DTLR Building Regulations Division Project Report :

A review of codes and standards relating to fire spread through windows

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Prepared for :

Anthony Burd
DTLR

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External fire Spread via windows

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Prepared for	Anthony Burd
Prepared by	Mark Bensilum Fire Safety Engineering Centre
BRE output/ milestone no.	203132

Approved on behalf of BRE

Signature	
Name	Nigel Smithies
Position	Director of Fire Safety Engineering Centre
Date	15 August 2001

BRE
Fire and Risk Sciences Division
Bucknalls Lane
Garston
Watford
WD25 9XX

Tel : [redacted]
Fax :

Email : frsenquiries@bre.co.uk
Website : www.bre.co.uk

Executive Summary

A review of codes and regulations related to the external spread of fire via windows has been carried out. It has proved difficult to find a great deal of information directly related to this phenomenon – many countries codes address general problems in external spread but few, it would seem, deal directly with floor-to-floor spread via the windows.

Most locales have codes that control the external spread of fire, primarily to protect the structure itself and to prevent the spread of fire to adjacent buildings. Those codes which have been obtained that directly address the problems of vertical spread via the windows, have tended to emphasise the conflict between the features which would be necessary to inhibit such spread, and the practical and aesthetic consequences.

Other protective measures, such as automatic sprinklers or fire-resistant glazing have been proposed in these cases, as alternatives to excessive window separations or horizontal projections.

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1 Introduction

This report describes the regulations and codes that are related to the external spread of fire via windows in buildings. Surveys have been carried out on regulatory aspects of the phenomenon in the UK and overseas.

Although it is widely accepted that most countries will have guidance which covers external spread vertically up the side of buildings, or between adjacent buildings, it was not clear whether the specific issue of floor-to-floor spread via the windows had been addressed.

Brief descriptions of the codes or regulatory guidance that have been obtained are given in the subsequent sections.

2 Findings – regulations and codes

Although information related to the phenomenon in question has been found, very few cases of explicit reference to external spread from floor to floor via the windows has been found. Most of the codes reviewed address the problems of external spread in a wider context, that is, controlling the nature of the external surfaces and roofs of the building (materials, cavities etc.), and the spread of fire beyond the site boundary.

2.1 United Kingdom

2.1.1 Current regulations

The UK Building Regulations are the main codes that control fire spread in and around buildings. Approved Document B (ADB) [1] provides practical guidance on meeting the requirements of the Building Regulations, 1991. Paragraph B4(1) of schedule 1 to the 1991 Building Regulations states:

External fire spread
B4.-(1) The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building.

Provisions are made in Section 13 ADB to limit the risk of ignition and fire spread in the external walls. The provisions depend on the height of the building and the distance to the notional boundary.

Section 14 of ADB presents provisions for the unprotected areas in the sides of buildings, which includes openings or areas with a combustible surface. These provisions are designed to limit the risk of fire spread by radiation from one building to another, although they are also related to the risk of external spread via the windows upon a single building.

Two methods are given in ADB for calculating the maximum acceptable unprotected area. Method 1 can be applied to small residential buildings (excluding institutional premises), and method 2 may be applied to all other building or compartment types. Both methods provide tables of boundary distances and maximum total area of unprotected surface. Method 2 is applicable only for buildings or compartments which are 10m or less in height.

Where a more precise calculation is required, or for buildings which are not small residential and which are greater than 10m in height, ADB Section B4 paragraph 14.15

refers to an alternative method, described in BRE Report BR187[2]. This report provides methods for calculating the level of radiation from compartment fires and fires on a building façade. It also outlines the factors involved in the ignition of the contents of a compartment due to radiation through the opening or glazing. The methods for calculating building separations may involve a 'geometric' method or a 'protractor' method. The objective of the methods is to ensure that the boundary distance of the building is sufficient to limit the thermal radiation at all the unprotected areas.

ADB Section B4 paragraph, 14.17 states that where a sprinkler conforming to BS 5306: Part 2 [3] is fitted, the boundary distance may be half of that given by the ADB methods or BR187 (subject to a minimum of 1m), *or* the total unprotected area may be doubled.

