NECESSITY OF REVIEWING TESTS FOR ASSESSING FIRE BEHAVIOUR OF LOCAL MATERIMALS

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ABSTRACT

Consequent to so many big building fires in the Far East including Hong Kong, there are concerns on building fire safety. There are not much combustibility data for local combustible products. Fire behaviour of building materials and contents should be assessed by appropriate tests. Useful risk parameters such as heat release rate can then be compiled for hazard assessment. The importance of studying their fire behaviour by new tests will be pointed out in this paper.

1. INTRODUCTION

As the number of fires appears to increase in the Far East, such as the big Garley Building fire in Hong Kong [1,2], some citizens are worrying whether they are safe in a fire. The occupant loadings in shopping malls, public transport terminals, multi-purpose commercial buildings and even offices are very high. An accidental fire started from igniting a small heat source might lead to hazardous consequences. Further, many new materials such as sandwich panels [e.g. 3,4] are used for thermal and sound insulation partitions. Their fire behaviour should be watched carefully as the core might be made of cellular plastics such as polyurethane foam. Accidental fires in double-deck buses made of sandwich panels are good examples in demonstrating the potential hazard [5].

Standard tests on assessing the fire behaviour of materials specified by the local government departments [6-9] taking care of fire safety are quite outdated. British Standards 476 are referred to on testing ignitability [10], non-combustibility [11], surface spread of flame [12] and fire resistance [13,14]. Apart from the fire resistance test, the others are on smaller samples of materials with a single component. They are not appropriate in testing materials with several components such as sandwich panels [3,4]. Further, these tests were developed years ago on assessing whether the materials can be ignited by a pilot flame without applying radiation heat flux [10]; or whether there is combustion under a small chamber with a certain thermal environment [11]; or on assessing flame spread over the materials under a standard furnace [12]. The standard fire tests [13,14] on fire resistance are on assessing stability, integrity and insulation of construction elements. Therefore, updated tests and standards should be recommended to assess the fire behaviour of materials. It had been pointed out in a recent fire conference that the combustibility of materials in the Far East had not yet been studied rigorously, though some works have just been started [15].

In-depth investigations should be started and the necessity of carrying out such studies is proposed in this short note. The materials should be tested at least, on whether it is easy to ignite when heat supplied from external sources is higher than the heat lost [16], the heat release rate [16-18], the amount of smoke and combustion product generated [16,18], smoke toxicity [19] and flame spread [20].

2. COMPARTMENT FIRE

In assessing the burning behaviour of materials in a room fire, the concept behind the key phenomena concerned should be clarified. When a fire starts in a compartment with walls, floors and ceilings made of materials which are difficult to ignite, or even 'non-combustible' following British Standards BS-476 [11], only a small amount of combustibles will be burnt. A plume will be formed over the burning item. Ambient air will be entrained into the combustion region because of the buoyancy-induced turbulence. Hot smoke will rise until reaching the ceiling. A radial plume known as the ceiling jet will be formed below the ceiling. It will move horizontally and entrain ambient air and another radial plume will be formed when the motion is bounded by the vertical walls. A stable stratified hot smoke layer will then be resulted [21].

The enclosure is divided into three regions: a hot upper smoke layer, a cool lower air and a plume. The phenomenon is similar to an inverted water sink with the tap turned on to get a water layer, an air layer and the running water tap. Smoke layer thickness will be increased if the fire is allowed to sustain. When the hot gas adjacent to the ceiling is heated up to high temperature, say 500 to 600 ^{o}C, strong radiative heat flux up to 20 kWm^{-2} will be resulted. This will ignite all the combustibles and flashover will occur as a thermal transition process.

Ignition should be tested for assessing whether the material is easy to start burning. There are two types of ignition, pilot and spontaneous. BS-476 on test of ignitability [10] is to assess the materials under a pilot flame for 10 s. This will test whether the materials are easy to be ignited, but not on assessing their behaviour in a compartment under fire. Materials stored inside the burning compartment might be ignited spontaneously under the flashover heat flux of 20 kWm^{-2}. A furnace with adjustable thermal radiation flux such as that in a cone calorimeter [16] should be used for assessing ignition. Not only that, the heat release rate, smoke emission rate, carbon monoxide and carbon dioxide levels under the specified burning conditions [17,18] can be measured.

