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Fire Safety of Construction Products

Fires at Grenfell Tower and other tower blocks have raised questions about how construction products affect the severity and spread of fires. This briefing considers how the fire safety of construction products is regulated, how products are tested and classified, and challenges for product testing and the Building Regulations more widely.

Overview

- The fire performance of construction products is assessed using standard tests, including for combustibility, flame spread and fire resistance.
- Official guidance states the class of product permitted in different situations.
- Compliance with the Building Regulations is demonstrated by following the guidance or via a bespoke assessment.
- Issues include: the lack of clarity of the regulations, guidance, roles and responsibilities; the use of certain assessments for assemblies of multiple products; and inadequate means of ensuring competence and oversight of work.

Background

In England, from April 2016 to March 2017, fire services attended approximately 162,000 fires that led to 261 deaths and around 7,100 casualties.[1] Most of these fatalities occurred in dwellings (82%) and were accidental. Deaths were mainly due to being overcome by smoke or gas (38%), burns (25%), or a combination of both (16%).[1] Misuse of appliances or equipment caused 35% of accidental dwelling fires.[1] If a fire occurs, some groups may be at higher risk.[2] A Government analysis has identified older people, people with disabilities, those living in single parent households, males aged 46–60 years who live alone and drink and smoke in the home, and young people aged 16–24 years (including students), as some of the groups at greater risk of dying in fires.[3] There has been an overall decline in dwelling fire-related fatalities since the 1980's, attributed in part to changing habits (e.g. greater smoke alarm use), improved safety standards, and fire prevention initiatives, among other factors.[4]

According to industry estimates, the use of plastics in the construction and renovation of buildings has more than doubled in the last 30 years in Western Europe.[5] This has been driven by the availability of new materials, changes to the regulatory requirements for buildings to have better thermal insulation, and other factors.[6-9] Plastic-based construction products (items manufactured for permanent incorporation into a building or other construction) can be inexpensive, durable, insulating, light-weight and easy to manufacture and install.[10-12] They can, like other combustible materials, catch fire under certain conditions.[13-16] Examples include: polyvinyl chloride (PVC) window frames, polyethylene roof membranes, foam insulation and polyethylene-core aluminium composite cladding.[17]

Fires at Grenfell Tower (2017), Lakanal House (2009), and other residential tower blocks have increased scrutiny of the use of construction products.[18-23] After the Grenfell Tower fire, the Government established an expert panel to advise on immediate action needed to make buildings safe and announced an Independent Review of Building Regulations and Fire Safety in England and Wales (see Commons Library Briefing 8305).[24-26] The review, led by Dame Judith Hackitt, published an interim report in December 2017 and a final report in May 2018.[27,28] In Wales, a Fire Safety Advisory Group was established to advise the Welsh Government.[29,30] A Ministerial Working Group was set up to review building and fire safety in Scotland,[31] and an Independent Reference Group was established to review safety aspects of tower blocks in Northern Ireland.[32]

Many factors affect fire safety including building design, choice and installation of construction products, building contents (which commonly include combustible materials), the use of appliances (such as electrical goods), and occupants' actions. This POSTnote focusses on construction products and explores:

- making buildings fire safe through regulation, design and the selection of construction products
- construction product testing and classification
- challenges with product tests and building regulations.

Making buildings fire safe

Regulation

England and Wales have a Building Regulations framework intended to ensure that building work meets a "reasonable standard" of safety for occupants and those nearby (Box 1).[33] The Ministry of Housing, Communities and Local Government (MHCLG) issues guidance for common types of building in England, in the form of 'Approved Documents'.[34] The Welsh Government issues equivalent documents in Wales.[35] Work conducted in accordance with the Approved Documents should comply with the Building Regulations. National and international standards and industry guidance give further information on best practice.[36] Responsibility for ensuring compliance with the Regulations lies with the "person carrying out the work" and depends on the contractual arrangements of the particular building project. Traditionally, design responsibility lay with the architect however, in 'design and build' contracts (common in high-rise construction), the main contractor is responsible for both design and build.[37,38] Building control bodies (Box 2) play a key role in checking that work complies with the Regulations, which local authorities have a duty to enforce.[39]

Upon completion of building work, the Building Regulations require the person carrying out the work to hand over fire safety information to the person responsible for the building, to help them maintain the building safely.[40] The Building Research Establishment (BRE), Construction Industry Council and others say that this handover is often not fully completed.[41-44] Once building work is complete, the Fire Safety Order (Box 1) applies for all non-domestic buildings, communal areas of multi-occupancy housing and aspects of flats that affect other occupants. It does not apply to individual houses.[45,46] Scotland and Northern Ireland have similar regulatory frameworks.[47-50]

