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Chicago Art Institute Building. Renzo Pianos Modern Wing

Intelligent Fire Safety Design

By Mike Wood

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Fire safety professionals have to admit that fire safety is too often relegated down the list of priorities. Others, sadly, do not share their passion. Fire safety tends to be seen pragmatically as a minimum measure, an imposition driven by regulations to be side-stepped if at all possible. There are lessons from the world of glass: work with the flow of design and not against it, as Mike Wood explains

Integrated design

Architects have had a dream for a light-filled, crystal palace of glass architecture ever since the mid 19th century, articulated by the visionary Paul Scheerbart in Glasarchitektur in 1914. This was taken several steps onwards by Walter Gropius and the foresight of the Bauhaus school in the 1920s and 1930s, and later explored by Mies van der Rohe in the towering skyscrapers of US cities from the 1950s onwards.

The central thread of the architectural story through the 20th century into the 21st is an international one that is fundamentally founded on an increasing use of glass in ever more creative building styles. This is linked to increasingly innovative and complex highly-engineered and calculated structures. Today's skyscrapers carry the legacy of London's original Crystal Palace of 1850 – which was destroyed by fire in 1936 – based on design and construction ideas a century ahead of their time.

It is the use of glass in buildings that has provided the continuity and drive for architectural development, to satisfy both basic psychological human needs and lofty ambitions. Natural daylighting, comfort, security, privacy, sustainability and energy efficiency rate highly. Image, decoration and presentation also receive a particular emphasis in this modern marketing-led consumer world. As a result there is a high technology sophistication to modern buildings. Fire-resistant glass has followed. And fire-resistant glazed systems, like all fire-resistant systems, have had to develop accordingly to match the sophistication of modern buildings.

The earliest development was wired glass, introduced in the 1890s for the first large span glass roofs of the central city rail transport hubs of the time – still one of the most effective, reliable and robust types of fire-resistant glass; the sterling workhorse of the fire-resistant range of glazing solutions. The current range of clear fire-resistant glass types have only developed, in the main, over the last 30 years. They are still relatively new, and based on a diversity of glass technologies each with its own strengths; some with weaknesses that could be potentially critical in some fire circumstances. They are still undergoing development in order to keep pace with the fast rate of architectural change.

The case is that fire safety has to catch up with design and building practice. Fire safety is not a leader. And therefore fire safety has to integrate with the full architectural context, as part of the functional mix. Fire safety cannot sit outside the design process and be seen simply as an add-on after all the other building needs have been addressed. The risk, however, is that this is where fire safety, in effect, chooses to make its stand.

Range of application

The range of application for some fire-resistant glass types is now so extensive that it is no exaggeration to say that virtually all potential major

applications where glass could be required in buildings are possible in fire-resistant glass. Other fire-resistant glass types are more limited and restricted in use. Each one needs to be taken on its own merits; evaluated in its own right. Assumption that one fire-resistant glass is exactly like another can be risky – potentially dangerous.

Internal applications cover door vision panels, full glass door sets and surrounding screens, large-area glazed partitions, some including integral blind systems, overhead panels and even sliding door systems. Advanced load-bearing fire-resistant glass floors are also possible. Pilkington has taken the lead in this development, being successful with not only steel framing but also timber framing for particular aesthetic effects. For older heritage buildings sensitive refurbishment may be needed to bring them closer to modern standards. Secondary fire-resistant glazing systems have been developed to preserve the character of the original casement without damage to the exterior while providing the required fire protection on the inside.

External applications include not only the façade but also multi-layered overhead glazings for horizontal or inclined roof applications to allow the maximum light presentation into corridors and working or living areas, also fulfilling safety requirements necessary for overhead glazing. One of the relatively neglected aspects of fire movement in buildings – that of break-out followed by break-in through the external glazing of upper floors – is receiving increasing attention in view of the analysis of fire disasters in glass towers. The fashion for atria in designs has also led to some interesting fire-resistant solutions, including smoke control and prevention of break-out and break-in of fire from adjacent room glazing looking out on to the atrium.

