SRI Charleroi

bbri.be
Researches • Develops • Informs

A publication of the Belgian Building Research Institute

June 2022 (update of the 2017 version)

Fire safety of multi-storey building facades

Fire safety of multi-storey building facades

Y. Martin, S. Eeckhout, L. Lassoie, E. Winnepenninckx and B. Deschoolmeester (BBRI)

The authors express their gratitude to the Federal Public Service Home Affairs (Directorate-General Safety and Prevention – Directorate Fire Prevention) and in particular to Fr. Ulens (leader of the 'Facades' working group of the High Council for Protection against Fire and Explosion) and J. De Saedeleer (deputy director, Fire Prevention Directorate, FPS Home Affairs).

The present publication was drafted by the BBRI, in collaboration with SECO and the Confédération Construction.

BELGIAN BUILDING RESEARCH INSTITUTE

BBRI, an establishment recognized under the Decree-Law of 30 January 1947
Registered office: Rue du Lombard 42, 1000 Brussels

This is a publication of a scientific nature. Its purpose is to help disseminate the results of building research from home and abroad.

The copying or translating, even partial, of the text of this monograph is permitted only with the written consent of the responsible publisher

Contents

PURPOSE AND SCOPE OF THE DOCUMENT

The 2017 version of the present document was drafted following several facade fires in high-rise buildings, and more particularly the *Grenfell Tower* tragedy in London in June 2017. In 2022, the paragraphs relating to the regulatory framework were adapted to the revised legislation. The section on the *Grenfell Tower* fire itself has not, however, been updated.

The objectives of the document are notably:

- to give an **overview of the current regulatory and normative framework** concerning the fire safety in Belgium, and more particularly with regard to the risk of fire spreading via facades. This document will present the **revision work to the regulation** currently under way as well as some proposed initial approaches
- to outline the **key points and constructional features** making it possible to guarantee the correct design and installation of the commonly used facade systems, taking into account the current and future requirements in Belgium.

We would like to point out that the 2022 version of this document is based on document HR 1762 N R3 approved on 17 January 2019 by the High Council for Protection against Fire and Explosion. This document was drawn up by the 'Facades' working group and was one of the reasons for the revision of the Royal Decree 'Basic Standards', which was published in 2022. This revision will apply from 1 July 2022 to all newly submitted applications for urban development permits.

1. Introduction

1.1 Impact of fires

In Belgium, more than 19,000 fires were recorded requiring the intervention of the fire services in 2014 (information supplied by 195 of the 250 fire services in the country, that is almost 80 %). According to the same information, more than 70 civilians were killed in these fires in the same year. Additionally, more than 1,200 civilians and over 20 firefighters were injured in 2014. Furthermore, we noted that as an overall gross average, the arrival time of the fire services to the site (time between the alert and arrival) is less than 10 minutes [1].

On a European scale, 5,000 fires are recorded each day, leading to the hospitalisation of some 70,000 people per year and causing close to 4,000 deaths [2]. These figures remind us that fire prevention is of paramount importance for our society.

The damage caused by fires also has an economic impact estimated at close to € 126 billion per year in Europe [2]. In addition to the direct damage (buildings, ...), many companies find themselves unable to overcome the consequences of a significant fire (loss of merchandise, infrastructure, temporary interruption of the operations, etc.) and are therefore forced to close.

The environmental impact of a fire should also not be underestimated.

1.2 Returning to the Grenfell Tower blaze in London on 14 June 2017

Important: *this section is based on the information we received in the first weeks following the* Grenfell Tower *fire, which at the time had not been officially confirmed by the experts responsible for the inquiry into the fire. At the time of drafting of the 2017 version, the inquiry was still in progress. The data provided hereafter can therefore not be considered as definitive and proven.*

During the night of 13 to 14 June 2017, a fire broke out in the building known as the *Grenfell Tower* in London. The high number of victims (over 79 deaths and 70 injured) and the speed at which the fire spread, urged the concerned parties (project owners, architects, contractors, public bodies, manufacturers, suppliers, ...) in Europe and elsewhere, to undertake an in-depth evaluation of the regulatory framework regarding fire safety. Built in the 1970s, *Grenfell Tower* was a residential block of 24 floors, some 67 m high with more than 120 apartments.

The typical floor plan was comprised of 6 apartments located around a central stairwell with lifts.

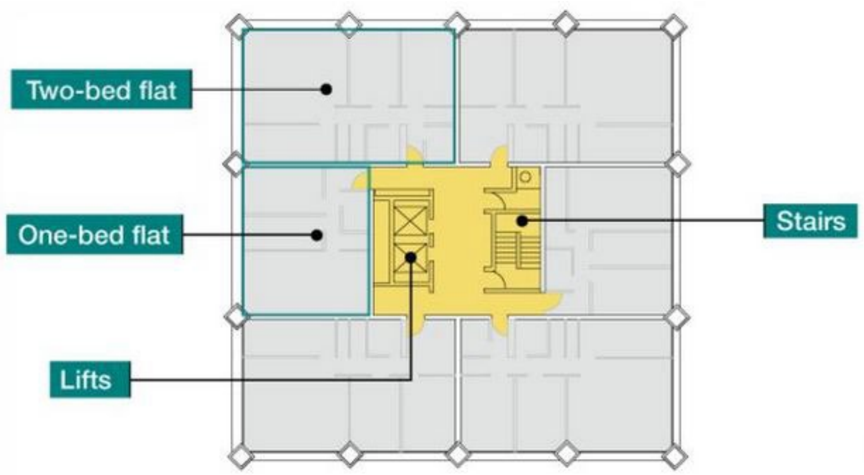


Figure 1 – Typical floor plan of the Grenfell Tower [3].

Energy renovation work to the facade was carried out in 2016. According to the information disclosed in the first weeks following the fire, the renovated facade was composed as follows (see figure 2).

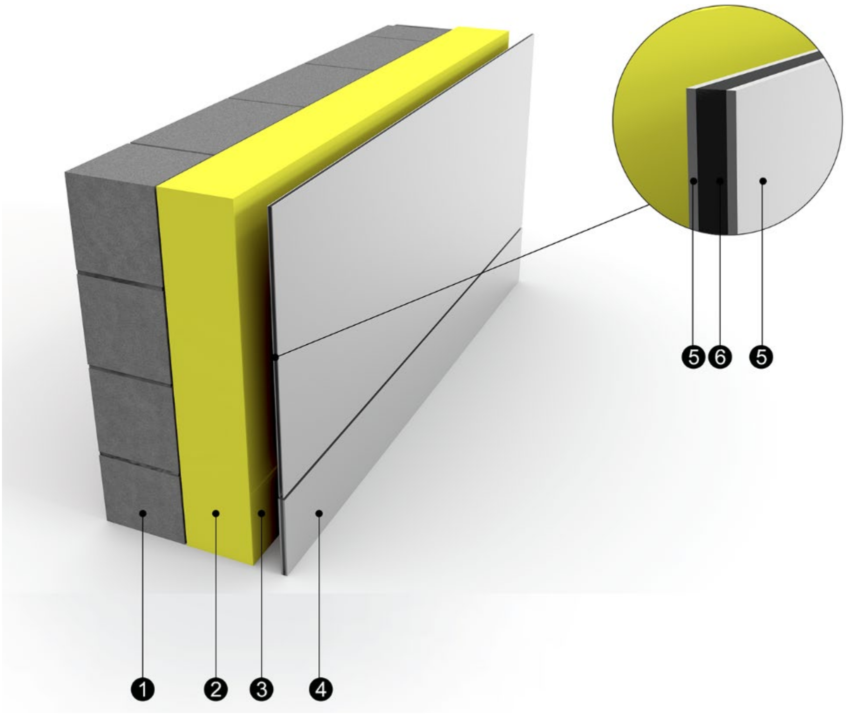
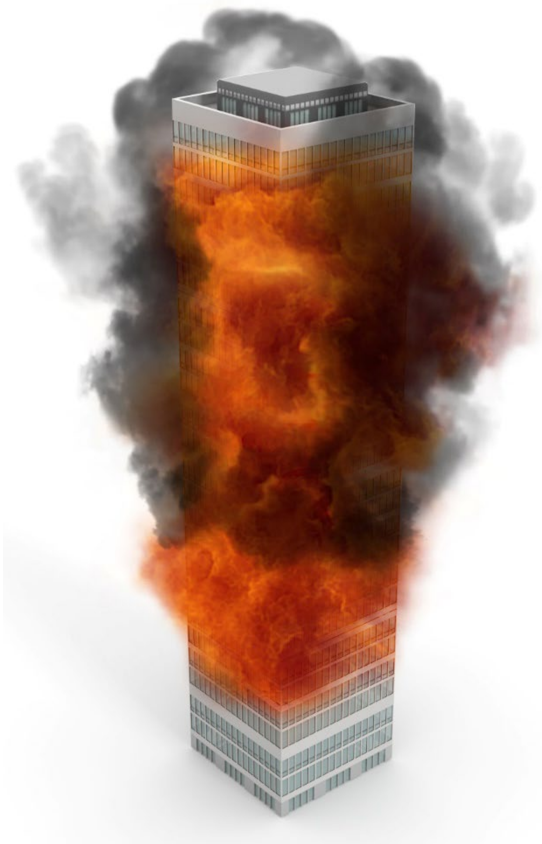


Figure 2 – Composition of the facade of the Grenfell Tower.

The fire allegedly started in an apartment on the 4th floor and is likely to have been caused by a faulty refrigerator. The fire services arrived on site quickly, but the fire had rapidly spread vertically via the facade. Moreover, it is probable that 'secondary' spreading also took place inside the building (via the vertical technical service shafts, the stairwell, ...). In several places, the fire got into the building again, completely destroying several apartments and trapping the occupants who had not been able to evacuate the premises by the only available stairwell, likely rendered inaccessible at some point.



The circumstances and the causes of the fire were still being investigated at the time of drafting of the 2017 version of the present document. Nevertheless, it is clear that the circumstances of a tragedy such as this are multiple and cannot be traced back to one single parameter. One can, however, raise questions concerning the very rapid vertical spread of the fire (figure 3) via the facade system (combustible insulation, ventilated air cavity and composite panels with a polyethylene core). The means of evacuation for the occupants in the over 60 m high building also appeared to us to be particularly limited, as the building only had a single stairwell[1]. In view of their crucial importance, the compartmentation and safety of the evacuation means (fire-resistant walls and doors, fire sealing and stopping of service installations penetrating fire-resistant walls, ventilation openings, putting the stairwell in overpressure, ...) and the apartments (fire-resistant doors, vertical shafts and penetrations of service installations, ...) also need to be taken into consideration.

Finally, at the time of drafting of the 2017 version of the present document, no information at all was available concerning the presence or the correct functioning of active prevention methods (detection, alarm, extinguishing methods, ...).

[1] In Belgium, it is mandatory to foresee two stairwells in high-rise buildings.

2. BASIC FIRE SAFETY PRINCIPLES

2.1 FIRE PREVENTION

The first axis of the so-called **passive fire prevention** consists of slowing down the development of a fire and its rapid spread by using construction materials with low flammability and combustibility. This measure is related to the **reaction to fire** (see § 2.2) of materials such as wall, floor, ceiling and facade claddings as well as materials (such as insulation) that are in the vicinity of the exposed surface. When a fire occurs, it needs to be detected and extinguished as quickly as possible. Active fire prevention measures (see below) will also have an important role to play in this regard.

When the fire has been able to fully develop and enters into its second phase (flashover), the second axis of the passive fire prevention strategy kicks in: this firstly relates to preventing the fire from spreading too quickly beyond the location(s) in which it has started, and secondly to ensuring the stability of the building during a specific time frame. This measure targets the **fire resistance of the construction elements** (see § 2.3), which must be able to maintain their load-bearing and/or separating functions for a defined period of time, in order to permit the evacuation of occupants and the intervention of the emergency services. The compartmentation of the building, or in other words the division of the building into volumes which are delimited by walls with a sufficient fire resistance, is of vital importance in this context.

Passive fire prevention relates to the building's structure as well as to the building's finishing and relies on the following principles:

- the use of cladding materials with good reaction-to-fire characteristics, in order to delay the development of an incipient fire
- the realisation of compartmentation to confine the fire, for a defined period of time, to the compartment in which it started
- to preserve the load-bearing function of structural elements (columns, beams, walls) during the fire
- to provide a sufficient number of exits to ensure the smooth evacuation of people
- the use of stairwells and evacuation routes as specific compartments in order to facilitate the evacuation of people in complete safety and the access to the building for the fire services
- a clear signalling system to facilitate the evacuation of the residents.

The so-called **active fire prevention** includes, amongst others, the fire detection, alert and extinguishing and the smoke and heat extraction. These measures relate to the equipment of the building and complement the passive prevention measures.

The *detection and warning systems* are intended to signal the start of a fire. Timely detection makes it possible to wake the inhabitants of an apartment or to alert nearby occupants of the incipient fire. Centralised detection is intended to warn the occupants, the prevention services of the building or even the fire department, in order to reduce the evacuation and intervention time.

Smoke and heat extraction systems (SHE) by definition aim to extract the smoke and heat released by an incipient fire, in order to limit its development and its spreading. The objective of these systems is to facilitate the evacuation of people and the intervention of the fire services and to reduce smoke damage.

Extinguishing equipments (fire extinguishers, fire hose reels, ...) allow occupants (primary response team) to act quickly and effectively to extinguish a recently started fire. Fire hose reels and fire hydrants should also be available for the fire services to facilitate their intervention.

Automatic fire extinguishing systems (sprinkler installations) are logically intended to operate automatically in the event of an incipient fire. Generally, they are not intended to put out the fire, but rather to stop it from spreading in order to limit the adverse consequences and facilitate the intervention of the fire department.

Furthermore, we want to point out that it is important that the inhabitants of the building are aware of the fire safety aspects, particularly regarding the correct functioning of the fire doors, the first things to do after the start of the fire and the fact that it is forbidden to store flammable goods in stairwells and evacuation routes, …

2.2 Reaction to fire

Reaction to fire is the response of a **construction product** that contributes, through its own decomposition, to a fire to which it is exposed under specified conditions [4] [5]. The European classification for the reaction to fire is divided into seven principal classes (A1, A2, B, C, D, E and F) with the following additions:

- class s for smoke production (s1 and s2 for floor coverings; s1, s2 and s3 for other construction products)
- class d for flaming droplets and particles (d0, d1 and d2 for all products except floor coverings).

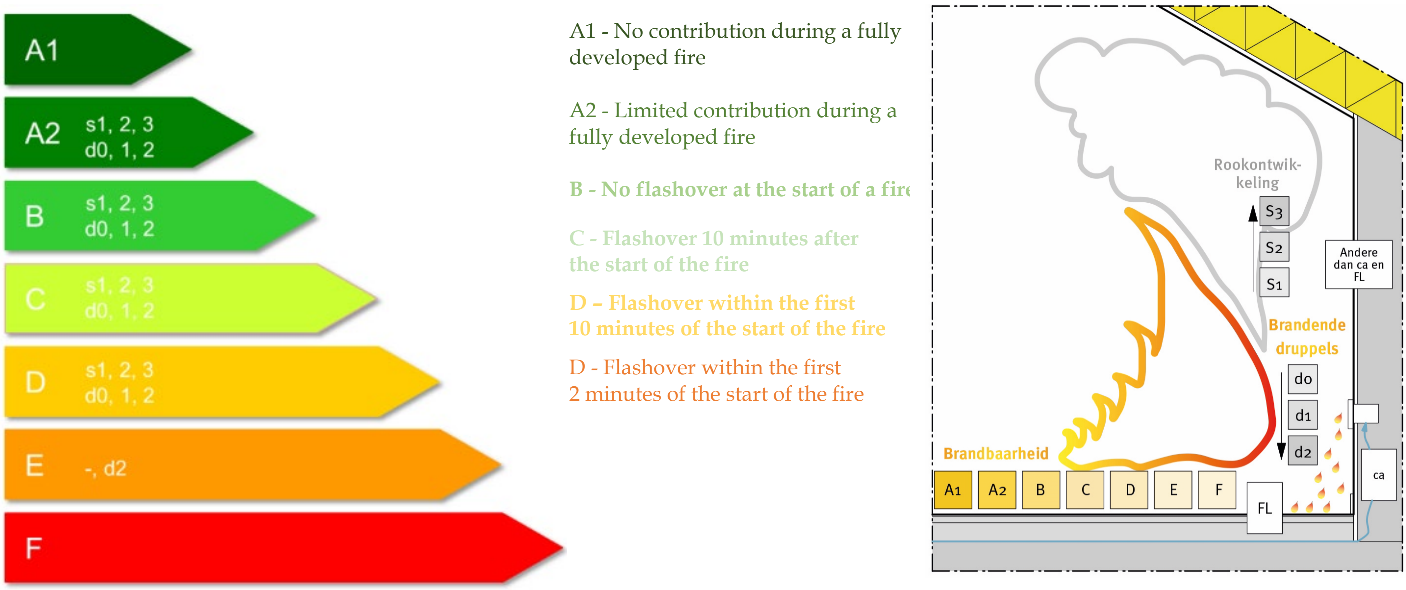


Figure 4 – Schematic representation of the reaction-to-fire categories.

