recent Progress in Japan

In these years, research on building material performance and testing has not been so active as that on fire safety design tools. In domestic conferences, several research groups reported their progresses. Seven papers appeared in the 1998 annual meeting of Japanese Association of Fire Safety Engineering. Twelve papers are appeared in the 1998 annual meeting of Architectural Institute of Japan. Seven papers appeared in the 1999 annual meeting of Japanese Association of Fire Safety Engineering. Four papers are appeared in the 1999 annual meeting of Architectural Institute of Japan.

Among these papers;
Five papers dealt with the fundamental flame spread phenomena,
Four papers dealt with the full scale and bench scale experimental results on flame spread phenomena,
Four papers dealt with the fundamental burning performance,
Three papers dealt with the small scale experimental results on burning characteristics of materials,
Ten papers dealt with the full scale or bench scale experimental results on burning behavior of materials,
Three papers dealt with the burning behavior of furniture.

Most of the research were done to get the input data to fire safety design system or verification of the system. This reflects the movement in Japan, which is the reform of the Japanese Building Standard Law to be performance based. Some of the research results will be presented in this session or the other.

2. Worldwide movement

Recently, CIB proposed two key program. They are "Performance Based Building Control" and "Sustainable Growth." The question was raised by the coordinator of CIB/W14 to its active members. It was what kind of new work item shall be launched in accordance with these new key program. The reaction from the members except a few was so cool that I felt strange. As I am deeply involved in both research program in BRI, I thought this kind of research is also active in the world.

In fact, "Performance Based Building Control" is the world wide slogan for the people engaged in building control. To activate the performance based building control system, various engineering tools to evaluate building performance are indispensable. Also industries now strongly recognize that it is very important to enable sustainable growth through the effort to reduce the load to environment. The progress in these area is most desirable.

But most of the active members of CIB/W14 are the professors of Universities and the researchers of

National Research Institutes. They are mainly doing fundamental research and may have small interface with building regulators or industry people. So they might not be interested in "Performance Based Building Control" nor "Sustainable Growth." Their main concern may be exchange of academic information on traditional scientific theme.

I experienced similar discussion at ISO/TC92 meeting. Now ISO/TC92 has a SC which deals with Fire Safety Engineering, which is SC4. SC4 recently published guidelines documents as ISO Technical Reports. SC4 people thought the speed toward the performance based building control will be boosted and the main job of standardization will become on those related with fire safety design. Through the discussion on new TC92 strategy, a new structure was proposed. The idea was the 4 SCs will be recomposed into new 2 SCs. One SC will in charge of the standardization of fire safety design methods. The other will be in charge of the standardization of measurement tools for the input parameters to the design system. This idea was appraised in SC4 but refused by the other SCs. Especially SC1(Reaction to Fire) and SC2(Fire Resistance) were strongly resisted the reform of the structure. SC3 was neutral but finally stand against the proposal.

I could learn something through these movement in two organizations. I felt the needs of Building Regulators and Industries might not been understood by the fundamental researchers or the testing organization people. Or they feel it is not necessary to respond such needs. This situation cannot be good but it comes to be real.

3. Hindrance to Performance Based Building Control

I have been involved in the reform of the Japanese Building Standard Law and related regulations. At the initial stage of this work, I was convinced that the research on combustion phenomena of solid fuel was fully advanced. If we could define the performance requirement clearly, we would find what physical properties shall be measured automatically. However, it was not so easy thing.

If changing the current expression of regulatory requirements composed of specification lists to performance expression, the work may be simple. But, without analysis to reveal what requirements are implied in the list of specification, the work cannot be completed and no change may be better than incomplete change since the range of choice is narrowed sometimes.

In case of the Japanese Building Standard Law, its main objective on fire safety can be interpreted to be safe egress in case of fire, prevention of collapse of the building after the fire and prevention of city fire. One of the main purpose of building material control may be to keep people in the building safe during egress. But to say what fire property control of material is necessary, we have to analyze the requirements carefully. The current expression of the requirement is based on the classification using test. So, first of all, we need to know what material performance is expected to be made clear. Many discussion had been done before the current test method was determined. Such as: What fire scenario is valid? What performance parameter shall be measured? But, unfortunately, there is little documents which report the discussion. Then we have to reduce the requirement from test apparatus and procedure.

The test methods currently used for building regulation are determined more than ten years ago. As the research on fire phenomena was not so advanced as now, they tried to represent a part of real fire phenomena in a small apparatus to observe material's reaction to fire instead of measuring fire property itself. This approach seems to be reasonable but it contains troublesome thing to proceed the reform process of regulation to be performance based.

It is desirable for the ideal structure of performance based regulation system to have layered requirements each of them are written in objective oriented. Most of the current regulation requires to

pass the test. This means that anyone cannot say fail or pass based on the test results obtained by another test method. If the regulatory requirement is written in objective oriented, we can easily define alternative solutions and it gives us big freedom of choice.

