FUTURE DIRECTIONS IN FIRE TESTING OF BUILDING PRODUCTS

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Abstract
This paper discusses recent developments and trends in fire testing building products, including the recent Building Code of Australia (BCA) Amendment 13, changes in Europe and new ISO standards for sandwich panels and external facades. Product-ranking tests are being replaced by newer ‘reference scenario’ tests where the end-use of the product is realistically represented. In some cases small-scale tests, in conjunction with models or calculation procedures, can be used to predict performance in the ‘reference scenario’.

KEY WORDS

Fire testing; test methods; regulation

INTRODUCTION

This paper discusses future directions in fire testing building materials and components for use in hazard analysis and for regulation.

Why do we subject building components to fire tests?
Because we want to be assured that building materials and components do not pose an unacceptable fire hazard when it comes to the safety of people and protection of property.

However, fire testing poses special difficulties in representing ‘real world’ behaviour because:

1. Fire behaviour can change with the ‘scale’ of the fire
2. Fire behaviour can change depending on the combustion environment
3. Fire behaviour can change depending on the material geometry/configuration
4. There are physical limits associated with fire testing apparatus

With advances in technical understanding and capability, the historical approaches of simplistic fire test methods used as product-ranking schemes are unsatisfactory and do not provide the data needed for fire-hazard analysis and risk assessment.

Today it is clear that new fire-test methods must closely simulate the actual end-use application and configuration of the materials, or the data from the test must have scientific value and, in conjunction with calculation procedures or models, enable predictions to be made of the appropriate end-use application.

Figure 1 shows a testing and classification approach developed for surface linings by Wickstrom (1990), which is also likely to be equally applicable for other building components. A large-scale test forms a ‘reference scenario’ for the building component which comprises a realistic end-use configuration. An alternative means of classification using a small-scale test requires that a method of calculation (or model) has been developed that allows a meaningful prediction of the component’s performance in the ‘reference scenario’.

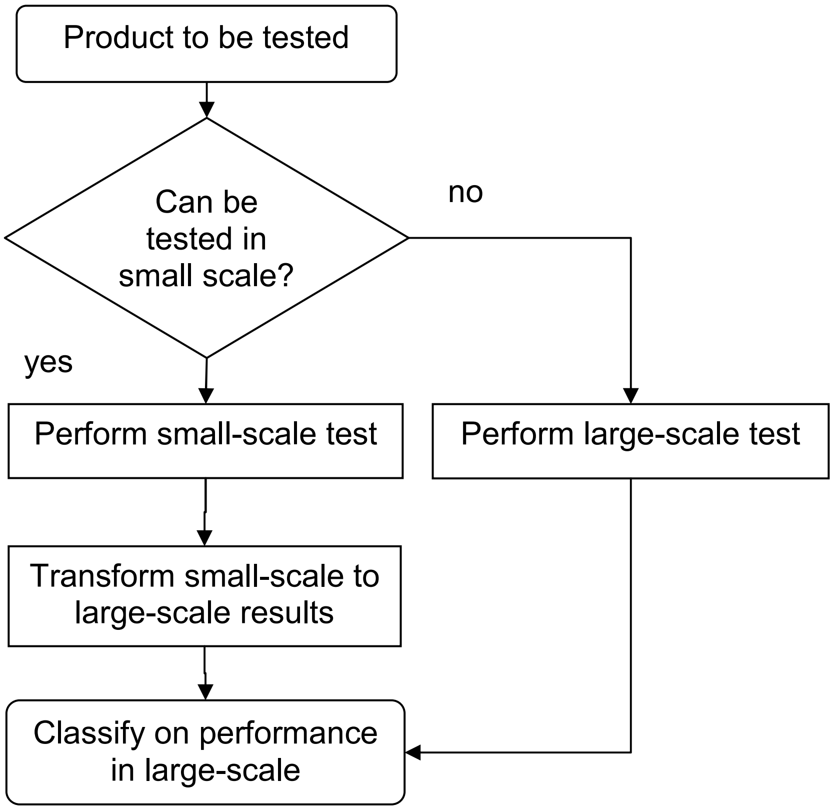

Figure 1: Principles of a testing and classification scheme (Wickstrom, 1990)