For products for which the reaction to fire has not been evaluated, the letters 'NPD' (no performance determined) are used [30].

Table 1 indicates the reaction-to-fire classes of some materials frequently used in the composition of facades.

Table 1 – Reaction-to-fire classes of several commonly used materials.

Product	Reaction-to-fire class of the product itself
Metals, masonry, concrete, …	Class A1
Glass wool and rock wool	Class A1 or A2
Cellular glass	Class A1
Extruded polystyrene (XPS) and expanded polystyrene (EPS)	Class E or F
Polyurethane (PUR)	Classes D to F
Polyisocyanurate (PIR)	Classes B to F
Resol foam	Classes B to D
Wood-based panels and solid wood panels	Classes C to E
Fibro-cement panels, plasterboards, …	Class A1 or A2
Cellulose	Classes B (treated) to D (untreated)
Wood wool	Class D or E

Moreover, we want to point out that several decisions of the European Commission detail the reaction-to-fire classes of certain materials, without the necessity to conduct a test[2].

2.3 Resistance to fire and compartmentation

The **resistance to fire** is the ability of a **construction element** to maintain for a certain period of time its fire stability, integrity, thermal insulation and/or any other required function [4] [6]:

- *fire stability* (criterion 'R') indicates the ability of an element or a structure to withstand the specified loads and/or stress. This refers to the ability of a building element to withstand, without losing its structural stability, a fire which, under

[2] See the BBRI's Standards Antenna on Fire Prevention on the following website: https://www.cstc.be/normalisation-certification/antenne-normes/quels-sont-les-objectifs-de-l-antenne-normes-prevention-du-feu/notions-de-base-et-evaluation/decisions-de-la-commission-europeenne/.

defined mechanical stresses and for a given period of time, strikes on one or more sides

- *fire integrity* (criterion 'E') is the ability of a construction element with a separating function that is exposed to fire on one side only, to prevent the transmission of fire to the unexposed side as a result of the passage of flames and hot gases
- *thermal insulation* (criterion 'I') is the ability of an element with a separating function to resist the passage of heat. The transfer must be limited in such a way that the unexposed side cannot ignite, nor any other element in the immediate vicinity of this side.

European classification (R)EI 30, 60, 120 …

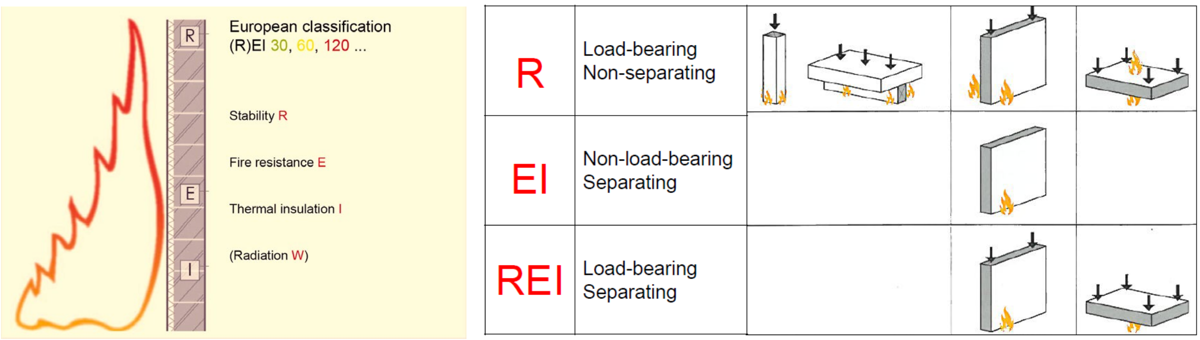


Figure 5 – Illustration of the ***fire resistance*** *classes for different construction elements.*

The fire resistance of construction elements can be evaluated by means of one or more levels of thermal attack, represented by a temperature-time curve [7]. According to the regulations applicable to new buildings in Belgium (see § 3.2), the fire resistance performance of a construction element must be determined on the basis of tests (since 1 December 2016, exclusively according to the European standards[3]) or on the basis of a calculation (according to the Eurocodes, 'fire' sections') – see figure 6[4].

3 According to the series of test standards mentioned in the classification standards [6] [8] [9], with the exception of suspended ceilings for which the Belgian standard NBN 713-020 [10] still can be used.

4 Based on article 2.1 of annex 1 to the Royal Decree 'Basic Standards' [11].

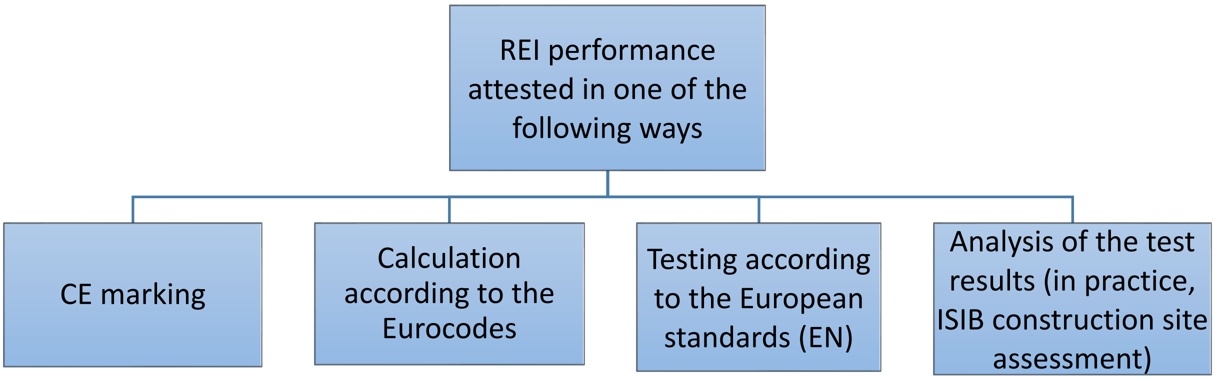


Figure 6 – Fire resistance attestation of a construction element in accordance with legislation (as per article 2.1 of annex 1 of the Royal Decree 'Basic Standards') [11].

3. Regulatory and normative fire safety framework in Belgium

3.1 General framework

The European Construction Products Regulation [12] sets out seven basic requirements with which structures need to comply in their entirety[5]. One of the requirements concerns fire safety and applies to buildings designed and built in such a way as to:

- ensure the stability of load-bearing elements for a specific period of time in the event of an outbreak of fire
- limit the generation and spread of fire and smoke
- limit the spread of fire to neighbouring structures
- allow occupants to leave the building unharmed or to be rescued in another way
- take into consideration the safety of rescue teams.

The Construction Products Regulation does not establish construction rules for buildings. It is the responsibility of the Member States to draw up implementing provisions to give effect to these seven fundamental rules. They are free to include or not implementing measures in their national law. In Belgium, such provisions have been elaborated for the fire safety of buildings.

The Belgian law of 30 July 1979 relating to fire and explosion prevention as well as compulsory third party liability insurance in these same circumstances forms the basis for the Belgian regulation relating to fire safety. This law gave rise to the Royal Decree of 7 July 1994 (and its modifications) [11], stipulating the **Basic Standards for fire and explosion prevention with which all new buildings must comply** (see § 3.3). The Royal Decree 'Basic Standards' issued by the Federal Public Service Home Affairs does not exclude the possible application of other regulations relating to fire prevention. As a consequence of the various State reforms, the competences regarding fire safety regulations of buildings have been divided between the Belgian Federal Authority and the Regions. The Federal Authority is responsible for the drafting of the regulations regarding the fire prevention in different types of buildings, whether intended for the current or future use of the building. The Regions can in turn issue specific regulations supplementing or adapting the Royal Decree 'Basic Standards'. However, the rules contained in the latter may not be prejudiced (i.e. they may not be globally relaxed or tightened).

5 See https://www.cstc.be/normalisation-certification/antenne-normes/quels-sont-les-objectifs-de-l-antenne-normes-prevention-du-feu/notions-de-base-et-evaluation/produits-de-construction/.

Beside these regulatory texts, the Belgian and European standards also have an important role. The application of a standard is not obligatory, unless an explicit reference is made in a regulatory text. The compliance to these standards is also obligatory if they are mentioned in the specifications, as this is often the case in public contracts and in some private contracts. Although the application of the Belgian standards is voluntary, they are nevertheless regarded as best practice rules as far as decennial liability of designers and contractors is concerned. Complying with these standards leads to a presumption of technical quality, whilst deviating from these standards creates a need for technical justification [13]. In Belgium, several fire safety standards are applicable (testing standards, classification standards, standards relating to active fire prevetion, …). Furthermore, some of these standards (dating from the 1980's) formulate additional fire requirements applicable to certain types of buildings[6].

The Spécifications techniques unifiées (Coordinated Technical Specifications – STS) issued by the Belgian Federal Public Service Economy are documents intended to assist the building owner or designer in drafting the technical specifications for a specific project. They describe how one can prescribe a product, depending on its specific application, how it can be verified and processed, and how one can evaluate its execution. Some design data may also be included in these Specifications. Clearly, these STS only acquire an obligatory nature if the building owner and contractor make reference to them in the contractual documentation, as is generally the case in the majority of the public contracts.

STS 71-2 'Systèmes d'isolation extérieure des façades' (External facade insulation systems) [15] is currently being drafted and should cover the following subjects:

- facade cladding (section 1)
- systems where the cladding is glued onto the insulation (section 2)
- systems with external masonry cladding (section 3).

[6] Amongst others NBN S 21-204 (1982) [14] on school buildings (currently being revised). The standard NBN S 21-204-2 on the fire protection of new school buildings was published in 2020.

Finally, the Technical Information Notes (TINs) of the BBRI can be considered as guidelines for correctly specifying and executing work according to the rules of best practice. Although the recommendations are not compulsory, these documents are nevertheless considered as references in the event of problems relating to parts of the building subject to decennial liability. The following TINs, drafted in consultation with the construction sector and in close collaboration with the representatives of the fire services and FPS Home Affairs, are specifically related to the subject of fire safety:

- TIN 282 Sécurité incendie des façades. Conception et mise en œuvre des façades-rideaux (acier et aluminium) (Fire safety of facades. Design and construction of curtain walls (steel and aluminium)) [31]
- TIN 256 Conception et mise en œuvre de bâtiments industriels conformes aux exigences de sécurité contre l'incendie (Design and execution of industrial buildings in compliance with fire safety requirements) [16]
- TIN 254 Obturation résistant au feu des traversées de parois résistant au feu. Prescriptions et mise en œuvre (Fire-resistant sealing and stopping of service installations penetrating fire-resistant walls. Requirements and installation) [17]
- TIN 238 L'application de systèmes de peinture intumescente sur structures en acier (Application of intumescent paint systems on steel structures) [18]
- TIN 234 Le placement des portes résistant au feu (Installation of fire-resistant doors) [19]
- TIN 226 L'entretien des portes résistant au feu (Maintenance of fire-resistant doors) [20].

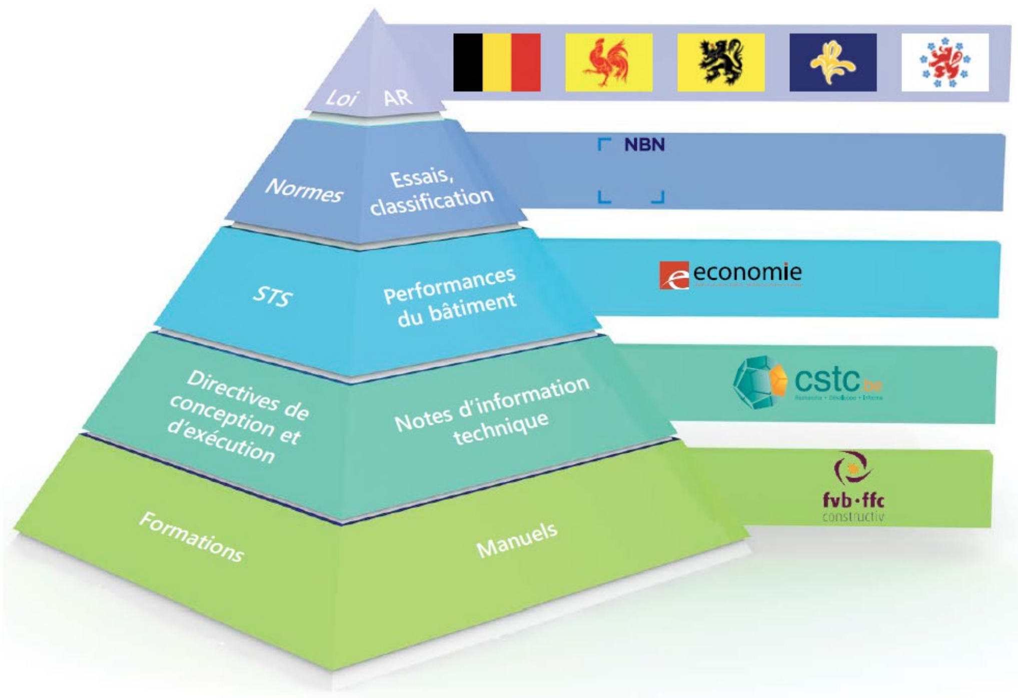


Figure 7 – Regulatory and normative fire safety framework in Belgium.

3.2 BELGIAN ROYAL DECREE 'BASIC STANDARDS'

The Belgian Royal Decree of 7 July 1994 (and its modifications) stipulates the Basic Standards for fire and explosion prevention with which all new buildings must comply [11]. This decree, which will be referred to as the RD 'Basic Standards', currently comprises seven annexes:

- annex 1: terminology
- annex 2: low-rise buildings (height < 10 m)
- annex 3: mid-rise buildings (10 m ≤ height ≥ 25 m)
- annex 4: high-rise buildings (height > 25 m)
- annex 5: reaction to fire
- annex 6: industrial buildings
- annex 7: common requirements.

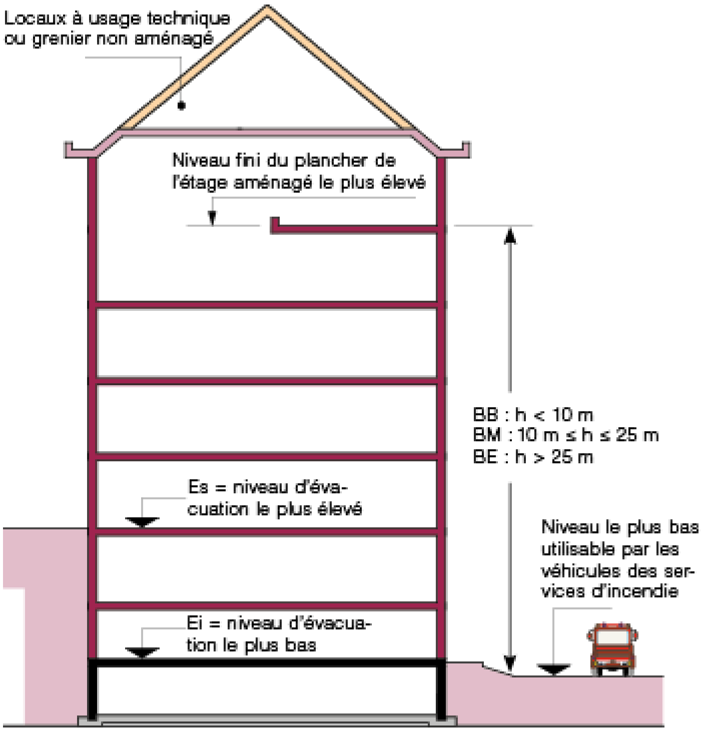


Figure 8 – Classification of buildings according to the Basic Standards.