The LPC Design guide for the fire protection of buildings [8] refers to the problem of spread via windows. Section 3 covers compartmentation, and paragraph 3.3.1.3 states:

> Without substantially affecting the nature or aesthetics of the building it is generally difficult to build in measures that will prevent vertical spread as a result of fire by-passing the compartment floor by egressing from the windows below and re-entering via the windows above. However, where each floor is sprinklered the risk of fire spread is smaller.
>
> It is important to asses the risk in order to identify whether additional protection is necessary to overcome or reduce the potential threat to floors containing operations that are vital to the business.
>
> Where the building is not sprinkler protected the following measures are recommended for consideration:
>
> (a) The external walls to the ground floor should have at least 30min fire resistance in terms of integrity and 15min insulation. Windows should be fire-resisting glazed assemblies and have fire resistance in terms of integrity of 30min. Secondary glazed with fire-resisting glass in fire-resisting frames that meets that standard may also be used. Glazed systems should be approved by LPCB in accordance with LPS 1158, issue 2. If part of the wall is less than 1.0m from the relevant boundary as defined in the supporting documents to the building regulations, higher levels of performance will be required. In addition, consideration should be given to the protecting the external walls and windows to upper floors to the same standard where appropriate;
>
> (b) Where floors contain high values or equipment which is vital to the business, the external walls to such floors should comply with (a) above.
>
> **Note**: Balconies, deflectors or upstands and downstands may not be completely effective but should be considered.

LPC also publishes several reports relating to the specific problems associated with curtain walls [12, 13, 14]. These have tended to focus on the most common route of fire

spread with such panels, which is between the floor slab and the façade itself, due to absent or inadequate fire-stopping.

No significantly different approaches to the problem were identified under Scottish, Welsh or Northern Ireland regulations and codes.

2.1.2 Previous regulations

According to Ashton and Malhotra [4], the issue of external fire spread in buildings first appeared in the regulations in 1952, as a result of the Fire Grading of Buildings Committee [5]. The byelaws recommended that a reasonable level of protection could be obtained by having a window separation of 3ft (0·91m), at least 2ft (0·61m) should be above floor level. The Department of Health for Scotland adopted this recommendation, and added an alternative approach of using a horizontal projection of 2ft (0·61m) or more. London County Council byelaws [6] limited the total area of openings above the soffit of the first floor to one half of the total elevational area, and specified a minimum height above the floor of 2ft 6in (0·76m) for openings on each storey. The authors noted that similar provisions were found in other countries and cities abroad.

The report [4] concluded that vertical separations of 3ft (0·91m) or horizontal projections of 2ft (0·61m) are insufficient to prevent the re-entry of flames from a lower floor unless fire resistant glazing is used.

2.2 Hong Kong

The Hong Kong regulations relating to external fire spread Building Authority of Hong Kong Code of Practice for Fire Resisting Construction 1996 [7]. The provisions for building separation is given in paragraph 7. Paragraph 12 provides details of the provisions for limiting external spread of fire. Paragraph 12.2 states:

> 12.2 A curtain wall or other similar construction, which protects the building against the elements and which extends beyond one storey in height, should be constructed entirely of non-combustible materials. Any void formed between the curtain wall and the perimeter of the building onto which the curtain wall is fixed should be solidly infilled at each floor level by non-combustible materials having an **FRP** [fire resistance period] of not less than that required by the floor.

Paragraph 12.3 gives explicit instructions on spandrel heights:

> 12.3 Subject to paragraph 7, the external wall of a building at any floor should be separated from the external wall at the floor next below by a spandrel which :
>
> (a) is not less than 900 mm in height; and
>
> (b) is of non-combustible materials having an **FRP** of not less that that of the intervening floor.

The fire resistance periods referred to in these clauses are determined both by the purpose group and compartment volume.

2.3 Australia

Fire Engineering Guidelines [9] provides guidance on meeting the provisions of the Building Code of Australia. Section 5 presents design guidance on various aspect of fire safety, and paragraph 5.5.5 describes the management of vertical fire spread. Paragraph 5.5.5.2 deals specifically with external vertical spread, and states:

12.3 Subject to paragraph 7, the external wall of a building at any floor should be separated from the external wall at the floor next below by a spandrel which :

(a) is not less than 900 mm in height; and

(b) is of non-combustible materials having an **FRP** of not less that that of the intervening floor.

5.5.5.2 External vertical spread route

Fire may spread to the next floor via flames which project through external openings and radiate back to the windows above. In the Building Code of Australia, if the building is unsprinklered, spandrels are required to be constructed to limit this type of vertical flame spread. Spandrels which project vertically have been shown to be less effective than horizontal projections whilst the latter lacks architectural appeal. Calculation of the radiation level on the window above, based on an empirically derived flame shape is available (Drysdale 1988). However, flame projections from windows are highly variable and such calculations should be used with caution.

Automatic sprinklers (see 5.6) are highly effective in controlling fire spread via an external route. Drencher systems are also effective if they are designed to prevent glazing from breaking out but may not sufficiently reduce the intensity of the fire.