REACTION TO FIRE

Surface lining materials

The recent BCA Amendment 13 has introduced major change in the fire-testing methods for the regulatory classification of wall and ceiling linings and flooring materials in Australia. This follows on from research by the Fire Code Reform Centre in Australia. The new methods include AS/NZS 3837 Cone Calorimeter (SA, 1998); ISO 9705 (ISO, 1993) full-scale room/corner test and ISO 9239 floor radiant panel test (ISO 2002a).

Figure 2 illustrates how both small-scale and full-scale testing is used in BCA Amendment 13 to achieve a product classification for wall and ceiling linings. The calculation procedure used to predict the 'reference scenario' from small-scale test data is one developed by Kokkala et al (1993).

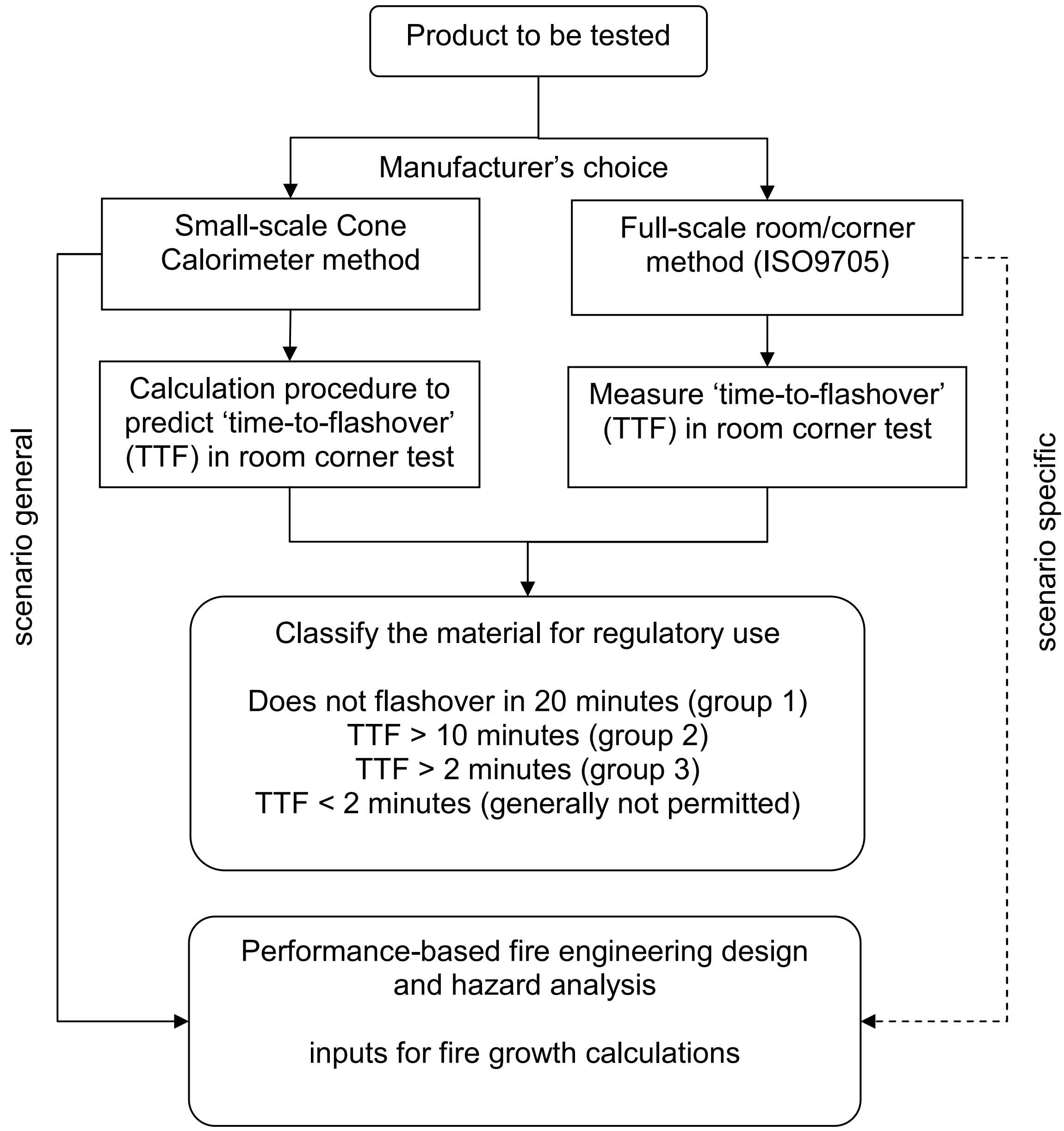

Figure 2: Classification approach used by BCA Amendment 13 for wall and ceiling linings

Figure 3: Flashover in the ISO 9705 room/corner test

In Europe there have also been changes, with new fire-test procedures adopted after many years of research as well as technical and political debate. A new test, known as the Single Burning Item (SBI) has been adopted for use across the European Union (CEN, 2002). This test may be regarded as a reduced-scale version of the ISO 9705 room/corner test (see Figure 3). Though the SBI now provides an adequate correlation against the ‘reference scenario’, its results are less directly useful than the cone calorimeter’s for use in fire-growth calculations and modelling of flame spread.

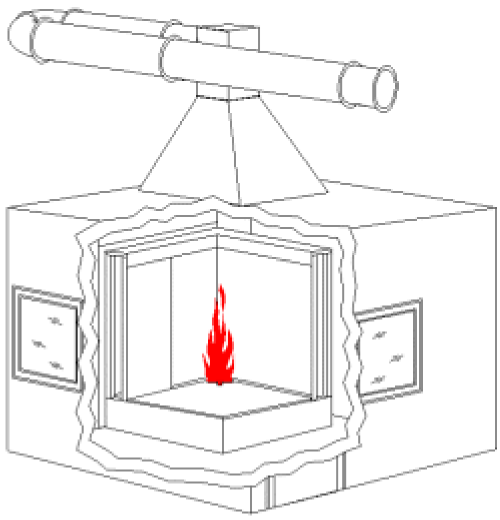