These Basic Standards apply to all new buildings. Renovation works no longer fall within their scope since the modification of 4 April 2003. The regulations therefore do not apply to existing buildings, nor to renovation works on existing buildings, neither to **single-family dwellings**. The following section of this document therefore does not apply to single-family dwellings[7].

The Basic Standards define the minimum conditions for the design and the construction of new buildings in order to:

- prevent the outbreak, the development and the propagation of a fire
- ensure the safety of people
- facilitate the intervention of the fire services.

3.3 Other regulations and standards

The Belgian Regions and Communities have the competence to issue other decrees supplementing the Basic Standards, in order to take the specific nature of certain buildings into account. It should also be noted that the Belgian Act on the well-being at work and article 52 of the Belgian General Regulation on Industrial Safety are at the base of the fire regulations within the employment contract context. These documents are applicable to all companies, public services and public-interest bodies at a national, provincial or municipal level, as well as their staff.

> The BBRI's Standards Antenna Fire Prevention (www.normes.be) offers a database[8] of all applicable regulations for each Region and building type in Belgium.

3.4 Scope of the fire service reports

The fire services must comply with the regulations for fire prevention when providing an advice. The requirements of the fire department may not be more stringent than those stipulated in the regulations. In the absence of regulations or when a certain aspect is not regulated or if the existing regulation is clearly incomplete, the rescue

[7] For an interpretation of the concept of single-family dwelling, please see: https://www.besafe.be/fr.

[8] See here: https://www.cstc.be/normalisation-certification/antenne-normes/prevention-du-feu/.

services may propose requirements to ensure a minimum safety level. The circular regarding the fire prevention report [21] states that:

‘The emergency services should not take the place of the legislator and arbitrarily impose additional requirements. The emergency services must ensure that their proposals and conditions are proportional and reasonable in relation to the intended purpose’.

4. IDENTIFYING THE RISKS OF FIRE SPREAD VIA THE FACADES

Fire spread via the facades mainly occurs in one of the following three manners. The measures that need to be taken to reduce these risks are detailed in § 5.1.

1 **Fire spread via the surface of the facade cladding:** to slow down this type of spreading, one generally needs to take measures relating to the *reaction to fire of the facade cladding*.

Figure 9 – Fire spread via the surface of the facade cladding (to the left) – Reaction-to-fire tests on wood cladding (centre and right).

2 **Fire spread from one compartment to another** (from floor to floor, for example):

- either internally, via the junction between the floor slab nosing and the facade element
- or externally, when the flames are coming out of the facade by passing, for example, through glazed elements that are not fire-resistant (see figure 10, left arrow: the fire comes out of the facade via the window of the burning floor and affects the window on the floor above).

To remedy this type of spreading, it is necessary to ensure the *fire resistance* of the junction (between the floor slab nosing and the facade) and that of the facade element at floor slab level.

Figure 10 – Internal and external fire spread. Left: schematic drawing; right: flames coming out of a burning floor.

❸ **Fire spread within the facade system** via combustible components (e.g. the insulation), the ventilated air cavity located behind the cladding (chimney effect), ... One can reduce this risk by using, amongst others, non-combustible or low-combustible elements, by interrupting the combustible insulation layers, by interrupting the ventilated air cavity, ...

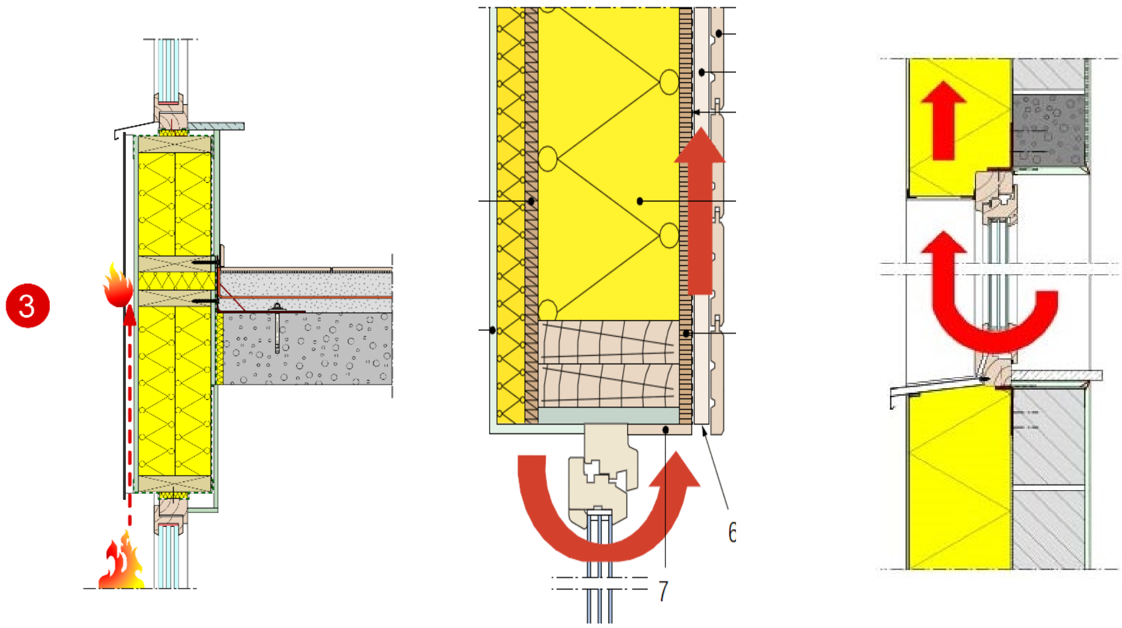


Figure 11 – Fire spread within the facade system.

5. Regulatory requirements intended to reduce the risks of fire spread via the facades

5.1 Regulatory provisions applicable to new buildings

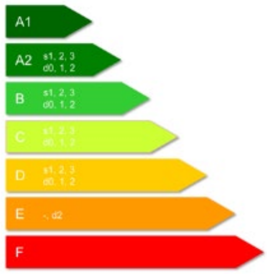
5.1.1 Reaction to fire of the facade cladding (requirements for building applications submitted before 1 July 2022)

The Belgian Royal Decree of 7 July 1994 stipulating the Basic Standards for fire and explosion prevention with which all new buildings must comply [11] defines the requirements intended to limit or to slow down the fire spread via facade claddings. These requirements relate to the reaction to fire of the facade cladding[9] and make it possible to avoid the risk 1 (fire spread via the surface of the façade cladding) identified in chapter 4.

For buildings for which the application for planning permission is submitted before 1 July 2022, the following requirements apply with regard to the reaction to fire of facade cladding.

'Facade cladding on low-rise buildings shall be class D-s3, d1. Facade cladding on mid- and high-rise buildings shall be class B-s3, d1. A maximum of 5 % of the visible surface of these facades is exempted from this requirement'.

- Industrial buildings: no requirements
- Low-rise buildings (h < 10 m): D-s3, d1
- Mid- and high-rise buildings: B-s3, d1



In the new regulations (from 1 July 2022), the requirements with regard to the reaction to fire of facade cladding have been amended. For this we refer to chapter 6 'Revision of the fire safety requirements for facades'.

It is important to stipulate that the requirements apply to construction products in their end use conditions, i.e. including the possible impact of underlying layers of materials and their method of fixing. The facade cladding on which the reaction-to-fire

[9] Article 6 of annex 5/1 to the Belgian Royal Decree 'Basic Standards' [11].

requirement applies cannot therefore be considered individually, but as it is executed on site.

Thus, in the case of an external thermal insulation composite system with rendering (ETICS)[10], the aforementioned requirements do not apply to the top-coat rendering alone, but to the entire system as executed, that is to say the rendering, the underlying layers (insulation) and the method of fixing. The reaction to fire of ETICS is declared by the manufacturer ('closed' system - see ETA and ATG technical approvals). It can reach the B-s3, d1 class required for mid-rise buildings in Belgium, even if the insulation used is highly combustible (EPS class E for example).

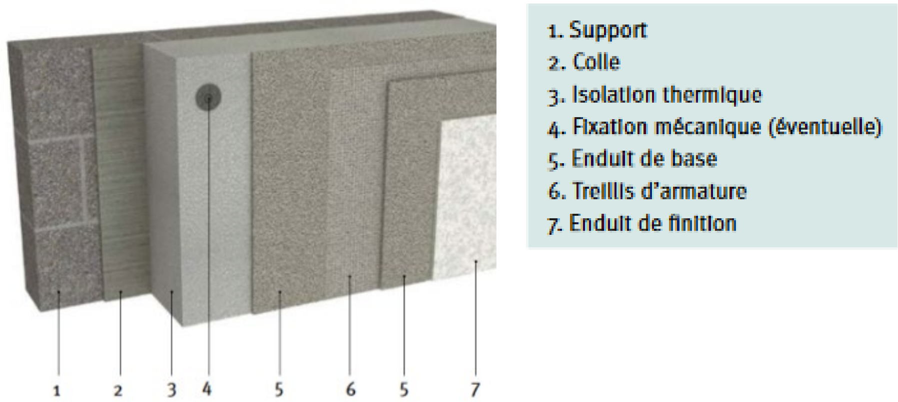
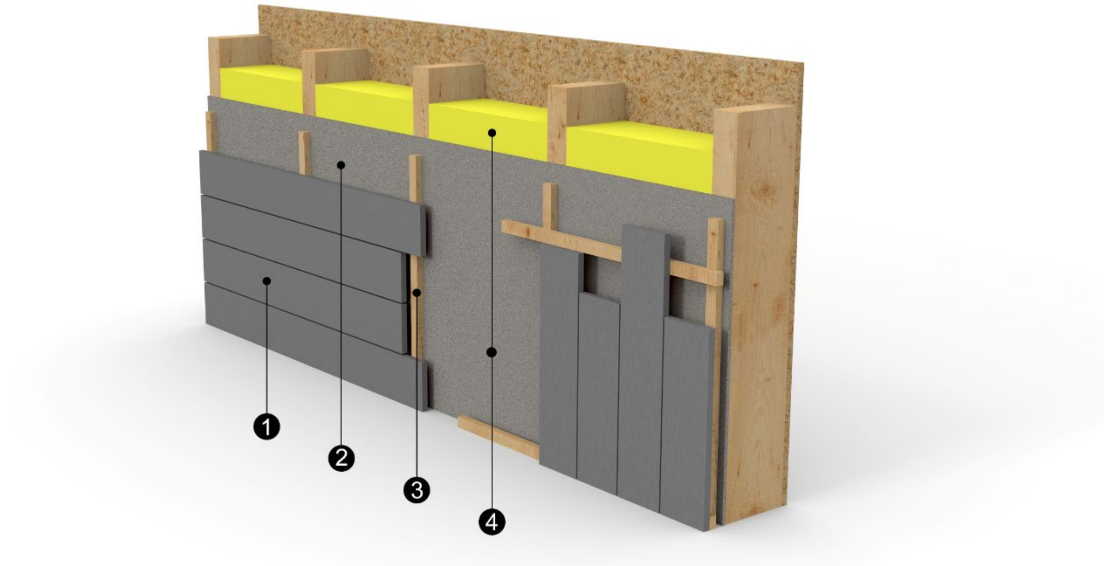


Figure 12 – The reaction-to-fire requirement for ETICS applies to the entire system.

For facade cladding (weatherboard), the reasoning is identical: the requirements apply to the complete system, that is to say the cladding, the ventilated air cavity, any underlying panel, the insulation and the method of fixing.

10 Abbreviation of External Thermal Insulation Composite Systems with Rendering.



❶ Facade cladding (type, thickness, density, vertical/horizontal arrangement, …)
❷ Ventilated air cavity behind the cladding
❸ Method of fixing of the cladding
❹ Layers located behind the air cavity (insulation, wood-based panels, ...)

Figure 13 – The reaction-to-fire requirement for a façade cladding (weatherboard) applies to the entire system.

The Belgian Royal Decree 'Basic Standards' stipulates however that the underlying layers do not need to be taken into account if protected by a construction element providing a sufficient 'fire protection capacity'[11], as shown in table 2.

Table 2 – Fire protection capacity classes K.

Applications for which at least class A2-s3, d2 is required	**Applications for which at most class B-s1, d0 is required**
K_2 30 or EI 30[12]	K_2 10 or EI 15

In other words, for facades (maximum requirement B-s3, d1 for mid-rise buildings for example), the materials located behind the cladding (insulation, panels, etc.) do not need to be taken into account if protected by an element with a K_2 10 protection class which preserves them from excessive heating and triggering combustion or charring during a period of 10 minutes.

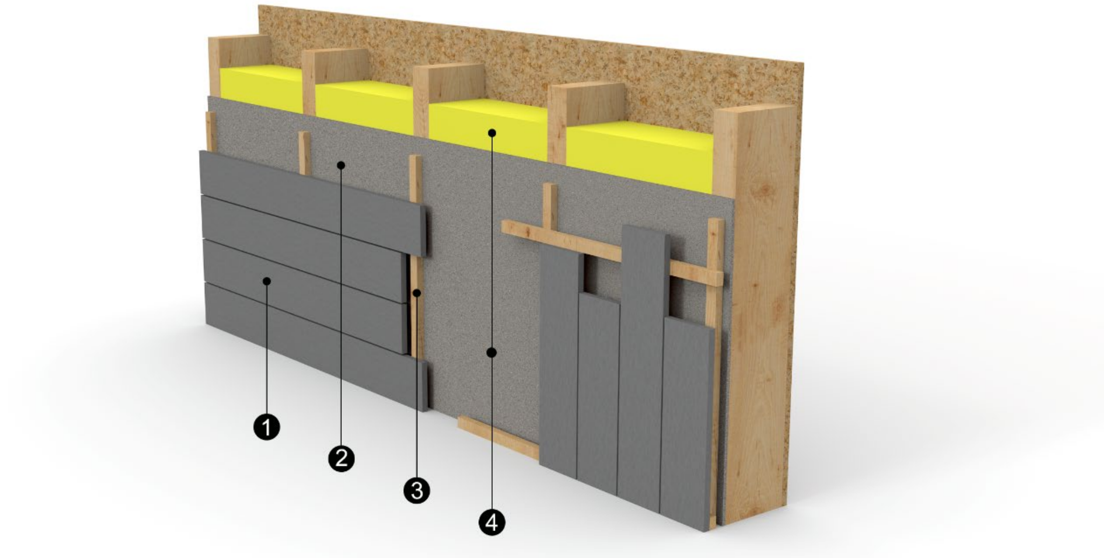
[11] According to NBN EN 13501-2 [6]: *The fire protection capacity K is the ability of a cladding to protect the materials behind the cladding against ignition, charring and other damage for a specific period.*

[12] EI 30 and EI 15 are added in the revision of the RD 'Basic Standards' (version 2022).

The principle that the reaction-to-fire requirement applies to **the cladding and, where appropriate, the materials located behind the cladding** is often poorly assimilated by professionals. For the contractor, it is often difficult to find the necessary information (technical data sheets from manufacturers, information accompanying CE marking, European Technical Approval Guidelines, …). And when such information is available, the data is generally insufficient to allow professionals to make the correct choices. Moreover, the **K_2 10 protection classes** are still too rarely mentioned in technical data sheets of materials.

Let us consider two examples by way of illustration.

1) The cladding system illustrated in figure 14 must meet the B-s3, d1 or Ds3, d1 reaction-to-fire requirement. It is therefore necessary to evaluate it by means of a test performed on the entire system as installed: with its ventilated air cavity ❷ (20 mm for example), its method of fixing ❸ (battens and counter-battens) and the materials behind the air cavity, that is to say the panels and the insulation. However, if the panels behind the air cavity belong to the K_2 10 class, in this case the insulation does not have to be part of the test (but the panels do).



❶ Wood cladding
❷ Ventilated air cavity
❸ Method of fixing of the cladding
❹ Layers located behind the air cavity (insulation, wood panels, ...)

Figure 14 – Cladding system considered in example 1 above.

2) The facade system on the *Grenfell Tower* in London consisted of a 3 mm composite panel (aluminium – polyethylene – aluminium), a 50 mm ventilated air cavity, a 150 mm polyisocyanurate thermal insulation and a concrete substructure (see figure 15). In view of its composition, the composite panel itself could achieve a fairly high reaction-to-fire class. However, the panel did not belong to protection class K_2 10. Consequently, in accordance with European standards and Belgian regulations, the reaction-to-fire class must be evaluated on the composite panel in the end-use conditions, that is to say, in this specific case, with the ventilated air cavity and the thermal insulation (depending on the type of material used in the core of the composite panel). Taking into account the indicated structure, this system is unable to achieve the class A2-s3, d0 required in Belgium for high-rise buildings. The cladding does not protect the insulation, which means that the latter will play an important role in the development of heat and smoke in the event of a fire.