The guidelines present a brief overview of the issues involved, but no quantitative guidance.

2.4 New Zealand

The New Zealand Building code is accompanied by the Fire Engineering Design Guide [10], which is a comprehensive introduction to fire safety & design. The approach is similar to that adopted in New Zealand. Section 8.4 deals with fire spread to other storeys, the paragraph on exterior spread states:

Exterior windows

Spread of fire via exterior windows is a major hazard in multi-storey building, as shown in figure 8.4 (b).

Building codes have traditionally specified vertical spandrels or horizontal apron projections to limit vertical flame spread. Vertical spandrels are not much use unless they are so high as to severely restrict window openings. Horizontal apron projections are much more effective (Oleszkiewicz, 1991), although they are often less acceptable for architectural purposes.

A suggested design procedure is to calculate the size and shape of the expected flame from a window and then calculate radiation back to the building via the window above. Approximate flame size calculations are given below (Drysdale, 1988). Flame sizes from windows are extremely variable, depending on room geometry, fuel orientation and especially wind conditions, so these calculations should be used with caution.

Again, the guide recommends sprinklers as an effective method of controlling the fire, or window drenchers to reduce the risk of window failure.

2.5 Singapore

Guidelines are presented in the Code of Practice for Fire Precautions in Buildings [11]. Section 3.5 deals with external walls, and specifies boundary separations, limits on unprotected areas in the sides of buildings, and external spread due to fires on roofs affecting the sides of a building. There is no explicit reference to spread via windows.

Conclusions

Regulatory guidance and codes that relate specifically to the external spread of fire via windows has proved hard to obtain. Codes from most locales will contain guidance on external spread due to flammable materials, or the spread of fire between adjacent buildings, yet few address the problem or re-entry of fire on upper floors directly. Of those that do which have been obtained in this survey, only one gives any quantified requirements (Hong Kong specifies 900mm spandrel widths). Others that do refer to the problem explicitly have tended to point the designer in the direction of various calculation methods, suggesting a more performance-based approach.

Many of the codes that have been identified stress the conflict between the effective hindrance of external vertical fire spread, and the aesthetic or practical issues of façade construction. For this reason, a number of other protective measures have been frequently proposed, particularly automatic sprinklers and fire resistant glazing.

There are indications that many regulatory and guidance codes tend to focus more on internal spread of fire (or smoke) through the building, rather than the potential for external spread (other than that which is confined to the outer surfaces). It may be that this reflects a genuine difference between the risks from internal and external spread. However, if it is to be assumed that the levels of internal compartmentation in modern UK buildings is now of a generally high standard, due to improved design and construction, it may be that the relative balance has shifted somewhat, and the potential risk of external floor-to-floor spread should not be neglected.

References

[1] The Building Regulations, Approved Document B, 2000 Edition.

[2] External Fire Spread: building separation and boundary distances, Ed. R.E.H Read, BR187, BRE, 1991.

[3] British Standards Institution. BS 5306: Part 2, Fire extinguishing installations and equipment on premises, Specification for sprinkler systems. BSI

[4] Ashton, L. A. and Malhotra, H. L. The protection of openings against spread of fire from storey to storey. FR Note No. 426, Fire Research Station, 1960.

[5] Post War Building Studies No.20, Fire grading of buildings Part 1, general principles and structural precautions. HMSO, 1946.

[6] London County Council, London Building (Constructional) by-laws, 1952.

[7] Hong Kong Building Authority. Code of practice for fire resisting construction. 1996.

[8] LPC. The design guide for the fire protection of buildings. Fire Protection Association, London, 2000.

[9] Fire Code Reform Centre. Fire Engineering Guidelines. FCRC, Australia, 1996.

[10] Buchanon, A. H. (ed.). Fire engineering design guide. Centre for Advanced Engineering, University of Canterbury, Christchurch, 1994.

[11] Singapore Civil Defence Force. Code of practice for fire precautions in buildings. Fire Safety Bureau, SCDF, 1997.

[12] LPC. Fire spread in multi-storey buildings with glazed curtain wall facades. LPR 11: 1999. Loss Prevention Council, 1999.

[13] LPC. Facades on multi-storey buildings: A fire risk assessment guide. LPR 18: 2001. Loss Prevention Council, 2001.

[14] LPC. Non-glazed curtain walling: Furnace test results and recommendations. Loss Prevention Council, LPR 19: 2001.

Annexes

Annex 1 – List of previous reports, with references, for this project

BRE output/ milestone reference	Title	Date submitted
203137	Quarterly progress report	June 2001