To make this dream real, I have tried to reduce what fire model was assumed and what performance would like to be verified. The detail information on pyrolysis process of solid fuel, heat release process by oxidation of flammable gas, emission of fuel gas from solid, etc. which are observed in real fire is indispensable to make this work completed. The research on combustion phenomena has greatly advanced in these years. But the information available are concentrated in those under ideal experimental conditions. This is not sufficient to reveal fire phenomena which was assumed when the current test method was defined.

If we introduce test methods to measure specified properties under simplified fire condition, this makes the test results to be suitable for common use but not to be suitable to understand what aspect of fire it is representing. Without close relation with real fire phenomena, the test results cannot appeal to satisfy regulatory requirement by the Building Standard Law. Then such kind of test methods cannot be used.

4. Fire Safety Concept

Why fire growth shall be prevented? How can we reduce fire damage to be minimum? The research on fire risk assessment has long history but the research to answer to these questions clearly is not popular. The most of people cannot understand the probability to experience fire damage. If they are told you may encounter fire in their life as same probability as or less probability than that of a traffic accident, they may understand what was told. Most of people want to know when the may experience fire and how big damage is expected.

I was asked to talk about fire rated materials at the seminar for consumer consultants. I thought the explanation of fire rating system would be good enough and went there without special preparation. Before the seminar, I talked with organizers and found that they were expecting me to talk how to distinguish fire rating of materials used in residences. Of course, I know what material is classified in what fire rating but it was hard to say what rating material was used in actual wall system. This experience make my view on fire safety changed.

Let's think about residential fire. In Japan, house wives spent the longest time in residence among her family. Most of wives would like to know how tough (non-ignitability or non-fire-spreadability) the material they see is and not on what class the material is rated. To make these people better knowledge on fire safety will contribute diminish the fire risk.

Recently, the word "Risk Information" became popular. This is reflecting the situation that people understand importance to transfer exact knowledge on risk to end user through the experience on nuclear plants' accidents and scandal on medicine. Researchers on risk reports that there is big difference in human reaction of to disaster between the people who understood the risk and those who did not understand it. If the people who was given exact information on risk fully and understood it well, they can behave themselves calmly. But if not, they behave themselves in panic.

This is also true in fire. In the work to reform the Building Standard Law to be performance based, relaxation of the requirement is done if it is reasonable. I am afraid the case where the requirement can be severe enough to give a certain safety factor and that give us great relief. In this case, the fire damage under unexpected condition can be too big if the safety factor was set small. Such a unexpected damage caused fire make people anxious and make the work for performance based regulation meaningless.

To avoid this situation, we have to define the risk clearly which the Building Standard Law is assuring. We have done the work to reform Building Standard Law taking care of this point. However, we encountered difficulty to explain clearly relationship between the essence of fire safety and the fundamental of the material combustion phenomena and could not attain excellent result.

5.Future work

In recent ISO/TC92 activity, the new future strategy has been discussed in addition to the future structure of the committee. Basic strategy is to supply International Standard quickly on demand of the customer. It was discussed in TC92 who is our customer. I believe our customer is the end user of the standards (consumer) who will get benefit finally and said so. But the direct users of the standards are industry, testing organization, regulators etc. Also consultant is new customer candidate.

Similar discussion was also done at the CIB/W14 meeting. It was reasonable that ISO/TC92 was raised as a customer of CIB/W14. But some said that the customer of CIB/W14 is the participant himself. Although this opinion may be reflecting the nature of CIB/W14, which is a researchers' forum, I believe engineer should do research which will fit to the social needs.

The needs of the research on material combustion phenomena is rising constantly. As I already pointed out, to understand fire phenomena exactly is important for fire safety assessment. Combustion characteristics of materials are important governing factor controlling this fire phenomena. Especially, combustion characteristics under real fire conditions such as heat release, heat transfer, flammable gas emission, generation of soot and toxic species, thermal deformation of solid fuel, etc. The real scale experiment is most desirable to study burning characteristics intensively. As this is not easy, we had better define several fire scenario and the model at first. Then burning behavior should be studied intensively under these fire scenario and model.

On the other hand, many computer model code has been developed. Recently, the importance of the verification and validation of them is strongly recognized. This is because the developer of the computer code and its user is not the same. The code can be used by the user in the way that the developer did not expect or without inspecting accuracy. To respond this new needs, the database for the verification of the computer code is desired.

Furthermore, the new demand of the society refused future use of halon. Nowadays halon replacement is a big issue. Many halogen compounds has been used as fire retardant. These chemicals block heat release process efficiently. But this means that it will produce halon and intermediate reaction product of oxidation process. These will increase soot generation and act as toxic species. At the development of new fire retardant, the fault point of halogen compound should be removed. From this view point, the development of the method to control flammable gas emission is most expected. For this purpose, the more intensive study on combustion phenomena of materials are indispensable.