Building design

A combination of design measures can be used to ensure occupants have the time and means to escape before a fire develops fully (Box 3) or, that fire is contained so that they can safely remain in a building.[51-53] These may include:

- fire prevention (e.g. using non-combustible materials or controlling sources of ignition)
- fire detection (e.g. smoke detectors or alarm systems)
- evacuation (e.g. suitable escape routes)
- compartmentation (to prevent fire and smoke spreading between areas of a building)
- fire suppression (e.g. sprinklers)
- controlling smoke (e.g. ventilation)
- ensuring structural integrity (e.g. fire-resistant columns).

Approved Document B (ADB) provides guidance on how to satisfy the Building Regulations relating to fire safety in England and Wales.[54-57] It categorises buildings based on their occupancy and height, and specifies fire safety measures for each category. There are some regional variations; for example, fire suppression is required for all new domestic premises in Wales, but is generally only required for residential tower blocks with a floor above 30m in England.[55,71] Compliance with the Building Regulations is usually demonstrated by following ADB guidance or through a bespoke assessment of the fire risk. For example, 'fire safety engineering' involves using engineering principles and calculations to demonstrate the fire safety of a specific building, structure or installation.[52,72,73] According to ADB, this may be the only practical way of achieving a satisfactory level of fire safety in some large and complex buildings.

Selection of construction products

The Building Regulations state that appropriate materials must be selected for the circumstances in which they will be used.[74] Other selection criteria can include cost, durability, aesthetics, environmental impact and ease of construction.[75]

Box 1. Fire safety regulations for buildings in England & Wales

Building Regulations[58]

The Building Act (1984) allows the Secretary of State and the Welsh Ministers to make Building Regulations.[59,60] These set mandatory requirements for building work, including the need to protect life. They apply to the construction of new buildings and material alterations to existing buildings.[61] They state that, in case of fire, all buildings must:

- provide adequate means of warning and escape
- maintain structural stability for a reasonable time
- inhibit fire spread internally and externally
- provide access and facilities for the fire service.[62]

Fire Safety Order[63]

The Regulatory Reform (Fire Safety) Order, 2005, stipulates that the "responsible person" (typically the owner, landlord or employer) has a duty to take reasonable precautions to ensure premises are safe for occupants and those nearby once building work is complete. They must ensure that a "suitable and sufficient" fire risk assessment of their premises is conducted and kept up to date, and that fire safety measures are not compromised. The Order is enforced by the fire authority (usually the local fire service) who may audit assessments and inspect buildings.[64,65]

Box 2. Building control bodies

A building control body (BCB) can be either the local authority or (except in Scotland) a commercial 'approved inspector'.[66,67] The BCB inspector checks compliance by reviewing building plans, conducting inspections throughout construction and providing final sign-off.[67,68] For buildings subject to the Fire Safety Order (Box 1), the BCB must also ask the fire authority to comment on the building plans.[67] Upon inspection of completed work, the BCB issues a certificate as evidence, but not a guarantee, of compliance with the building regulations.[67]

Box 3. Development of a fire

When a fire starts in a room or any fire compartment in a building, the oxygen concentration does not change much and the initial temperature rise is modest. As the fire grows, flames spread to new material, increasing the temperature and leading to a layer of hot smoke accumulating at ceiling level. The heat increase becomes so large that the smoke layer and other combustible materials in the room ignite. Flames engulf the room, to become a 'fully developed' fire. This process can occur in minutes. Flames may emanate from windows and doors, potentially spreading from the compartment.[69] Windows are not usually fire resisting. Fire doors typically have a fire resistance rating of 30 or 60 minutes. According to Home Office data, 90% of dwelling fires attended by Fire and Rescue Services in England between 2010/11 and 2016/17 were contained in their room of origin,[70] however fire spread between compartments can have very serious consequences, as seen in the Grenfell Tower fire.

ADB lists the fire safety product classifications deemed suitable for different applications. The architect may specify particular products or provide contractors with performance specifications to follow when choosing products.[76] Contractors may be able to substitute products, for example to reduce costs or if a product is unavailable.[77,78] The Royal Institute of British Architects (RIBA) have suggested that product substitution may not always be properly assessed.[44] Building control bodies are required to assess products specified in building plans and inspect building work (Box 2).