The designer has many available options in glass. And the adaptation of fire-resistant glass to fit the overall glass and natural lighting concept is a key development in allowing designers and specifiers to meet their overall design objectives.

Function

Glass, of course, is used primarily for its transparency. That imposes limits on fire-resistant glass types that have only a basic integrity function, lacking significant performance as a fire insulation heat barrier. The dangers of heat in a fire are high, so basic integrity function limits such glass types to relatively smaller sizes and limited runs of glazed panels. Such types may also only really be suitable for the immediate needs of fast escape, within 15 minutes or at most 30 minutes from the time occupants start to move to a place of relative safety.

Fire-resistant glass types, which have a full insulation capability and integrity, provide a much wider scope of application and they are capable of countering a much wider range and type of fire risk. Insulation performance provides less uncertainty for those who rely on fire protection and have a much greater capability of providing safe working conditions for firefighters.

Products with good insulation performance are therefore especially appropriate when escape could be more hazardous, the building more complex and the conditions less certain. That would apply, for example, to health and education establishments, transport centres – particularly airports – multi-functional buildings where the occupants are not accustomed to the building, sleeping accommodation, and major buildings, for example museums, art galleries, modern offices and industrial plant containing high value assets. Fires may well last for up to 24 hours and the exposure of an element of construction could be several consecutive hours within that period. Fires in modern buildings, based on fixtures, fittings and furnishings with a high plastic and synthetic content, can be particularly intense and fast moving. Insulation performance provides the additional assurance to minimise risks.

Flexibility in design

One of the main requirements for designers is flexibility and freedom to develop core design concepts; in particular, an ability to make adjustment to meet the demands of the client's specification and budget, without compromising on the basic requirements for safety, security, comfort and efficiency. Implicitly, fire safety has to be a balance, in tune with design.

One of the prime objectives of fire-resistant glass, in addition to providing safe escape, is to allow effective fire compartmentation without sacrificing openness, vision and innovation in layout and building arrangement. The first requirement for fire-resistant glass is to fit the design requirements. The second objective is to satisfy the demands of fire protection for the building and its occupants, restricting fire to its place of origin, preventing spread and avoiding collapse. Fire compartmentation is a basic requirement for fire safety in buildings, as it provides a basic foundation for all other fire-safety measures.

Clear fire-resistant glass cannot readily be distinguished from other glass products surrounding it. That has been a key objective for the development glass technologist, as fire-resistant glass has to look and function the same in all other respects, with the addition of resistance against fire. That is why it is particularly important to specifically identify fire-resistant glass with a permanent, easily readable mark, normally positioned in a bottom corner, at least noting the product name, manufacturer, fire performance class and, where relevant, impact classification. Too often, the mark is illegible or non-permanent. If there is no mark, the assumption must be that the glass is not a fire-resistant glass.

Fire-resistant glass can now be combined with a whole range of other functions demanded of glass, such as impact safety, energy efficiency, security, privacy, and solar control, while providing the highest performance of all – fire resistance. One of the particularly useful additional benefits of the