Figure 4: Schematic of SBI Apparatus (courtesy, Fire Testing Technology Ltd)

In the case of fire testing for floor covering materials, the Floor Radiant Panel (see Figure 5) (ISO, 2002a) has been adopted for regulatory use in Australia. This does generally follow the European changes and more closely represents the end-use application compared to the previous method. Though a meaningful measurement of the critical heat flux for sustained flame spread is obtained, the test results are not as fundamentally useful for more general use in fire-growth calculations.

Figure 5: Floor radiant panel apparatus (courtesy, Fire Testing Technology Ltd)

Facades

New tests for evaluating the potential for flame spread on combustible external facades have also been developed. ISO 13785 (ISO, 2002e) is a full-scale test method developed as a ‘reference scenario’ for external facades. It is similar to that shown in Figure 6 but requires the installed cladding to include a corner arrangement. Propane burners are used as an ignition source within a combustion chamber arranged to simulate a fire plume emerging from a window opening. The major measurement of interest is the extent of fire spread above the window opening.

Recent research by BRANZ (FCRC, 2001) has recommended the Vertical Channel Test (see Figure 7) for use in Australia. This is also a full-scale test but narrower than the ISO standard test rig. It would be less expensive and more economical while still demonstrating a reasonable correlation with the results of the larger test.