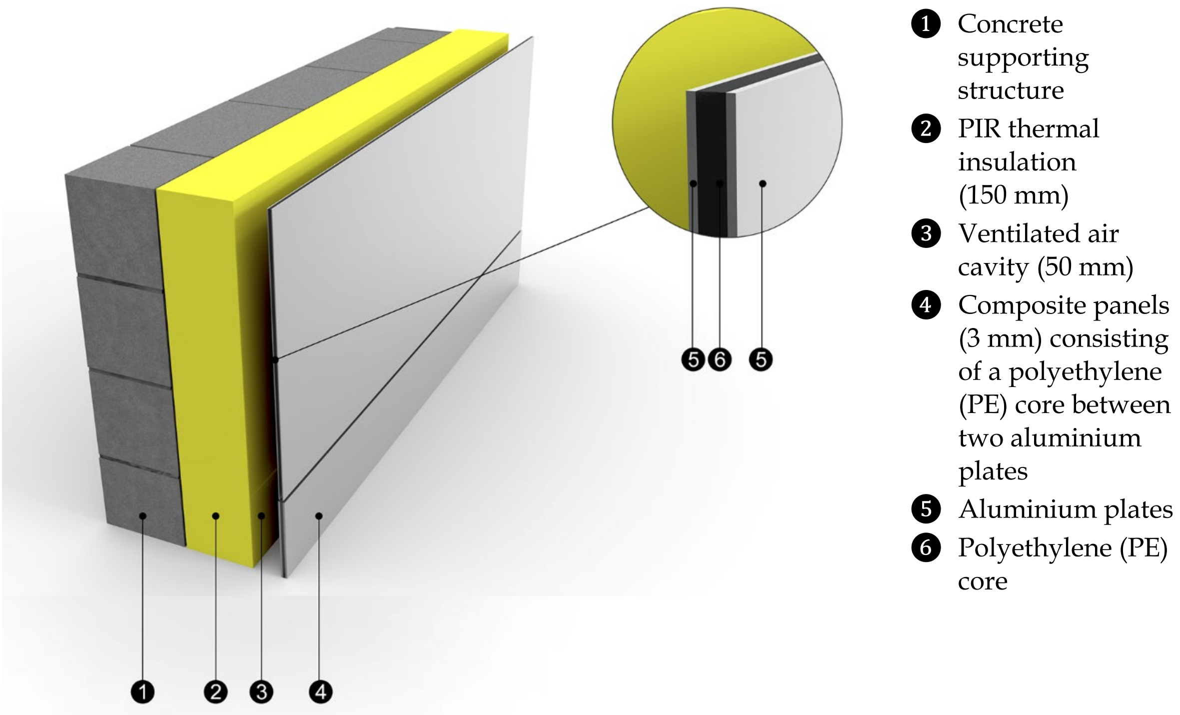


Figure 15 – Facade system on the Grenfell Tower in London.

5.1.2 Internal and external fire spread from one floor to another

The Belgian Royal Decree 'Basic Standards' establishes measures intended to limit or to slow down the fire spread from one compartment to another via the facades both vertically (towards the top) and horizontally. These measures [13] aim to limit the risk ❷ (internal and external fire spread from one compartment to another) identified in chapter 4.

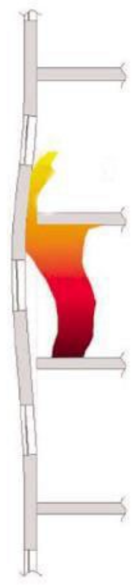
Figure 16 – Internal fire spread (left) and external fire spread (right).

A. Internal fire spread

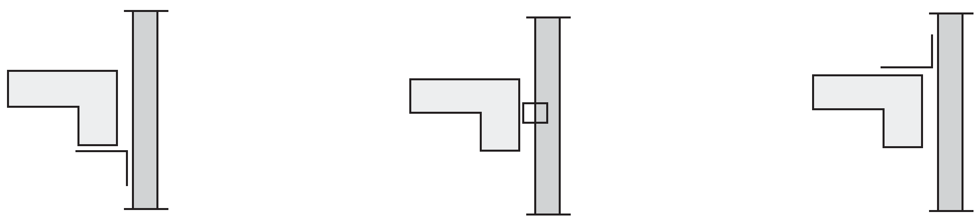
In order to limit the risk of internal fire spread, the junction between the compartment elements (floor slabs for example) and the facade must at least have an EI 60 fire resistance, except in low-rise buildings (see table 3). The linear junction between the compartment floor slab or wall and the facade must be compatible with the presumed deformation of the facade in the event of a fire.

13 Belgian Royal Decree 'Basic Standards' [11], article 3.5.1 of annexes 2/1, 3/1 and 4/1 concerning single-wall facades and article 3.5.2 of annexes 2/1, 3/1 and 4/1 concerning double-wall facades.

Table 3 – Resistance to fire of the junction between compartment walls and the facade.

Type of building	Resistance to fire of the junction between the floor slab and the facade	
Low-rise building (h < 10 m)	**EI 60**, unless the linear joint is less than or equal to 20 mm in width, in which case it is sufficient to seal it using a deformable airtight product (flexible mastic for example) in order to prevent cold smoke from penetrating between the facade and the compartment floor slab.	
Mid-rise building (10 m ≤ h ≤ 25 m)	**EI 60**	
High-rise building (h < 25 m)		

Moreover, in the case of a curtain wall, the struts of the framework must be fixed on each level to the supporting structure of the building to avoid the facade from collapsing in case of fire. The fixing anchors must show a R 60 fire resistance (low-, mid- and high-rise buildings) or be protected against fires occurring in the compartment immediately below. They may be positioned under the floor slab, at the floor slab nosing or above the floor slab (see figure 17).



Anchoring under a beam or a floor slab (to be protected where necessary)

Anchoring at the floor slab nosing (in principle protected by the fire-resistant sealing of the floor slab nosing)

Anchoring above the floor slab (protected by the fire-resistant sealing of the floor slab nosing)

Figure 17 – Diagram illustrating the position of the frame fixing anchors.

In the event of a fire in the lower compartment, the anchor located above the floor slab is protected by the compartment floor slab and by the EI 60 fire-resistant sealing between the compartment floor slab and the facade. Thus, it meets the requirements without further protection.

> The anchors positioned above the floor slab are the most frequently used in practice, so that their R 60 fire resistance does not generally pose any problems as long as the EI 60 fire-resistant sealing between the floor slab nosing and the facade element is correctly realised.

B. External fire spread

In order to prevent the external fire spread from one compartment to another, the facade element at the level of each compartment wall (storey floor slab for example) must show a certain level of fire resistance.

In low-rise buildings (≤ 10 m) there are no prescriptions in this regard, since the intervention of the fire services and the evacuation of occupants are facilitated by the limited height of the building. However, it should be noted that for certain buildings such as schools, other regulatory texts may impose additional provisions (see § 5.2).

To limit the risk of external fire spread in the case of mid- or high-rise buildings, one of the following three requirements must be met:

1. the facade shall be fitted with a fire-resistant construction element E 60 and shall have a minimum developed length of 1 m at the compartment floor slab level (figure 18)

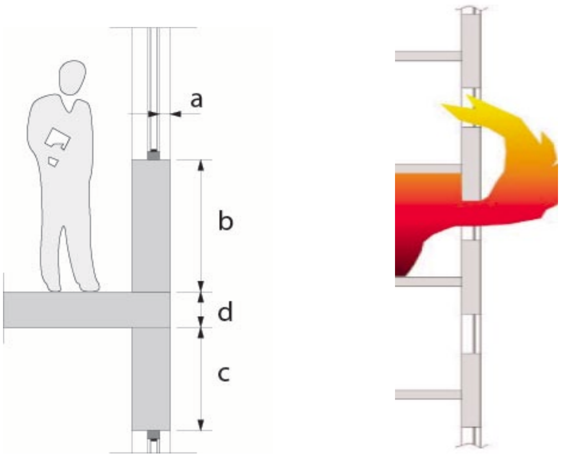
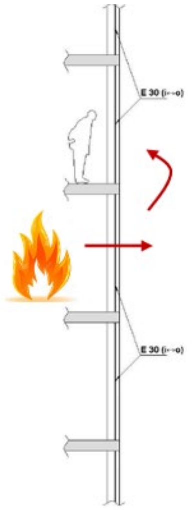
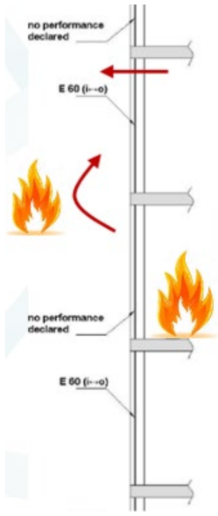


Figure 18 – Diagram of the facade element with an E 60 fire resistance (minimum length a + b + c + d ≥ 1 m).

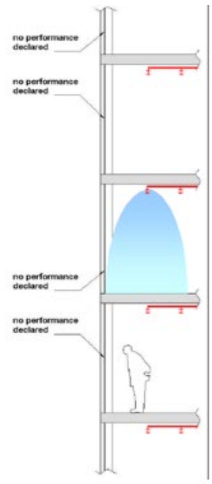
2. the facade shall provide at least a fire resistance E 30 for the entire building height or at least E 60 every two levels
3. the compartments located along the facade shall be equipped with an automatic sprinkler system. In this case, it is not necessary to take additional measures to limit the external fire spread.



Facade with an E 30 fire resistance for the entire building height



Facade with an E 60 fire resistance every two levels



Compartments equipped with an automatic sprinkler system

Figure 19 – Limiting the risk of external fire spread in mid- and high-rise buildings.

An alternative to the 1 m vertical E 60 facade element (solution 1) is to provide for a 60 cm horizontal E 60 projection (see also § 7.1.2 regarding masonry and cast concrete facades).

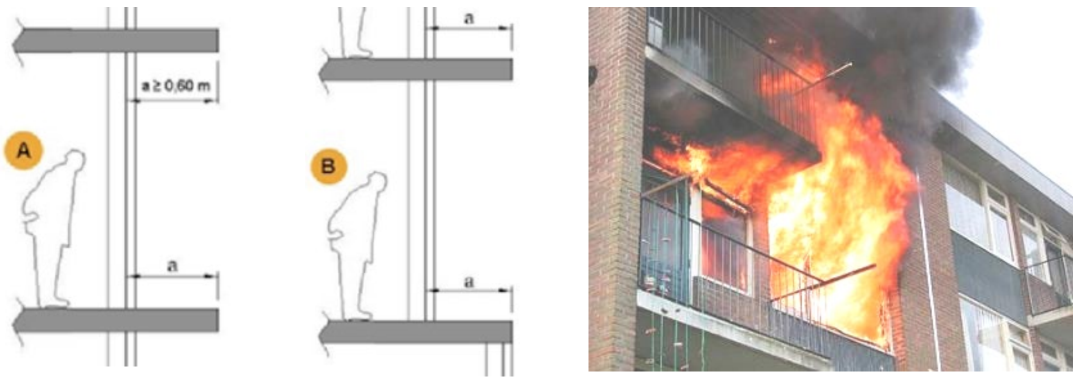


Figure 20 – Horizontal E 60 projection of minimum 60 cm.

The E 60 fire-resistant element must also be installed at the vertical compartment walls level (internal compartment walls perpendicular to the facade – see figure 21).

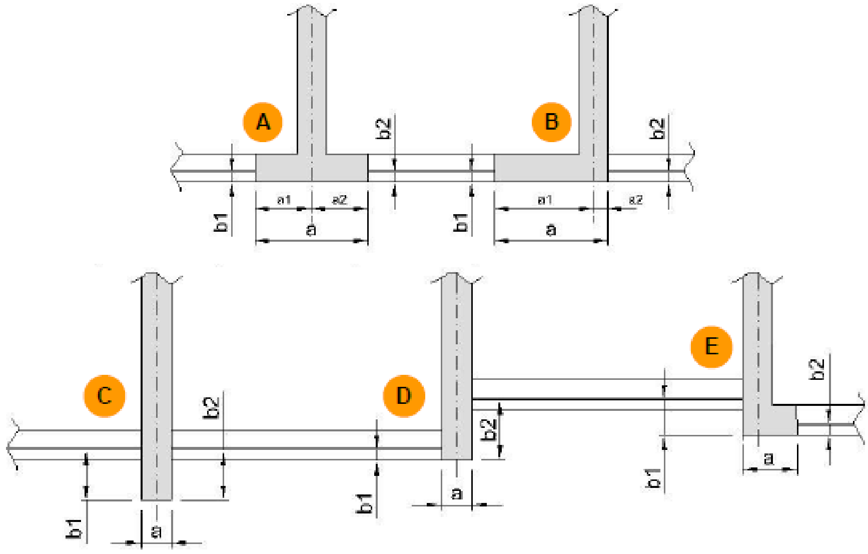


Figure 21 – E 60 fire-resistant facade element at the vertical compartment walls level (with b1 + a + b2 ≥ 1 m).

We would like to emphasise that this last point only applies to vertical compartment walls. By compartment walls, we mean fire-resistant walls separating two compartments. A fire-resistant wall separating two apartments or two hotel rooms is not considered as a compartment wall. In this case, an E 60 fire-resistant facade element is therefore not required.

The method of determining the minimum developed length of 1 m is explained in § 7.2.

5.1.3 Fire spread within the façade system

At present, the risks of fire spread within the facade system itself (see § 4, 3) cannot be evaluated directly according to European testing standards. These risks were therefore not explicitly covered by the former regulatory requirements in Belgium. In the 2022 revision of the regulations, on the other hand, requirements have been included to seek to prevent flash-over via the facade system (see § 6.1 and § 6.2). As stipulated in the Belgian ministerial circular relating to items to be covered by the fire services' report (see § 3.4), the fire service may formulate recommendations on this subject in the context of its advice on permit applications submitted before July 2022.

5.2 Regulatory provisions applicable to specific buildings

As specified in § 3.3 'Other regulations and standards', regulatory texts and standards supplement the Belgian Royal Decree 'Basic Standards'. As far as requirements relating to facades are concerned, it should be noted for example that the regulation for retirement homes in Flanders requires the installation of an E 60 fire-resistant facade element with a length of 1 m (see § 5.1.2) in all cases (i.e. including low-rise buildings). Thus, to meet the standard, a two-storey (i.e. low-rise) building shall have an E 60 fire-resistant facade element at the compartment floor slab level between the first and second floors.

5.3 Renovation of existing building facades

Renovation works on a building for which a permit application has been submitted after the entry into force of the Belgian Royal Decree 'Basic Standards' of 7 July 1994 must clearly be executed according to the requirements of this decree. *Example: a building built in 1999 and renovated in 2017 shall continue, after renovation, to meet the requirements that were in force when it was built.*

These requirements are not intended for renovation works on a building for which the permit application was submitted prior to the entry into force of the Belgian Royal Decree. The fire service shall nevertheless be consulted during the permit application process and will generally base its response on the rules applicable to new buildings.

If the building is subject to complete renovation, the fire safety assessment shall be based on the building as a whole and more specifically on the compartmentation between floors, evacuation routes and stairwells as well as the possibilities for evacuation and intervention.

In the case of energy renovation works to the facade, the fire service will generally recommend, for the renovated elements, compliance with the requirements of the Belgian Royal Decree.

6. Revision of the fire safety requirements for facades[14]

6.1 Risk of fire spread within the facade system

At present, risk ❸ 'Fire spread within the façade system' described in chapter 4 is not directly covered by the European testing methods. This risk is taken into account in the revision of the regulations. This relates to flash-over via the combustible components of the facade (insulation notably) and via the continuous air cavity located behind the cladding and which can cause a chimney effect, …

The fire services may possibly propose recommendations to cover this risk within the framework of their advice related to permit applications (see § 3.4) submitted before 1 July 2022.

The High Council for Protection against Fire and Explosion has examined this issue and introduced new fire safety rules for facades (see § 6.2). These were published in the Belgian Official Gazette in 2022.