Testing and classification

Construction products are tested in accordance with defined standards to see how they behave when exposed to fire. The resulting classifications help to ensure that the products selected for an application are appropriate. However, due to the complex and unpredictable behaviour of fires, classifications are used to benchmark products against each other but do not directly reflect behaviour in a real building fire.[79,80] In England, Wales and Northern Ireland, products can be classified under two systems: the National system (BS 476 series) and the European Reaction to Fire classification system (Euroclasses, EN 13501 series). ADB provides guidance in terms of both systems. Scotland has its own classifications, based on these two systems.[81]

Although National classifications are still used for some products and applications, many construction products require a Euroclass classification to comply with the EU Construction Products Regulation (CPR).[82] Under the CPR, suppliers of certain construction products must provide a declaration of the product's performance and ensure that it is 'CE' marked.[83-85] Product classifications are based on tests undertaken by 'Notified Bodies' such as BRE and Exova, which have been designated by an EU Member State.[86] Tests may also be used as part of independent certification (e.g. by the British Board of Agrément), which aims to provide confidence in a product's performance and ongoing production.[27,87] Products can be classified in different ways, often by using multiple tests in combination. 'Reaction to Fire' tests include tests for combustibility, flame spread and (in the Euroclass system only) smoke production. Structural and compartment building elements (e.g. compartment walls, beams and fire doors) can also be classified with 'Fire Resistance' tests.

Combustibility

Combustibility characterises how easily a material burns. Tests can be conducted to classify materials as non-combustible, of limited combustibility or combustible (Box 4). Some inert materials (e.g. concrete) do not require testing.[55]

Flame spread

Flame spread characterises how far and fast flames move across the surface of a combustible construction product (Box 4).[88] When combustible materials are combined into assemblies, their arrangement may inhibit or contribute to a fire in unexpected ways. Therefore, depending on the application, large scale fire performance tests may be required to assess fire spread and damage. For example, ADB states that the external surfaces of a building below 18m tall can contain combustible materials, although surface products with Class 0 performance or better (or an Euroclass alternative, Box 4) are required if the building is within 1m of the property boundary.[55] For buildings with floors over 18m, compliance with the building regulations may be demonstrated via one of the following:

- adhering to ADB guidance that external surfaces of walls should be of Class 0 performance or better and that "any insulation product, filler material … etc. used in the external wall construction should be of limited combustibility"
- a large scale assembly fire performance test (Box 5)[96]
- a 'desktop study', in which a fire specialist assesses whether the assembly would pass the large scale fire performance test, based on tests of similar assemblies (not explicitly referred to in ADB but used in practice)[97]
- a fire safety engineering exercise that considers the assembly as part of a building-wide assessment.

Interpretations of this ADB guidance and how it applies to cladding assemblies, vary.[98] For instance, MHCLG has said that the requirement for limited combustibility applies to cladding panels.[99] However, RIBA says that experts have questioned this broad interpretation and whether "filler material" has been understood within the construction industry to apply to rainscreen cladding at all.[44]

Smoke production

The smoke produced when construction products or building contents burn causes harm, as it displaces oxygen, limits visibility for escape, and is toxic and irritant. Assessing the

Box 4. Reaction to fire tests

Product combustibility

Combustibility can be tested in a range of ways, depending on the type of material and the classification system used. ADB provides guidance in terms of both the National and Euroclass systems. For example, products with either a National 'non-combustible' rating or Euroclass 'A1' classification can both be used for certain applications. Tests involve heating a product sample and observing whether flames form. Under the National system, products may be classified as:

- **non-combustible** – behaviour includes absence of flames (e.g. stone, metal and glass-based products)[89,90]
- **material of limited combustibility** – behaviour includes the temperature remaining below certain thresholds (e.g. some paper faced plasterboards)[91,92]
- **combustible** – if those thresholds are exceeded (e.g. wood and most plastic-based products).[55,91,92]

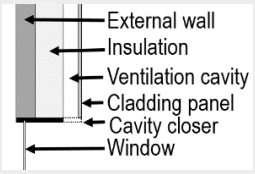
Flame spread and other characteristics of combustible products

Tests differ between the National and Euroclass systems.

- **Euroclass tests** classify combustible materials from B to E (B has the lowest contribution to flame spread).[93,94] They include two panels of the product being arranged to form an internal corner, which is exposed to a flame. The heat produced, rate of flame spread, smoke density and amount of flaming material falling from the sample are measured.
- **National tests** for flame spread classify materials from 1 to 4 (1 has the lowest contribution to flame spread). An extra classification of 0 is defined in ADB, which can be achieved for products that meet both Class 1 plus an additional fire propagation criterion.[88,95] Smoke and flaming material are not considered in National tests or in ADB.