Figure 6: Full-scale façade fire test at the National Research Council Canada

Figure 7: Vertical Channel Apparatus at BRANZ

Insulating sandwich panels

With the increased use of insulated sandwich panels in food processing and other industries, there has also been heightened interest in their fire performance. In Europe this has led to greater use of less flammable core materials and the development of new, full-scale fire test methods within ISO, e.g. ISO 13784 (ISO 2002b, ISO 2002c).

Research indicates that large-scale testing is required to gain reliable results. Smaller scale tests (including cone and SBI) cannot evaluate the ability of the panel sheet and joints to prevent ignition of combustible cores.

Though ISO 9705 may be relevant, there are practical difficulties in achieving a representative installation, hence there is now a preference for fire testing a free-standing room (see Figure 8). However, this requires relatively large facilities not currently available in Australasia. Use of the ISO 9705 room/corner might still be practical with innovative means of getting the specimen inside the room.

Recent European research recommends that:

- Tests should be carried out on a free-standing room and measurements taken of heat-release rate and smoke production
- Sandwich panels should not be tested using small-scale methods (e.g cone, SBI)

Figure 8: Fire testing of free-standing room built from sandwich panel in accordance with ISO 13784 (photo SP, 2001)

FIRE RESISTANCE

The performance of fire-rated construction elements has been determined using standard furnace testing, as prescribed in AS 1530.4 (SA, 1997), for nearly a century. Although the standard furnace test is useful for comparing one product with another, it can poorly represent performance in some real-fire scenarios. There are also limitations associated with furnace testing, when the dimensions and edge-support conditions are restricted by the design of the furnace.

In some cases real-fire performance can be improved compared with a standard fire-resistance test. Figure 9 shows a furnace test on an unrestrained concrete slab carried out as part of a dissertation by Lim (2002). He found the slabs resisted collapse even though the calculated load capacities dropped significantly below the level of the applied loads, illustrating the beneficial effect of tensile membrane action on the structural fire resistance.

Figure 9: Fire resistance test of a concrete floor using water-filled drums to simulate gravity loads on the floor

On the other hand, with increased use of non-cellulosic materials contained within buildings, compartment fire exposures can result in a more rapid increase in room fire temperatures compared with standard furnace temperatures. For some materials this can mean dramatic changes in actual performance under fire conditions.

Figure 10 shows an experiment by Nyman (2002) when standard fire rated plasterboard wall and ceiling systems were used to construct a compartment. The fuel was a combination of wood cribs and polyurethane foam furniture. For some of the components, 'failure' occurred at times significantly less than for the same construction tested in a standard fire-resistance test. Nyman found that by comparing the equivalent radiant exposure between the standard fire-resistance test and that of his experiments, a method of predicting the real failure time could be proposed.

Figure 10: Compartment fire to assess performance of 'fire-rated system' to non-furnace fires

This type of predictive technique is useful because standard fire resistance test data collected over many decades might still be used for evaluating performance in alternative fire scenarios. it would be very expensive to test and re-test specimens using a wide range of different thermal environments.

New research on structural fire resistance was initiated after the catastrophic collapse of the World Trade Center towers. A key issue will be identifying improved techniques to evaluate the structural fire performance of building structures. In the final analysis, it matters little whether building components achieve one or four hours, fire-resistance in a standard furnace test, rather whether they are able to withstand the effects of an actual fire and continue to provide the expected level of performance anticipated by our codes, building owners and society. Use of calculations and modelling to evaluate structural fire performance is already well advanced.

Figure 11: Collapse of the World Trade Center. The disaster initiated new research into structural fire resistance.

CONCLUSION

The major trend in fire testing building products is the development of fire tests that adequately represent the realistic end-use application of the building material or system. This has certainly been the approach taken in the recent changes in fire-test methods included in BCA Amendment 13.

The use of appropriate bench-scale tests, in conjunction with models or calculation procedures, will become more common in the future and allow the evaluation of fire hazards for fire scenarios where large-scale fire testing may be too difficult, expensive or impractical.

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