6.2 Approved requirements – Revision of the Royal Decree (version 2022)

A 'Facades' working group was created in December 2015 on the initiative of the High Council for Protection against Fire and Explosion. This working group includes experts in the field and other construction professionals. Its secretariat is provided by the engineers-group leaders of the FPS Home Affairs. This working group is tasked with proposing new rules for the fire safety of building facades, particularly with regard to high-rise buildings.

As in the current Royal Decree 'Basic Standards', the revision of the regulations includes requirements for the reaction to fire of facade cladding in its end use conditions (see table 4 and § 5.1).

[14] See also the article '[Sécurité incendie des façades : la nouvele réglementation expliquée]' (Les Dossiers du CSTC 2020/3.4).

Table 4 – Reaction to fire of the facade cladding as a function of building height and type of users (1)

High-rise buildings	Mid-rise buildings	Low-rise buildings	
		User types	
		Not self-reliant (type 1)	Self-reliant and sleeping (type 2) or self-reliant and awake (type 3)
A2-s3, d0 (2)	B-s3, d1	C-s3, d1 (2)	D-s3, d1

(1) The doors, facade decorations, joints and technical equipment in the facade (e.g. signboards, lighting devices, ventilation grilles, gutters, plantboxes and wall ducts of heating installations) are not subject to the stated requirements, insofar as their total visible surface is less than 5 % of the visible surface of the relevant facade.
(2) Stricter than current requirements.

In an attempt to avoid the spread of fire via the facade components, the revision of the regulations also includes requirements with regard to the reaction to fire of the substantial facade components (insulation, struts, etc.). This concerns the reaction to fire of the substantial component parts themselves, as placed on the market. The facade cladding itself, just like the window and door profiles and the glazing, are not taken into account here. Table 5 gives an overview of these requirements as a function of the building height.

Table 5 – Reaction to fire of the substantial facade components as a function of the height of the building.

Type of facade component	Type of building		
	High-rise buildings	Mid-rise buildings	Low-rise buildings
Not fully shielded against fire			
All parts except the vertical struts	A2-s3, d0	A2-s3, d0 OR E, in the case of a standard solution	E
Vertical struts	A1	A1 or wood	–
Fully shielded against fire by an element that meets the following requirements			
	K_2 30 or EI 30	K_2 10 or EI 15	–
All components	E, in the case of a standard solution	E	–

We wish to point out here that the requirements in table 4 (facade cladding in end use conditions) and those in table 5 (substantial facade components) need to be met simultaneously.

A substantial component is defined as follows [22]:

'a material which constitutes a significant part of a non-homogeneous product. A layer with a mass per unit area ≥ 1.0 *kg/m*^{2} *or a thickness* ≥ 1.0 *mm is considered as a substantial component'.*

A non-substantial component is therefore a *material that does not constitute a significant part of a non-homogeneous product. Thus, a layer with a mass per unit area* < 1.0 *kg/m*^{2} *and a thickness of* < 1.0 *mm would be considered as a non-substantial component.*

Where a successful large-scale test has been carried out on the facade system, then the aforementioned reaction-to-fire requirements for the facade cladding and the substantial facade components from tables 4 and 5 do not have to be met. This test is intended to allow manufacturers to demonstrate that their system does not present any risk of fire spread. Although no standardized test exists yet at European level, work is in hand on developing a harmonized test method. However, this is not yet available for the time being. Table 6 provides an overview of the foreign test standards and associated documents with performance criteria that are accepted in the revision of the Belgian regulations for assessing the risk of fire spread via the facade system.

Table 6 – Accepted foreign test standards with their respective interpretation documents.

Test standard	**Document stating the performance criteria**		
	High-rise buildings	**Mid-rise buildings**	**Low-rise buildings**
BS 8414-1	LPS 1581	BRE 135	
BS 8414-2	LPS 1582	BRE 135	
DIN 4102-20	/	Document HR 1882 of the High Council for Protection against Fire and Explosion	
LEPIR 2	Arrêté français du 10 septembre 1970 relatif à la classification des facades vitrées par rapport au danger d'incendie		

The new requirements and their associated standard solutions per building height are explained below.

6.2.1 Low-rise buildings

For **low-rise buildings (height < 10 m)**, the requirements currently in force remain largely unchanged. In other words, the only additional element to be taken into account is the type of users:

- the facade cladding must exhibit the following reaction-to-fire class in its end use conditions (see § 5.1.1)
  - D-s3, d1 (or better) for buildings with sleeping self-reliant users (type 2: e.g. hotels and apartment buildings) and waking users (type 3: e.g. office buildings and shops)
  - C-s3, d1 (or better) in buildings with non-self-reliant users (type 1: e.g. hospitals, prisons, crèches)
- the other substantial facade components must have an E reaction-to-fire class (or better)
- the junction between the floor slab nosing and the facade element must show an EI 60 resistance, except if the joint is less than 20 mm (see § 5.1.2).

6.2.2 Mid-rise buildings

The requirement with regard to the reaction to fire of the facade cladding in end use conditions (see § 5.5.1) for mid-rise buildings remains unchanged. The facade cladding must minimally comply with reaction-to-fire class B-s3, d1.

In addition, the substantial facade components must be non-combustible. This means that they must belong to reaction-to-fire class A2-s3, d0 or better, and that the vertical struts of any supporting structure (e.g. timber frame walls) must belong to reaction-to-fire class A1 or must be constructed from wood.

However, if one wishes to use combustible components in the facade with a reaction-to-fire class E or better (e.g. insulation), then one must:

- either completely shield the substantial components against fire, both from the inside and the outside, by means of elements with a fire protection capacity K_2 10 or a fire resistance EI 15
- or opt for standard solutions for mid-rise buildings in which fire-resistant screens are provided in the facade. These are devices that interrupt the

combustible facade materials (e.g. the insulation) and any continuous air cavity in order to limit the risk of a fire spreading through the facade.

The rules relating to internal fire spread (EI 60 fire-resistant sealing between the floor slab nosing and the facade element) and external fire spread (E 60 fire-resistant facade element at the compartment floor slab level) remain nonetheless applicable (see § 5.1.2).

When choosing the sandard solutions for mid-rise buildings, a distinction is made between:

- facades with a continuous air cavity (e.g. traditional cavity walls, facade cladding with a ventilated air cavity ...)
- facades without a continuous air cavity (e.g. ETICS, curtain walls, etc.).

6.2.2.1 Standard solution for facades with a continuous air cavity

For facades with a continuous air cavity, the insulation must have a reaction-to-fire class E or better. However, the use of insulating materials of the expanded polystyrene (EPS) or extruded polystyrene (XPS) type is not permitted.

The standard solution consists of providing a fire-resistant screen at the level of the floor slab between the first and second floors. The vertical distance between ground level and the first fire-resistant screen should never exceed 8 m. A fire-resistant screen must then be placed every two storeys or around each window opening (see figure 22).

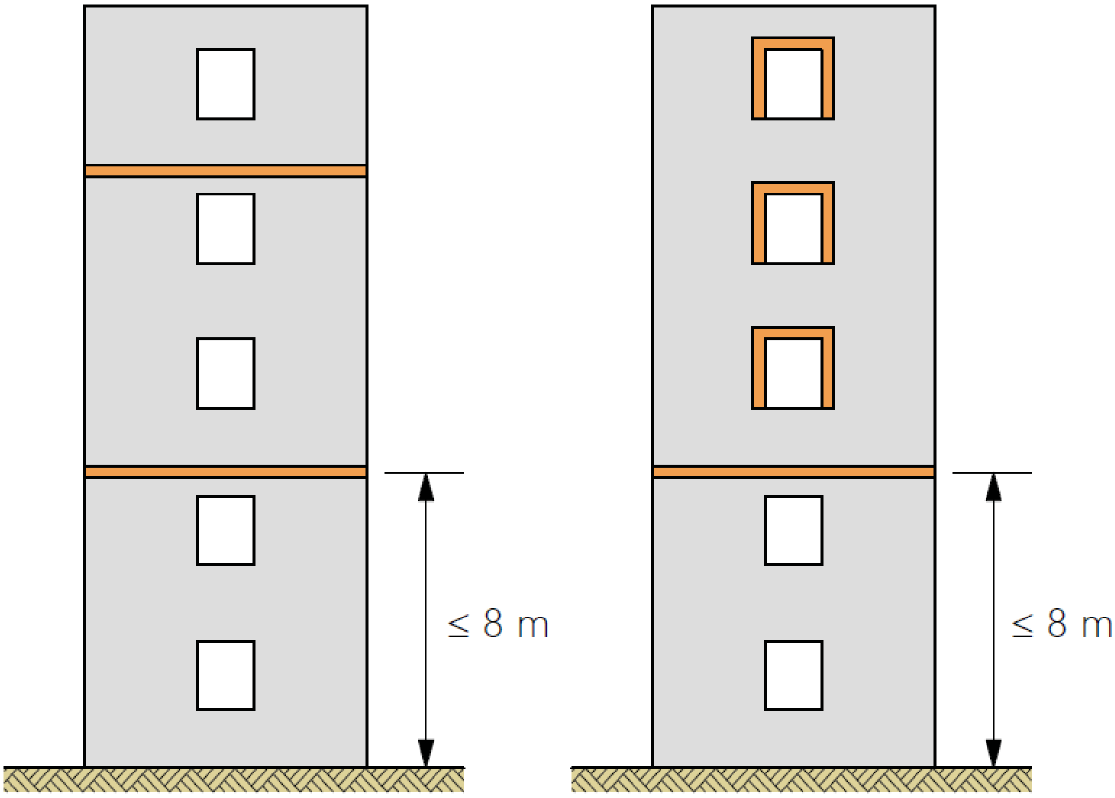


Figure 22 – Standard solution for facades of mid-rise buildings with a continuous air cavity.

The fire-resistant screens can be designed in two ways:

- either an interruption is provided over the entire width of the facade in the form, for example, of a steel profile, a wooden batten or a strip of rock wool
- or, for example, a steel profile, a wooden frame or a strip of rock wool is applied horizontally (above) and vertically (along the sides) around each facade opening.

If rock wool is used, these strips must be at least 200 mm wide or high and must be mechanically fixed into the substrate. The rock wool used must have a minimum density of 60 kg/m^3 and belong to reaction-to-fire class A2-s3, d0 or better.

The steel profile or frame must be mechanically fixed into the substrate and be at least 1 mm thick. However, one must not lose sight either of the energy performance regulations.

If one opts to install a wooden batten over the entire width of the facade or to provide a wooden frame around the facade openings, the wood must be at least 25 mm thick and have a minimum density of 390 kg/m³. The wooden batten or frame must be mechanically fixed into the substrate.

Notwithstanding the fact that the fire-resistant screen must completely interrupt the continuous air cavity, it may contain a number of ventilation openings of maximum 100 cm² per linear metre. This means that a 10 mm gap may be left between the fire-resistant screen and the facade cladding or masonry.

6.2.2.2 Standard solutions for facades without a continuous air cavity

In the revision of the regulations, two standard solutions are provided for facades without a continuous air cavity:

- either combustible insulation materials are used, with the exception of EPS or XPS:

  in a facade of a mid-rise building without a continuous air cavity, combustible insulation materials with a reaction-to-fire class E or better can be used, with the exception of EPS and XPS. If the insulation material is not EPS or XPS, then no specific measures need to be taken to limit the spread of fire via the facade system
- or EPS or XPS is used and fire-resistant screens are provided.

The first fire-resistant screen must be installed at floor slab level between the ground floor and the first floor. The vertical distance between this screen and the ground floor level should, however, not exceed 4 m. If this distance is nevertheless greater, a fire-resistant screen must be placed every 4 m. A fire-resistant screen must then be fitted again at the level of the floor slab between the second and third floors. However, the distance between these two screens should not exceed 8 m. After this, a fire-resistant screen must be provided:

- either every two storeys, by providing a continuous horizontal interruption of rock wool over the entire width of the facade (see figure 23A)
- or above each facade opening, by placing a horizontal strip of rock wool protruding at least 30 cm from both sides of the facade opening (see figure 23B)
- or around each facade opening, by implementing a rock wool frame on the top and sides of each facade opening (see figure 23C).

The rock wool fire-resistant strip must have a minimum density of 60 kg/m³, be at least 20 cm high or wide and belong to reaction-to-fire class A2-s3, d0 or better. This strip must also be mechanically fixed into the substrate.

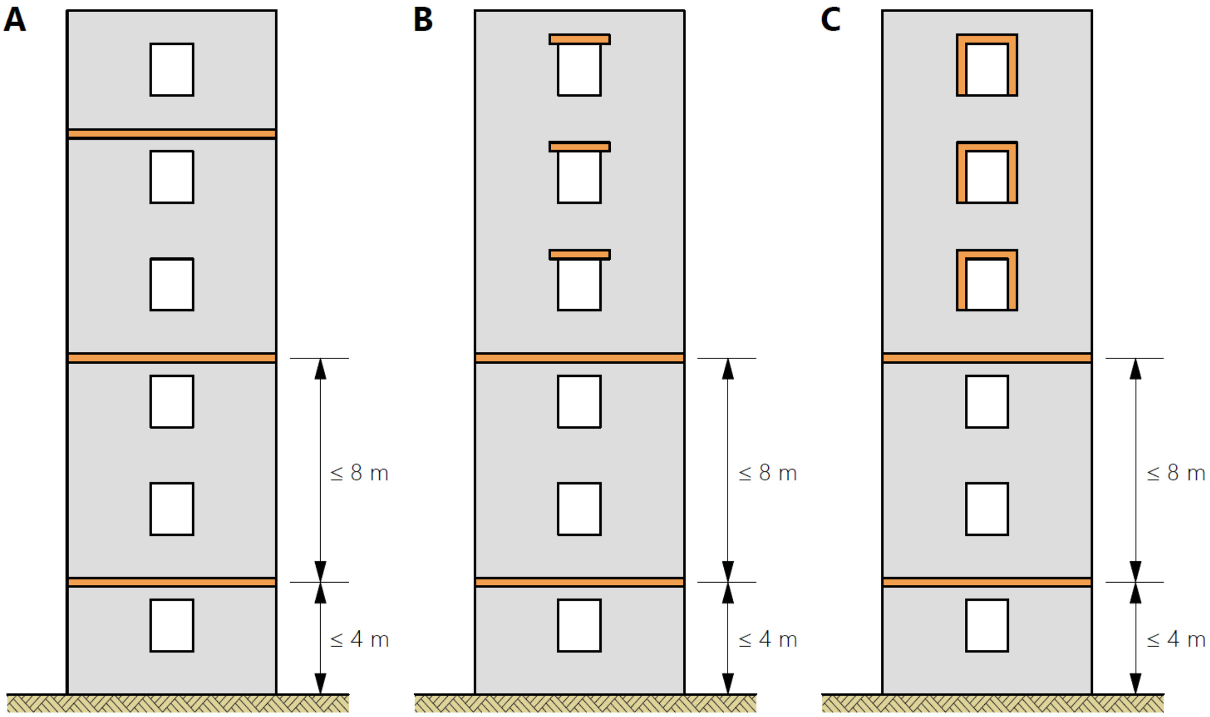


Figure 23 – Standard solution for facades of mid-rise buildings with a continuous air cavity.

The recommendations relating to the good design and proper execution of the standard solutions detailed above are presented in § 7.3 for external thermal insulation composite systems with rendering and in § 7.4 for ventilated facades.

6.2.3 High-rise buildings

For **high-rise buildings (height > 25 m)** according to the new regulations, the facade cladding must comply with reaction-to-fire class A2-s3, do in end use conditions (see § 5.5.1).

In addition, for high-rise buildings, all substantial facade components (insulation, panels, etc.) must be non-combustible (reaction-to-fire class A2-s3, d0 or better). The struts of the facade supporting structure must in turn be non-combustible and belong to reaction-to-fire class A1.

However, the substantial facade components may belong to reaction-to-fire class E or better where the conditions of the standard solution for high-rise buildings are met. Here (see figure 24):

- on the one hand, the substantial facade components must be fully protected against fire, both from inside and from outside. This protection consists of a building element (e.g. panel or masonry) with a fire protection capacity K_2 30 or a fire resistance EI 30
- on the other hand a fire-resistant screen must be placed at floor slab level between the first and second floors. If the vertical distance between ground level and this fire-resistant screen is greater than 8 m, a fire-resistant screen must be added every 8 m. After this, a screen must be placed every two floors.