At least, the systematic accumulation of the following four properties data are keenly necessary.
- Pyrolysis and charring rate of solid fuel which emits flammable gas with generating charring layer under constant heat flux.
- Pyrolysis rate of composite material.
- Flame shape and heat input profile to unburned fuel from flame.
- Individual process which is necessary to reveal the above phenomena.

Old research may give us some information. But more practical information on materials actually used in buildings should be corrected to make the model study applicable for actual building fire.

6. Summary

As I discussed, there is big demand in the research on combustion of materials. It is just to say that we, who are doing the research of material combustion, are standing on treasure island. Combustion of the material is one of the most important part of building fire. Correcting detailed data on this matter and putting them into database will make great contribution to wide spread of knowledge to control fire and improvement of building fire safety level.

Summaries of Technical Papers of Annual Meeting, JAFSE(1998)

1. Effect of Radiation on Flame Spread over Paper Sheets Containing Ammonium Phosphate, M.Suzuki et al.
2. Characteristics of Pyrolysis of Cellulose Sheets Permeated with an Adhesive, L.Gao et al.
3. Properties of Pyrolysis Zone in Downward Flame Spread over a Thin Paper with Opposed Flow, K.Sato and Y.Sakai.
4. Effects of Inert Gas and Water Vapor on Flame Spread over Paper, T.Danbara and N.Saito.
5. Combustion Characteristics of Wood and Fire Phenomena Observed in Small Compartment Fires, Y.Kudou et al.
6. Experimental Study on the Flame Spread beneath a Combustible Ceiling in a Room Configulation, T.Natori et al.
7. Comparison between Experimental and Simulation for Fire Spread on Lining Material, M.Matsudo et al.
8. Evaluation of the Combustibility of Interior Linings with the Revised Model Box Test, T,Kimura et al.

Summaries of Technical Papers of Annual Meeting, AIJ(1998)

9.A Study on Fire Spread behavior of Upholstered Funiture, H.Hayashi et al.
10. Experimental Study on Behavior of Chairs : Part 1, T.Mizuno et al.
11. Experimental Study on Behavior of Chairs : Part 2, H.Yamada et al.
12. Correlation of Gas Analysis Values between Toxicity Test and Model Box Test, S.Tasaka et al.
13. Evaluation of the Non-Combustibility of the Fire-Protecting Material Which Used ISO1182 Test Method, T.Goto and F.He
14. Burning Behavior of All-Weather Track in Athletic Field, S.Uehara and T.Nagaoka
15. Experimental Study on the Influence of Joint and Construction Details of Wall Assembly on the Conbustion of Linings (Part2: Intermediate Burning Test), Y.Sawada et al.
16. Experimental Study on the Ignition and Flame Spread beneath a Combustible Ceiling in a Room Configuration, T.Natori et al.
17. Development and Verification of Simulation Methods for Fire Growth on Interior Lining Materials, W.Takahashi et al.
18. Ignition Temperature of Wood due to fire behind Separation Wall, T.Yabuta
19. Evaluation of the Combustibility of Interior Linings with the Revised Model Box Test, T.Kimura
20. A Model of Flame Spread on Wooden Walls, T.Nagaoka et al.

Summaries of Technical Papers of Annual Meeting, JAFSE(1999)

21. Various Characteristic Change of Woods or Construction Materials under Pyrolysis Condition, H.Hayasaka et al.
22. Internal Temperature Distribution and Combustion Characteristics of a wood, Y.Kudou et al.
23. Effects of Dilution of Surrounding Gas on the Structure of a Flame Spreading over a Thin Paper, T.Takano et al.
24. Study of Modeling Fire Growth on Lining Materials in Enclosures, T.Kinoshita et al.
25. Full Scale Flammability Test for Fire Retardant Fabric Materials (Part1. Standard Fire Models as Test Ignition Heat Source), T.Yamada et al.

26. Full Scale Flammability Test for Fire Retardant Fabric Materials (Part2. Flammability Test of FR and non FR curtains), E.Yanai et al.
27. Study on the Measurement and Evaluation of a Theater Curtain in a Heating Environment, O.Komuro and Y.Ogino

Summaries of Technical Papers of Annual Meeting, AIJ(1999)
28. A Burning Properties of Woody Material - Boron Compound Composites, Y.Tamura et al.
29. Various Characteristic Change of Woods or Construction Materials under Pyrolysis Condition, H.Hayasaka.
30. Evaluation of The Fire Performance of the Fiber Reinforced Composite Building Materials, H.Shinagawa et al.
31. Full Scale Flammability Test for Fire Retardant Fabric Materials, T.Yamada and E.Yanai

* This paper is essentially English translation of my paper published on Combustion Science and Technology (Japanese edition) Vol.7 (2000), pp21-.