3. FLAME SPREAD

If the walls, floors and ceiling are made of combustible materials, the compartment fire will be even more complicated. Fire might spread over the lining materials if they are made of plastics products, or over carpet floors. Some specifications on testing the ignitability [10], non-combustibility [11] and surface spreading of flame [12] might not be applicable for new materials. Even if the materials passed the bench-type test such as the BS-476: Part 7 on surface spread of flame [12] (note that this is a not a full-scale burning test), that does not mean they are safe in a fire.

There are no specifications on the new generation of fire tests in the current codes [6-9] by the Fire Services Department (FSD) and Buildings Department (BD) yet. The codes have not been upgraded to cater for the rapid development of new materials and testing standards on fire spread. A reason is that whether those testing standards such as ASTM-E84-99 [22], NFPA-255: 2000 [23] and ISO-9705 [24] used in overseas codes [e.g. 25-27] are workable for local buildings should be demonstrated by research. An obvious example is in karaoke establishments where combustible lining materials and carpets are found.

Therefore, studying fire spreading [20] over surface of finishing and lining materials used as floors, ceiling and walls is essential before drafting workable fire safety regulations for recommendation to government FSD and BD.

4. ACCEPTANCE CRITERIA

In recommending the standard tests, acceptance criteria have to be worked out. The ignition time required under a certain radiation heat flux while carrying out tests with the cone calorimeter can be a criterion. A sample of materials should be collected with their tested results compiled. Acceptance criteria should then be determined scientifically, for example, relating the peak heat release rate with the thermal contribution of the materials to the fire environment. Flame spreading results from the ISO-9705 [24] will also be useful in deducing the time to flashover for a typical office. Correlation expressions will be worked out for determining the acceptance criteria.

5. HEAT RELEASE RATE

The heat release rate of burning materials [17,18] is believed to be the basic element in understanding how big is the fire. This can be assessed by a bench-scale cone calorimeter [16,18]. Intermediate scale tests such as the furniture calorimeter [28] and single burning item (SBI) [29] are useful.

Further, the new ISO room-corner fire test [24] is a full-scale burning test to measure fire spread, heat release rate and time to flashover. Such a full-scale burning facility, the Chinese Assembly Calorimeter [30], was developed with support from the Harbin Engineering University (HEU) in Heilongjiang, China.

6. FIRE BEHAVIOUR OF MATERIALS

Updated standard tests for assessing the fire behaviour of materials should be reviewed. Feasibility studies on new materials and products should be carried out. Suitable tests can then be recommended to the authority. It is necessary to study the following areas in more detail:

- Ignition under radiation heat flux.
- Heat release rate.
- Smoke emission rate
- Smoke toxicity.
- Flame spreading.
- Acceptance criteria.
- Data for fire safety design.

Scopes of works in the first phase of study should be on reviewing standard tests available in the literature for assessing the fire behaviour of local materials. Both bench-scale tests and full-scale burning tests are useful. Relevant experimental studies on assessing those local materials by some more important tests such as cone calorimeter should be carried out systematically. A database can then be compiled. At least, recommendations to the local authority on drafting more scientific fire safety regulations related to updated tests on assessing the fire behaviour of materials can be made.

Statistical analysis on the burning parameters and derivation of correlation relations will be conducted.

7. CONLUSION

Standard tests specified in the existing codes [6-9] for assessing the fire behaviour of new materials should be reconsidered. Those tests are basically on assessing materials used years ago. New materials with more than one component such as sandwich panel might not be applicable. Such current standard tests on assessing the fire behaviour of materials should be reviewed.

Updated tests developed in the literature should be justified for suitability for local use. Scenarios simulated in such tests might not be applicable for local buildings, local environment and local living style.

Fire safety regulations cannot be set up without support from research for local products. Fire tests for combustibles must be clearly understood. However, such information is absent in Hong Kong. It is obvious that carrying out such studies with full-scale burning tests [30] would be very expensive. But such study is necessary, especially in applying fire engineering approach [31].

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