The purpose of the fire-resistant screen is to interrupt the combustible materials (e.g. the insulation) and any continuous air cavity in order to limit the risk of fire propagation through the facade. This fire-resistant screen can be composed of a horizontal strip of rock wool that interrupts the insulation material and any continuous air cavity over the entire width of the facade. The fire-resistant screen has the following features:

- height ≥ 200 mm
- reaction-to-fire class A2-s3, d0 (or better)
- density ≥ 60 kg/m^3
- mechanically fixed into the substrate.

Notwithstanding the fact that the fire-resistant screen must completely interrupt the air cavity, it may contain a number of ventilation openings of maximum 100 cm^2 per linear metre. This means that a 10 mm gap may be left between the fire-resistant screen and the facade cladding or masonry.

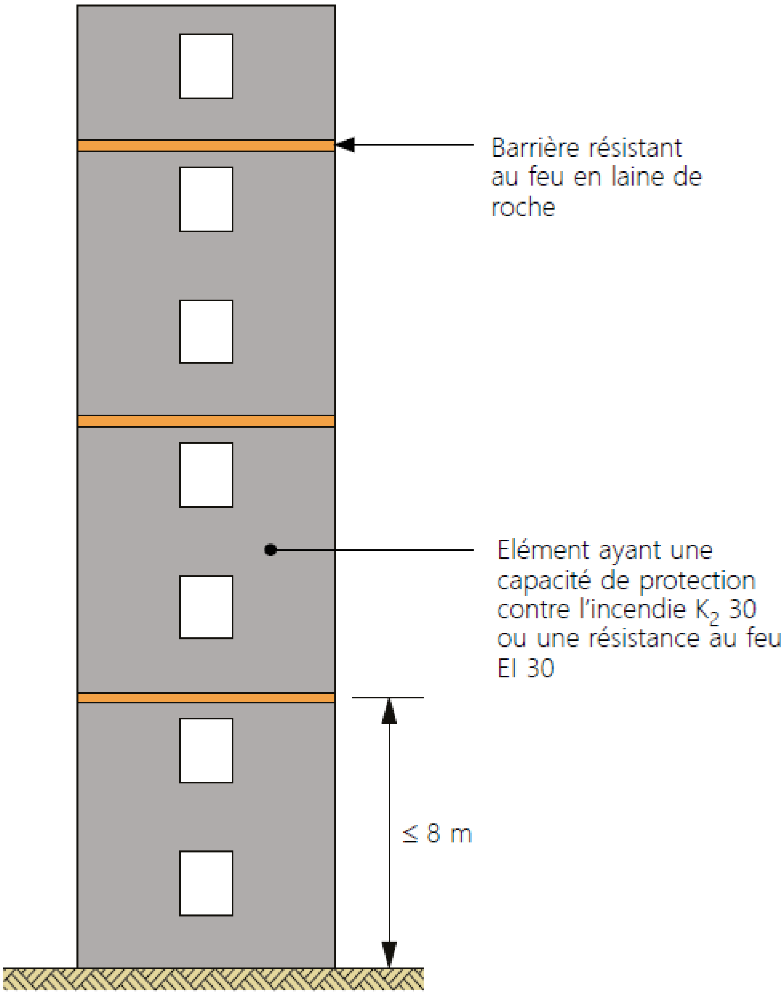


Figure 24 – Standard solution for facades of high-rise buildings.

The non-substantial facade components (e.g. the thin rain screen) do not have to meet this requirement.

The rules relating to internal fire spread (EI 60 fire-resistant sealing between the floor slab nosing and the facade element) and external fire spread (E 60 fire-resistant facade element at the compartment floor slab level) remain nonetheless applicable (see § 5.1.2).

7. KEY POINTS FOR THE DESIGN AND THE EXECUTION

This chapter presents the key points and constructional features that will ensure the good design and proper execution of facade systems, and thus make it possible to meet the requirements currently in force as well as those which may be introduced in the future. These constructional features are notably based on the revised requirements detailed in table 4 of § 6.2.

7.1 REALISATION OF THE E 60 FACADE ELEMENT AND ITS JUNCTION WITH THE STRUCTURE

7.1.1 Determination of the developed length of 1 m

As indicated in § 5.1.2, one of the options to slow down the external fire spread in mid- or high-rise buildings is the execution of an E 60 fire-resistant facade element (fire integrity lasting 60 minutes) with a minimum developed length of 1 m (a + b + c + d). This length must be calculated according to the Belgian Royal Decree 'Basic Standards' [11] (see figure 25).

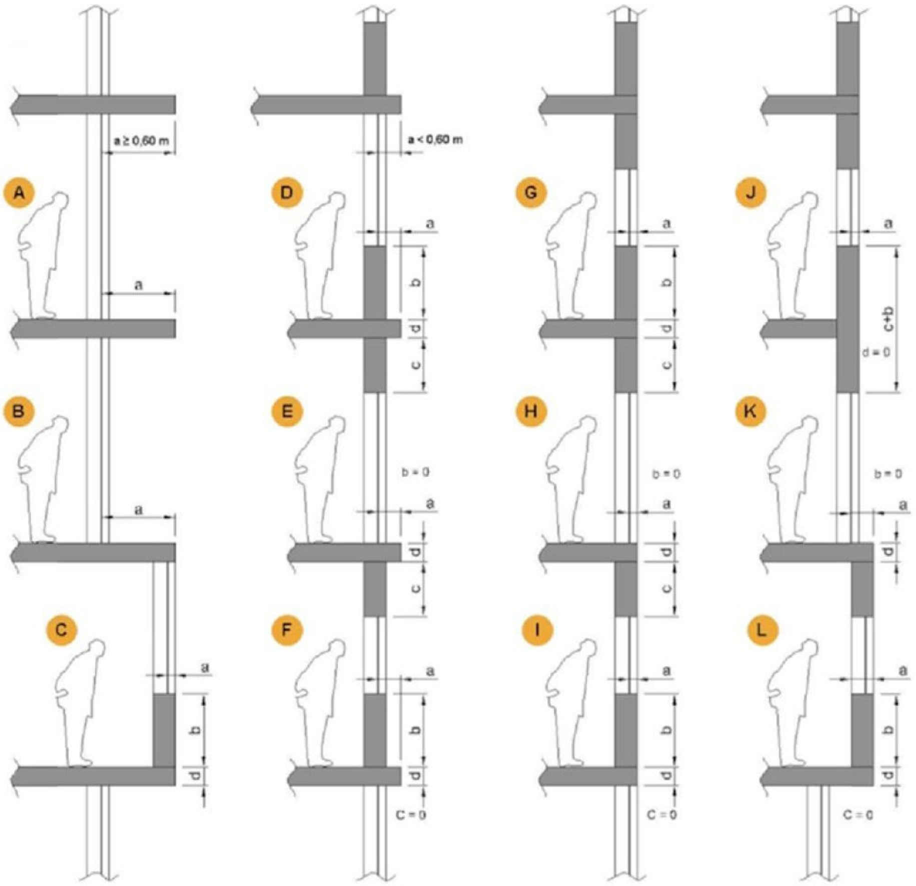


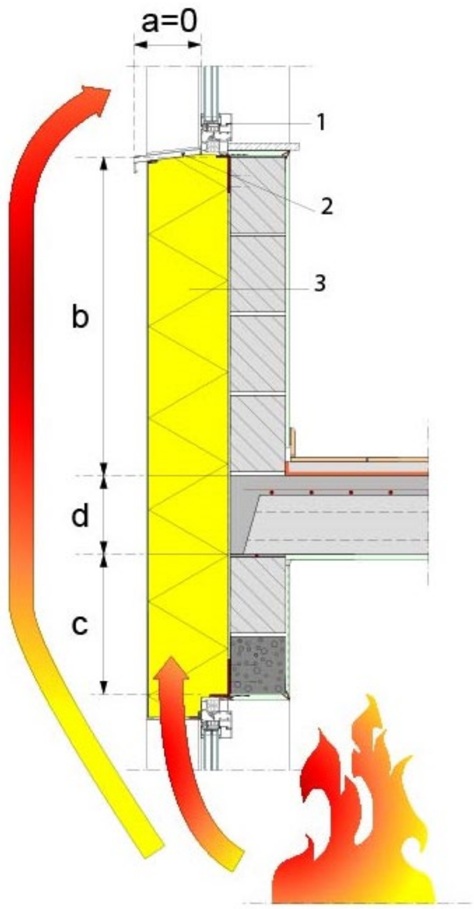
Figure 25 – Calculation principle of the 1 m developed length of the E 60 fire-resistant facade element (extract from the Belgian Royal Decree 'Basic Standards') [11].

Only elements with an E 60 fire resistance are taken into consideration here, which therefore in principle excludes aluminium sills, aluminium or PVC frames, external thermal EPS insulation composite systems with rendering, … (see also the illustrations in § 7.1.2). Moreover, all penetrations (e.g. ventilation ducts) and weak points in these E 60 elements shall be made fire-resistant (see TIN 254) [17].

> In practice, it is regularly noted that the minimum developed length of 1 m is not calculated correctly. If the E 60 fire-resistant facade element does not have the required length right from the design phase, it can prove particularly complicated to rectify it at a later date. The correct fixing of the E 60 fire-resistant element on the structure is also significant.

7.1.2 Masonry or on-site cast concrete facades

In the case of 'solid' facades composed of load-bearing masonry or on-site cast concrete walls, the E 60 fire-resistant element is generally formed by the load-bearing structure, i.e. the apron, the lintel and the concrete floor slab. The correct calculation of the developed length of 1 m when designing the building remains nevertheless important (see § 7.1.1 and figure 26 for illustration).



The E 60 fire resistance is ensured by the load-bearing rough structure (apron wall, lintel and concrete floor slab). The external thermal insulation composite system with rendering (ETICS with EPS) (3) does not offer an E 60 fire resistance; its thickness cannot therefore be taken into account.
Similarly, the aluminium threshold (2) and the aluminium frame (1) do not have an E 60 fire resistance. In this example, the distance 'a' is equal to 0; the developed length of 1 m shall consequently be guaranteed by distances 'b', 'c' and 'd'.

Figure 26 – Example of the calculation of the 1 m developed length (a + b + c + d) for an external thermal insulation composite system with rendering.

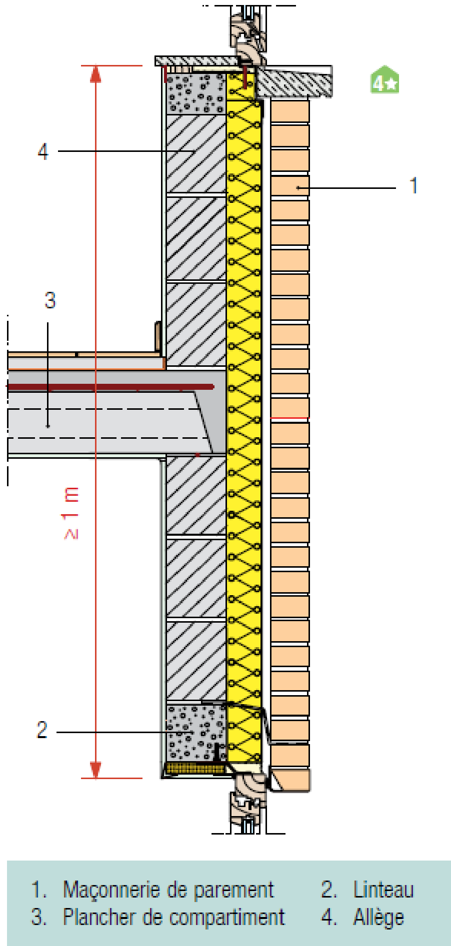


Figure 27 – Realisation of an E 60 fire-resistant facade element in a traditional cavity wall composed of facade masonry and load-bearing concrete elements.

Figure 27 shows a diagram of how to obtain an E 60 fire-resistant element in a traditional cavity wall composed of facade masonry and load-bearing masonry or cast concrete elements.

Solid wood panel facades (CLT panels for example) are treated in a similar way. Depending on their type and thickness, solid wood panels in general have an E 60 fire resistance (or RE 60 if they support floor slabs).

As already indicated in § 5.1.2, an alternative to the vertical fire-resistant facade element E 60 could be provided in the form of a fire-resistant horizontal projection (balcony) E 60 of at least 60 cm. Given that concrete balconies generally form a thermal bridge, they are often made with thermal breaks to comply with thermal regulations. This break is generally realised using rigid combustible insulation panels, which in principle cannot ensure the fire integrity during 60 minutes. The combustible insulation may be replaced with a non-combustible material (minimum reaction-to-fire class A2-s1, d0) such as cellular glass or rock wool over a minimum height of 8 cm (see figure 28). Another option would be to place a flame-tight panel at the level of the thermal break or the junction between the window and the insulation. In all cases, one needs to ensure that the reinforcement intended to anchor the balcony to the floor slab maintains a sufficiently low temperature, so as to guarantee the stability of the assembly for a period of 60 minutes.

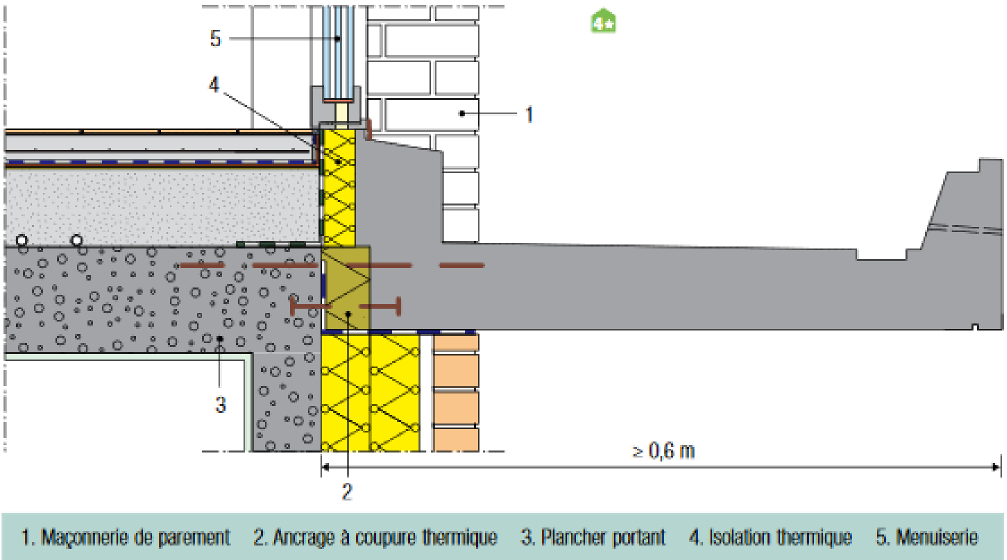
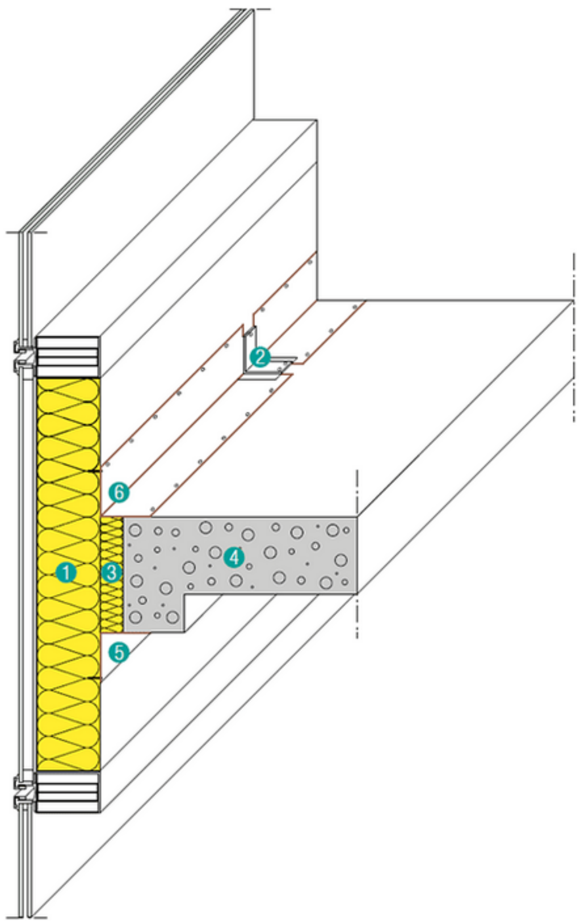


Figure 28 – Balcony fitted with a non-combustible thermal break.