Box 5. Example of large scale assembly fire performance test

Modern rainscreen cladding is a common way of covering external walls. A typical build may include: a layer of insulation, ventilation cavity, outer cladding panel, and cavity closer. One example of outer cladding is Aluminium Composite Material (ACM), which has a core of polyethylene or other material, in between thin aluminium sheets.[100-102]



A typical cross-section of rainscreen cladding above a window.

Large scale tests can be run on a cladding system such as this, to see how far and how quickly fire spreads away from its source.[103,104] In test BS 8414, a cladding assembly measuring roughly 8m tall is installed in an inside corner configuration, and a wooden crib (an arrangement of timber) placed in an opening at the bottom to represent flames emanating out of a broken window onto the outside of a building.[105,106] The assembly is deemed to have failed if: a temperature rise of 600ºC or more is recorded for 30 seconds or more in or on the cladding system within 15 minutes of exposure to flame, or if flames spread off the top of the system during the 60 minute test.[101,107] Such tests may also be used to check compliance retrospectively. MHCLG commissioned large scale tests on rainscreen cladding assemblies following the Grenfell Tower fire.[108]

risk of smoke toxicity is complex. For example, flame retardant chemicals may be added to combustible materials to reduce their flammability,[109] which can allow occupants more time to escape, but increase smoke toxicity.[110] Smoke density is classified under the Euroclass system (Box 4), but no limits for this are set in ADB. The smoke toxicity of construction products is not classified under either the National or Euroclass systems, nor is it referred to in ADB.[111] There is disagreement across EU national authorities, trade bodies, and others on whether smoke toxicity testing and classification should be required for construction products.[111] A European Commission report concluded that it could not assess whether regulating the smoke toxicity of building products would be effective due to a lack of data.[111]

Fire resistance

A fire resistance rating indicates the duration over which certain building elements (such as a structural column, or a compartment wall) can continue to support their load or contain fire during a furnace test.[55,112] Tests involve heating a sample (e.g. a weighted section of floor) to see how long it remains functional.[113-116] The furnace test does not necessarily represent the conditions in a real fire, where premature failure is possible.[117] Under ADB, the minimum fire resistance rating for loadbearing elements used in dwellings varies from 30 minutes for two storey buildings, to two hours for buildings over 30m tall.[54,55]

Challenges

There are challenges specific to the testing of construction products, as well as wider issues associated with the building regulations that can affect the selection, installation, and maintenance of products. These wider issues are the subject of several ongoing reviews.[25,27,31,32,118]

Testing

The Hackitt Review reported that many industry and fire safety experts had expressed concern that test conditions do not necessarily reflect real-world conditions and that a failure to replicate defective installation when conducting tests can have a misleading effect on test results.[27] It also stated that the marketing of construction products and assemblies can present data in ways that can easily be misinterpreted and that full assemblies are often not tested as a system. Few facilities are able to conduct large scale tests such as BS 8414. Desktop studies were introduced as a more accessible way of demonstrating compliance for new assemblies and were intended for minor design modifications (e.g. changing the colour of a panel). The Hackitt Review also reported that the widespread use of desktop studies is currently not properly managed, both in terms of when they can be used and the qualifications and experience of those undertaking them.[27,44,119,120] The Government announced a review of desktop studies in April 2018, as part of a wider review of building safety.[121]

Building Regulations

Responsibility for meeting regulations

Building contracts vary and responsibilities may be divided between the client, architect, contractor, subcontractors and suppliers.[122] The Hackitt Review stated that the clarity of roles and responsibilities was poor.[27]

Clarity of the Building Regulations guidance

A survey of over 300 ADB users, commissioned by MHCLG in 2017, reported that ADB was considered useful, accurate and comprehensive, but complex and in need of clarification.[123] The Hackitt Review also stated that regulation and guidance is complex and unclear.[27] A survey of industry professionals concluded that ADB and the Building Regulations do not reflect modern building design and use; for example, it may be unclear how new types of product fit under existing guidance.[124-126] The Government says that it is working with industry experts and the Building Regulations Advisory Committee to clarify ADB.[127,128]

Oversight of building work

A 2016 inquiry by the All Party Parliamentary Group for Excellence in the Built Environment noted skills shortages at all levels in the construction industry.[129] The Building Control Performance Standards Advisory Group reported that the proportion of fully qualified building control body staff fell from 59% to 51% between 2012/13 and 2015/16.[130] The Hackitt Review stated that enforcement and sanction measures are poor and do not provide adequate means of compliance assurance.[27] It also noted that the means of assessing and ensuring competency (e.g. of designers, builders, fire engineers, inspectors etc.) are inadequate.[27]

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