Comparison of acoustic sound insulation data

Products not classified for fire resistance	**Sound attenuation index** R_w ($C;C_{tr}$), reference EN ISO 717-1, in dB
Pilkington Optilam (6.4mm standard laminate)	32 (–1; –3)
Pilkington Optiphon (6.8mm acoustic laminate)	35 (–1; –3)
Pilkington Optiphon 6.8mm in dgu, 16mm gap	38 (–2; –6)
Pilkington Optiphon 9mm in dgu, 16mm gap	39 (–2; –6)
Products classified for fire resistance Integrity fire resistance	**Sound attenuation index** R_w ($C;C_{tr}$) index, reference EN ISO 717-1, in dB
Pilkington Pyrodur Plus (7mm, E/EW 30, EI 15)	35 (–1; –3)
Pilkington Pyrodur (10mm, E/EW 30, EI 15)	36 (–1; –2)
Pilkington Pyrodur 10mm in dgu, 12mm air gap	38 (–2; –5)
Pilkington Pyrodur (13mm, E/EW 60, EI 15)	38 (–1; –2)
Products classified for fire resistance Insulation with integrity fire resistance	**Sound attenuation index** R_w ($C;C_{tr}$), reference EN ISO 717–1, in dB
Pilkington Pyrostop (15mm, EI 30)	38 (–1; –2)
Pilkington Pyrostop (18mm, EI 30)	38 (0; –2)
Pilkington Pyrostop 18mm in dgu, 12mm air gap	40 (–1; –5)
Pilkington Pyrostop (23mm, EI 60)	40 (–1; –3)
Pilkington Pyrostop 18mm in dgu with Pilkington Optiphon™ (9mm), air gap 12mm	45 (–1; –5)

proprietary intumescent laminated fire-resistant technology utilised for Pilkington Pyrostop and Pilkington Pyrodur, for example, is enhanced acoustic insulation performance, which is a requirement of increasing importance in modern high-density occupancies. The special glassy fire-resistant interlayer and the composite-layered structure of these laminated products together deliver good sound insulation; a valued benefit when combined with fire-resistance in one product.

Her Majesty's question

On a visit to the London School of Economics in November 2009, HM Queen Elizabeth II is reported to have asked the assembled accomplished economic experts why no-one had foreseen the financial credit crisis and provided a warning.

It is a valid question and one that Her Majesty might equally ask, given the opportunity, of fire safety specialists in the context of fire. Why do we still have major property losses in fire that in the UK amount to £1.3 billion a year, and are rising? And why do we still have tragedies when lives of residents and firefighters are unnecessarily lost? We know how to build and operate buildings with enhanced levels of fire safety; the difficulties lie rather in application and operation according to principles of good or best practice, which are well demonstrated. Enforcement is also part of the problem; compliance with clear standard and regulatory guidelines. Another major factor is a disturbing tendency to ignore requirements and apply them down to the lowest possible level, too often in the face of knowledge, with too close an eye on cost cutting.

Her Majesty might equally have followed her first question with a supplementary for the gurus on whether risk-taking practices had perhaps crossed over the boundary from prudence to recklessness, and if it could possibly be that practitioners had been so wrapped up in what they were doing that they did not notice that limits had been transgressed. That question is also one that fire safety needs to ask, as fire safety design and engineering is increasingly cast adrift from the anchor of prescriptive guidance in a move towards risk-based techniques, dependent more and more on unchallenged expert judgment. There should be circumspection that risk-based techniques do not become adventures in the land of probability and chance.

Performance

Modern buildings and assets are high value, while cities and buildings more congested. The risk to people in some senses is higher than it was because of developments in the built environment. Fitness for purpose of designs and, in turn, of building elements, products and components is essential if the overall objective is fire safety. Because of the unpredictability and intensity of fire, attention to quality of performance has to become an obsession. That, in turn, requires recognition and acceptance of personal responsibility, applying to all those along the chain from the design to installation, including product supply, building operation and ownership. That above all is the critical imperative needed for advances in fire safety. IFP

Notes:

1. Sound insulation data measured in accordance with BS EN ISO 140-3.
2. Correction factors C and Ctr take into account the different frequency spectra of residential and traffic noises, respectively.
3. "dgu" refers to a double glazed unit with a 6mm float glass pane unless otherwise indicated.
4. Fire resistance classifications in accordance with BS EN 13501-2
   E = integrity; EW = integrity and radiant heat; EI = fire insulation performance; 0, 60 etc = classification test time in minutes.
5. The Pilkington Pyrodur and Pilkington Pyrostop range are also classified for impact safety according to BS EN 12600.
6. It is advisable only to directly compare acoustic indices measured and recorded on the same basis. Estimates may be used in place of measurement and each determination has a natural measurement variation.

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