7.1.3 Curtain walls

Curtain walls are made of a framework usually consisting of horizontal profiles and vertical struts and containing glass or opaque filling elements.

The solutions proposed below have already been discussed in the article 'Réduire le risque de propagation de l'incendie via les façades-rideaux', published in CSTC-Contact 2013/3 [23], as well as in the article 'Sécurité incendie des façades-rideaux : une NIT pour tout savoir', that appeared in the Dossiers du CSTC 2022/02.07 [32]. Other solutions are possible, provided that they have been validated by means of a laboratory test. Technical Information Note no. 282 [31] is entirely devoted to the design rules for and the implementation of curtain walls.



1. E 60 fire-resistant facade element with a minimum length ≥ 1 m (metal sheet and rock wool)
2. Fixation of the curtain wall frame to the supporting structure at each level
3. EI 60 rock wool sealing
4. Compartment floor slab (REI 60 or REI 120)
5. Thin steel sheet under the floor slab
6. Thin steel sheet above the floor slab

Figure 29 – Example of an E 60 fire-resistant element and its junction with a concrete floor slab in the case of a curtain wall.

Figure 30 – E 60 fire-resistant facade element consisting of internal steel sheets (Leuven Fire Brigade).

The EI 60 fire-resistant sealing between the compartment floor slab nosing and the E 60 facade element may be realised in the following way (see photos below):

- filling by means of rock wool panels and/or loose rock wool ③
- over a height of 150 mm for example, for a panel with a density of 45 kg/m³ compressed by 20 %
- across the entire distance between the floor slab nosing and the fire-resistant facade element ①, without interruptions, by pressing the material firmly in order to ensure complete sealing of all joints (no openings can remain).

Figure 31 – EI 60 fire-resistant sealing with rock wool between the floor slab nosing and the fire-resistant facade element (left photo: Leuven Fire Brigade; right photo: SECO).

Under the floor slab, steel sheets ⑤ make it possible to hold the rock wool insulation in place ③ in the event of a deformation of the fire-resistant facade element ① in a fire. These sheets, with a maximum thickness of 1 mm, are placed with a minimum overlap of 30 mm. They are attached on both sides of the seal (on the fire-resistant facade element ① and on the compartment floor slab ④ using steel accessories with a minimum diameter of at least 4 mm (M4 or M5, ST 4.8 …) that are anchored in the concrete at most every 200 mm to a minimum depth of 40 mm.

Above the floor slab, steel sheets ⑥ seal the joint between the fire-resistant facade element ① and the compartment floor slab ④. These make it possible to fix the fire-resistant facade element to the supporting structure and to guarantee the fire integrity of the junction.

7.1.4 Timber frame facades

This type of facade is comprised of a frame made of vertical wood components (struts) placed at regular intervals (generally every 400 or 600 mm) and linked together by horizontal wood elements. An insulation material is inserted between the struts. The frame is covered with panels on the inside and/or the outside.

In order to meet the fire safety requirements, the research project 'DO-IT Houtbouw'[15] led to the development of new solutions for E 60 fire-resistant timber frame facades that are positioned against the floor slab nosing[16]. Some of these solutions are presented hereafter. Other options are possible both for the E 60 fire-resistant facade element and for the EI 60 sealing, provided that they have been validated by means of a laboratory test.

The EI 60 fire-resistant sealing between the floor slab nosing and the facade is realised as follows:

- filling using rock wool with a minimum thickness of 15 cm (minimum compression of 20 %, minimum density of 55 kg/m³ after compression; for example: insulation panel with a density of 45 kg/m³ compressed by 20 %)
- installation of a panel on the inside of the timber facade element in order to allow the correct compression of the insulation
- possible installation of a continuous airtight membrane (maximum thickness of 1.5 mm) between the panel and the rock wool filling.

The E 60 fire-resistant timber frame facade element must be executed in accordance with the following provisions:

- vertical timber struts (class C24, minimum average density of 420 kg/m³) with a minimum section of 38 x 190 or 44 x 183, with a maximum space of 600 mm between them
- complete filling using rock wool panels:
  - with a thickness equal to that of the timber struts in the case of rock wool with a density of 45 kg/m³
  - with a thickness equal to that of the timber struts + 20 mm in the case of rock wool with a density of 35 kg/m³

15 Project conducted in collaboration with WOOD.BE, with the financial support of VLAIO (Agentschap Innoveren & Ondernemen).

16 See also the article 'Nouvelles solutions de façade à ossature en bois répondant aux prescriptions de sécurité incendie', published in CSTC-Contact 2015/3.

- juxtaposition of different modules one on top of another. The space between the top rail of the lower module and the bottom rail of the upper module shall be filled with rock wool (minimum density: 45 kg/m³; compression: 20 %). If the space is less than 1 mm, it can remain unfilled
- the facade element shall have a minimum developed length of 1 m (see figure 32). It may be designed as a lintel (A), an apron (B) or a combination of both (C).

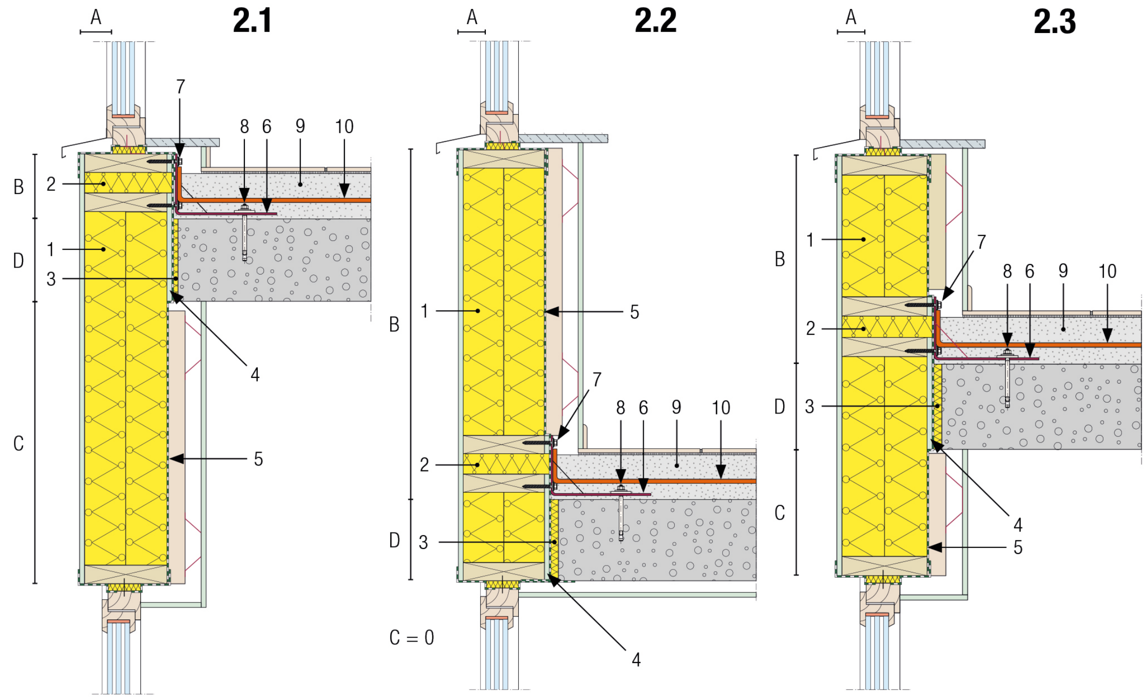
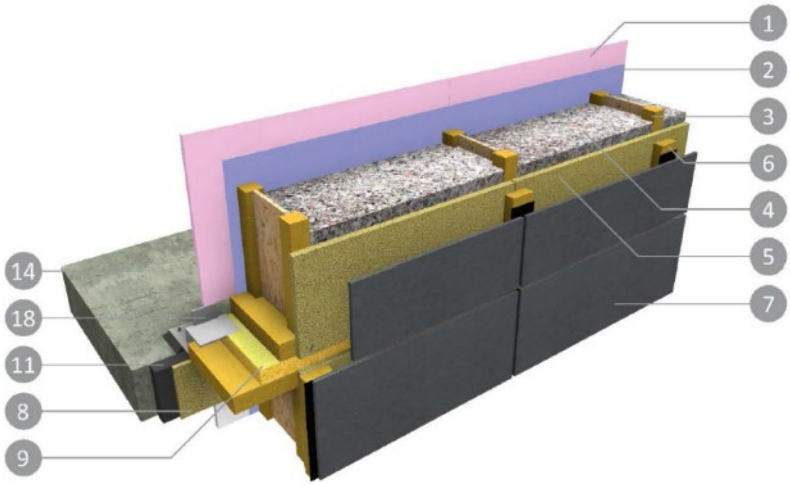


Figure 32 – Fire-resistant facade element designed as a lintel (A), an apron (B) or a combination of both (C) (a + b + c + d ≥ 1 m).

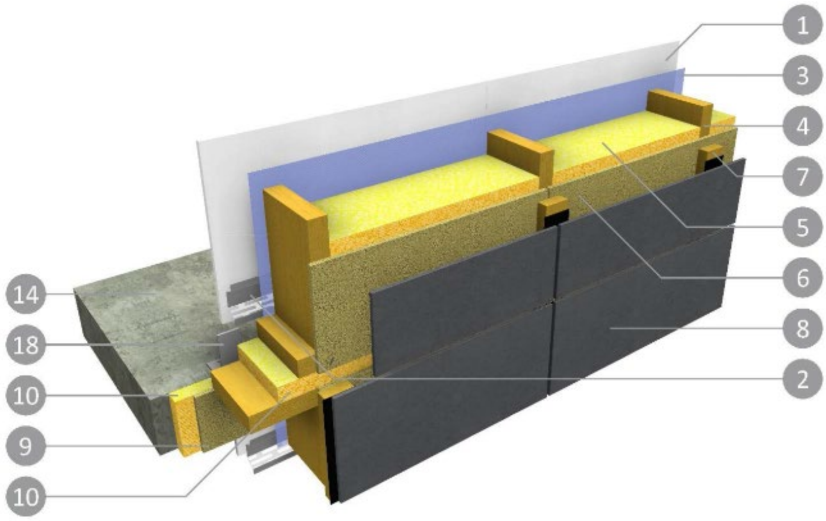
The stability of the timber frame in the event of a fire is guaranteed by fixings in the floor slab of each storey. These anchors ❻ being positioned above the floor slab, they are protected from a fire raging under the floor. In this configuration, the panels are optional both on the inside and on the outside to ensure fire resistance. They shall be selected according to other considerations, notably their acoustic, hygrothermal and/or aesthetic properties.

Figure 33 – E 60 fire-resistant timber-frame facade element, R 60 fixing on the floor slab and EI 60 sealing with the floor slab nosing. Left: installed lower and upper modules; right: installed lower module (photos BBRI – URBICOON worksite, Antwerp – MBS).

This solution has been completed with a series of other configurations for timber facade elements with an E 60 fire integrity. The latter are made up of specific inner and outer panels surrounding an insulation material (rock wool, glass wool or cellulose). Some configurations include rectangular timber struts, others I-shape wood joists (more commonly known as I-joists). In some cases, the sealing between the facade element and the floor slab nosing can be carried out by using an appropriate fire-resistant foam. Two examples are illustrated in figure 34. One must ensure that these solutions are implemented while respecting all parameters, in accordance with the tests conducted (type and thickness of inside/outside panels, type of insulation, type and section of timber elements, type of sealing between the compartment floor slab and the facade, …).



From inside to outside
1. Type F plasterboard
2. Vapour barrier membrane
3. Timber I-joist
4. Cellulose insulation
5. Cement-bonded particle panel
11. Fire-resistant foam or rock wool
14. Concrete compartment floor slab



From inside to outside

1. Plasterboard
2. Metal profiles
3. Vapour-barrier membrane
4. Timber strut
5. Rock wool insulation
6. Cement-bonded particle panel
10. Fire-resistant foam or rock wool
14. Concrete compartment floor slab

Figure 34 – Configurations for E 60 fire-resistant timber facade elements and their junctions with the concrete compartment floor slab (ETEX Group).

7.2 Key points for the design and execution of ventilated facades

These facades feature, behind the cladding, a ventilated air cavity likely to create a chimney effect and thus to accelerate the fire spread (see chapter 4, risk 3 'Fire spread within the façade system'). One option to counter this would be to interrupt the air cavity (and the thermal insulation, if combustible), as in the new regulations for buildings higher than 10 m.

To this end, it is possible to divide up the air cavity (and the combustible insulation) using non-combustible, corrosion-resistant horizontal steel strips or profiles with a minimum thickness of 1 mm and placed with a 5 % gradient to allow water to run off to the outside.

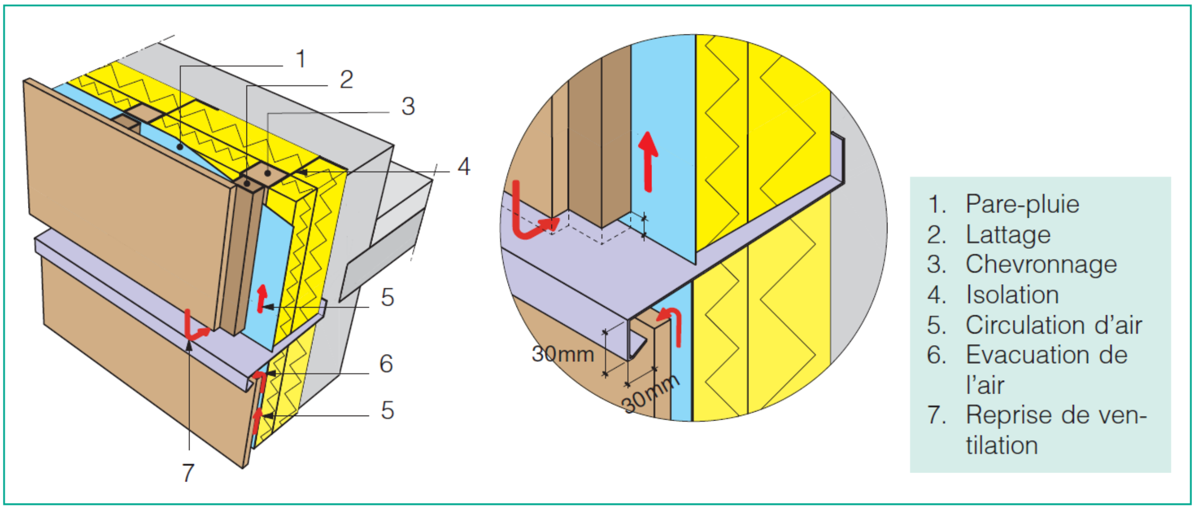


Figure 35 – Example of the division of the air cavity and insulation [29].

In addition, one can also use fire-resistant strips that interrupt the combustible insulation and the air cavity of a traditional cavity wall (see § 6.2.2.1). In this case, the necessary attention must be paid to the drainage of the air cavity (see figure 36).

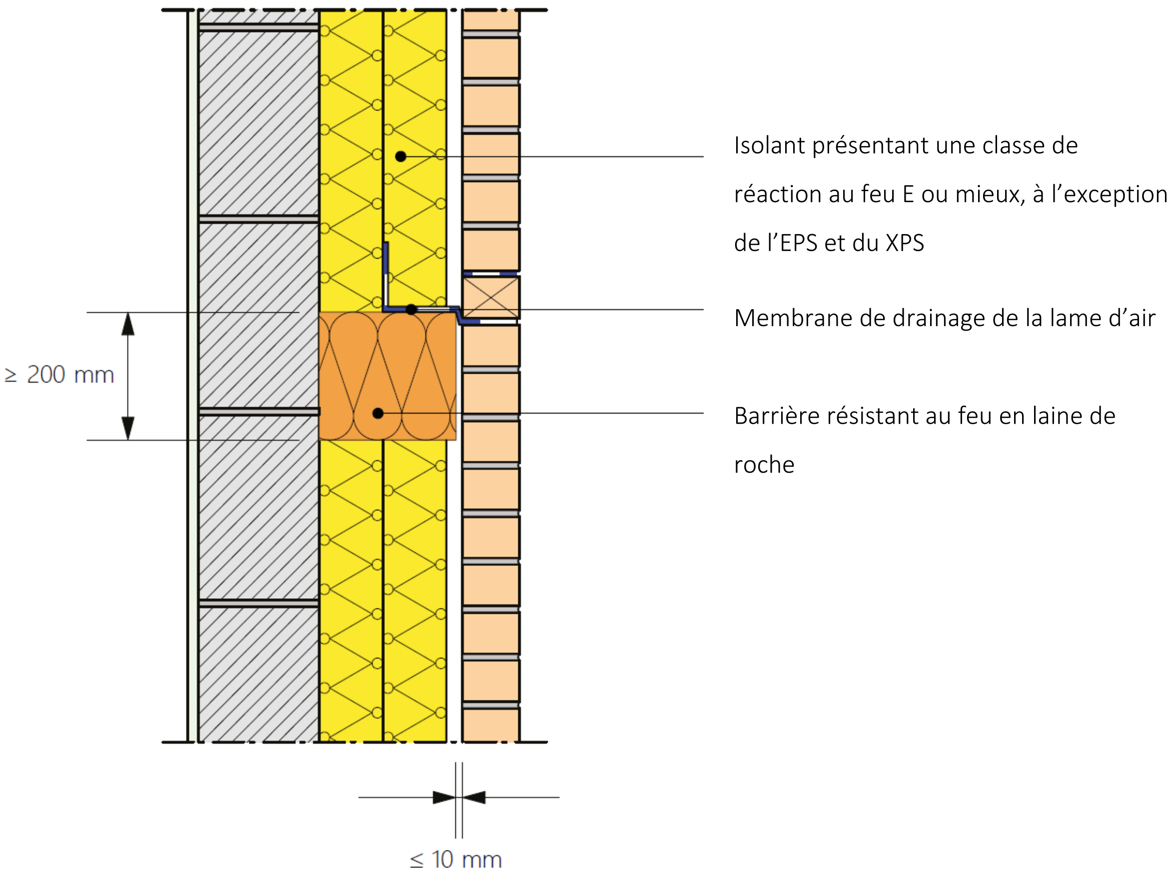


Figure 36 – Application of a fire-resistant screen in a facade of a mid-rise building with a continuous air cavity.

There are also devices that interrupt the air cavity in the event of a fire (intumescent water-resistant products for example); the air cavity remains thus ventilated under normal circumstances (see figures 37 and 38).

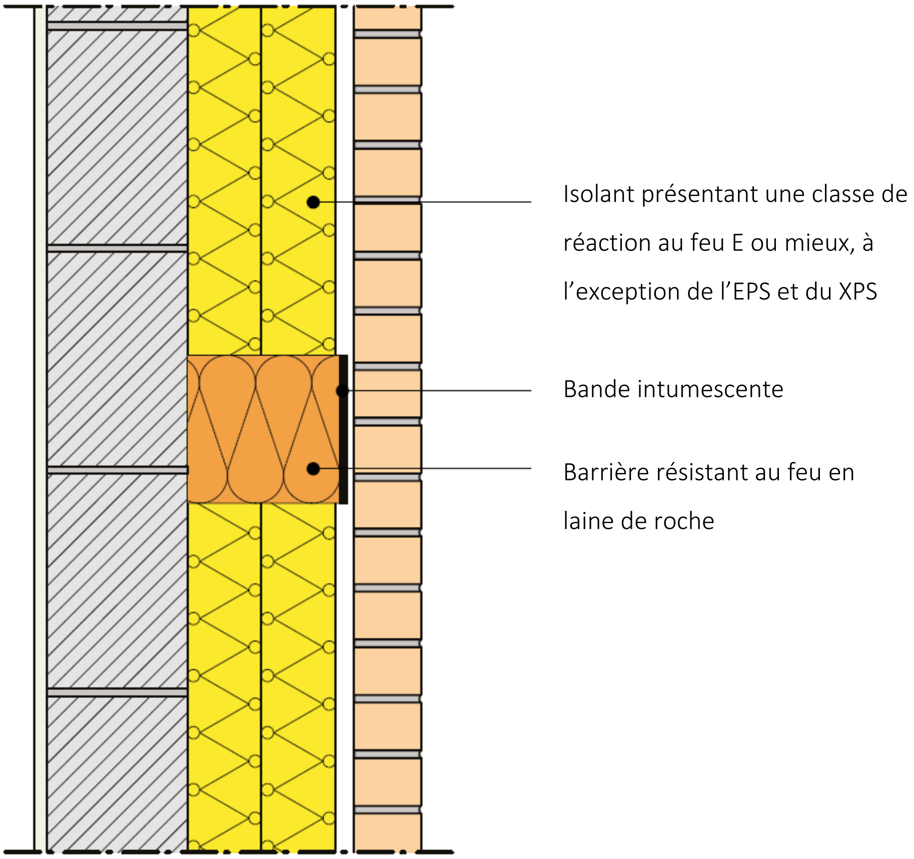


Figure 37 – Standard solution where the combustible insulation is interrupted by a fire-resistant screen and an intumescent strip.

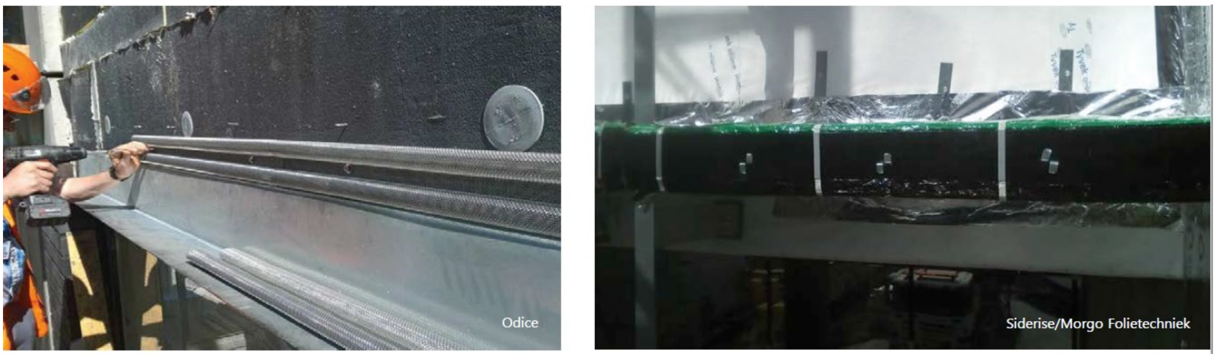


Figure 38 – Application of an intumescent strip in a ventilated facade.

7.3 KEY POINTS FOR THE DESIGN AND EXECUTION OF ETICS

In recent years, there has been an increase in external thermal insulation facade surfaces, in the associated insulation thicknesses, and consequently in the amount of combustible material in the facades. The risk of fire migrating into the core of the facade system, notably via the combustible insulation of an ETICS (EPS for example), is therefore real (see chapter 4, risk ❸ 'Fire spread within the façade system').

This risk is not directly covered by the European testing methods and the previous Belgian fire regulations. However, the new regulations do cover this risk (see § 6.2).

When installing a fire-resistant screen in an ETICS (see § 6.2.2.2), it is recommended not only to fix the rock wool strips mechanically, but also to glue them completely onto the substrate. These strips must be as thick as the EPS insulation and at least 200 mm high. To limit the risk of cracking in the rendering, an additional reinforcement fabric must be applied. This fabric must overlap with the ETICS insulation by a distance of at least 200 mm (see figure 39).

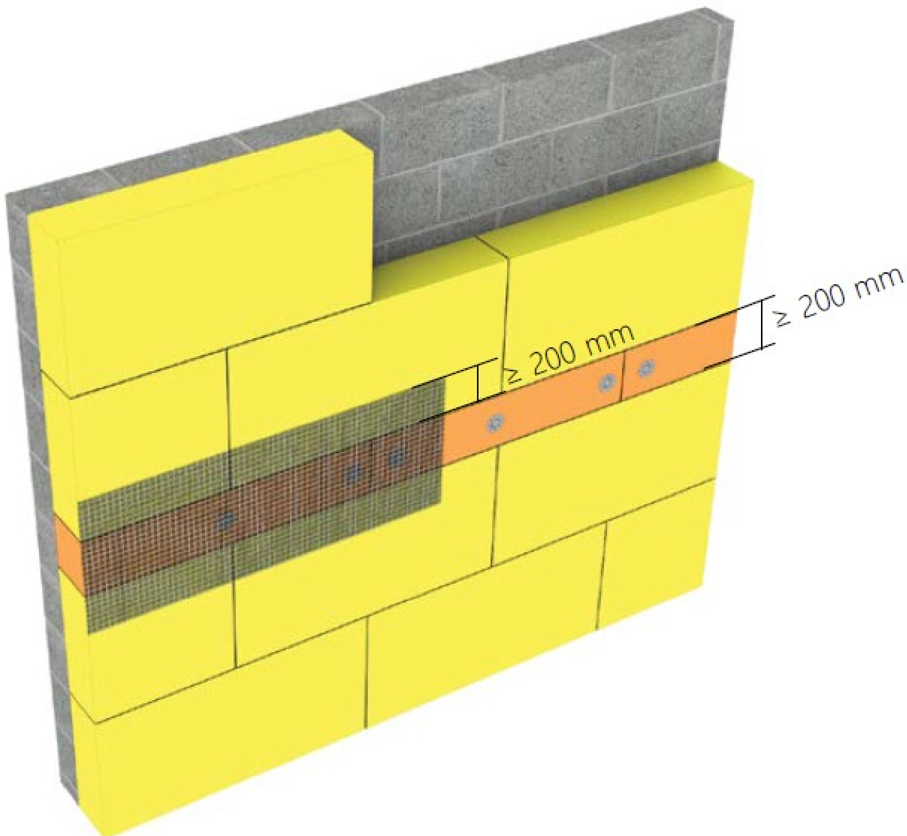


Figure 39 – Installing an additional reinforcement fabric at the level of the fire-resistant screen.

7.4 KEY POINTS FOR THE DESIGN AND EXECUTION OF TRADITIONAL CAVITY WALLS (SYSTEMS WITH EXTERNAL MASONRY CLADDING)

The continuous reinforcement of thermal regulations has had the effect of increasing the thicknesses of insulation inside facades. Consequently, the external joinery no longer fully seals the gap in cavity walls, which implies the risk of a fire spreading this way into the upper compartment in spite of the presence of a fire-resistant element with a length of 1 m.

However, the risk of fire spread within the cavity of the walls is smaller than in a ventilated facade or even in an ETICS system. Indeed, the air cavity for water draining is in general not ventilated intentionally, which strongly limits the intake of combustion air. Compared to an ETICS system, facade masonry offers a much higher level of protection against fire than that provided by a thin rendering (< 15 mm), so that only the lower section of the insulation (level with the joinery junctions) will be exposed to the flames. In all cases, the fire spread via the cavity can be contained if the passage of flames is prevented by realising a fire-resistant sealing in the spaces between the joinery and the internal masonry or the facade masonry (see figure 40).

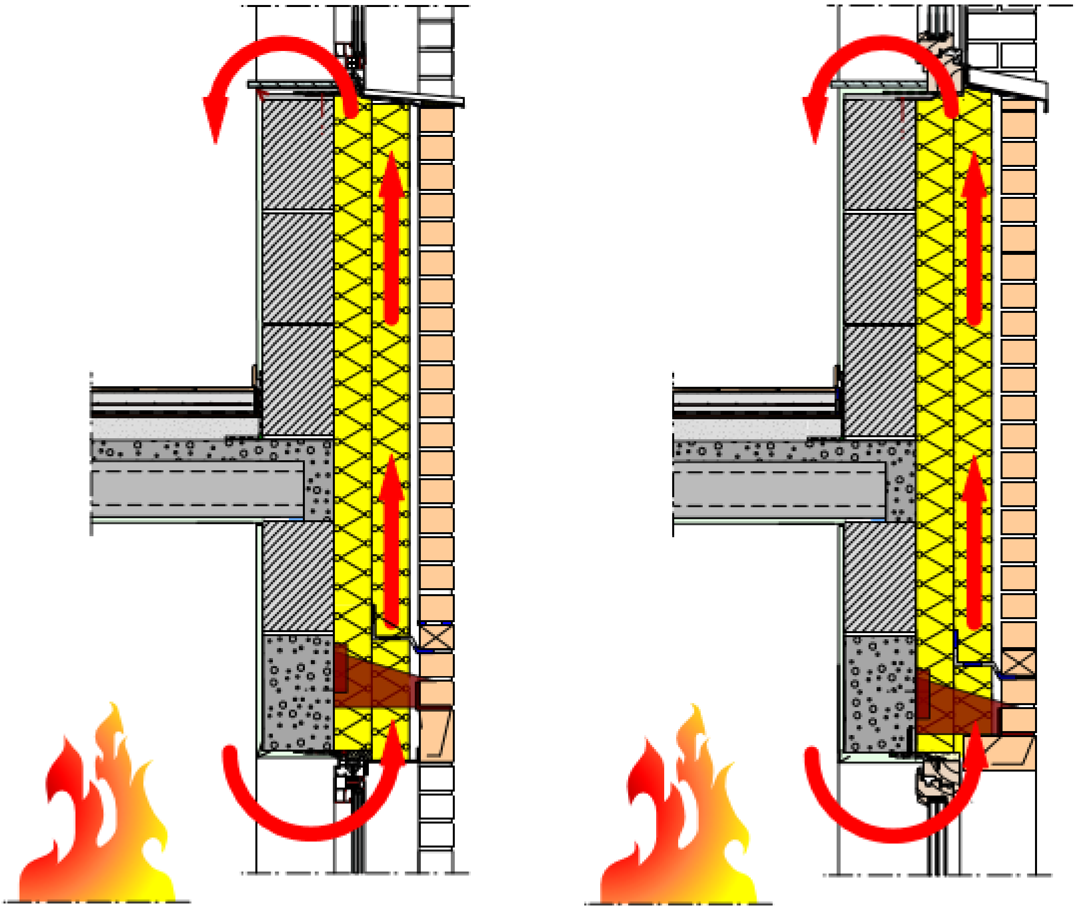


Figure 40 – Containing the risk of fire spread within the cavity of a wall.

In practice, this would notably be the case when the following conditions are met simultaneously:

- the joinery is made of wood (minimum frame section of 50 mm for example) or shows an E 60 fire resistance
- the internal sealings are realised using a plaster or similar layer, natural stone elements (window sills for example), …
- the external sealings are realised with steel plates or ideally with a facade brick return.

CONCLUSION

This document has made it possible to demonstrate that the fire regulations applicable to new buildings in Belgium cover the majority of risks, even if their interpretation is not always easy. In particular, we are referring to the reaction-to-fire requirements for facade cladding, which must be evaluated while taking into account the influence of the underlying layers (panels, insulation, ...) and the execution conditions (ventilated air cavity, ...).

As for the renovation of existing buildings, no regulations currently in force deal with the subject. However, some works require the submission of a permit application. The fire service can thus be consulted within this context and propose recommendations in this regard. In the case of significant renovation works, the requirements for new buildings will generally need to be applied.

Finally, we would highlight that the BBRI has been working for many years in collaboration with the sector on proposing practical solutions that make it possible to satisfy regulations and to take into consideration all criteria imposed to today's buildings (airtightness, thermal insulation, acoustic performances, ...).

This publication was drafted within the framework of the BBRI's Standards Antenna 'Fire Prevention' financed by the Belgian Federal Public Service Economy, SMEs, Middle Classes and Energy.

Bibliography

[1] Statistics - Belgian fire services - FPS Home Affairs - General Civil Security Directorate - KCCE/CFSSC (Federal Civil Security Knowledge Centre).

[2] The EU Needs A Fire Safety Strategy. Fire Safe Europe, 2016.

[3] Studio E Architects - BBC - http://www.bbc.com/news/uk-england-london-40272168.

[4] NBN EN ISO 13943:2017 Fire safety Vocabulary (ISO 13943:2017).

[5] NBN EN 13501-1:2019 Fire classification of construction products and building elements Part 1: Classification using data from reaction-to-fire tests.

[6] NBN EN 13501-2:2016 Fire classification of construction products and building elements. Part 2: Classification using data from fire resistance tests, excluding ventilation services.

[7] NBN EN 1991-1-2 ANB (2008) Eurocode 1: Actions on structures. Part 1-2: General actions - Actions on structures exposed to fire.

[8] NBN EN 13501-3:2010 Fire classification of construction products and building elements. Part 3: Classification using data from fire resistance tests on products and elements used in building service installations: fire resisting ducts and fire dampers.

[9] NBN EN 13501-4:2016 Fire classification of construction products and building elements. Part 4: Classification using data from fire resistance tests on components of smoke control systems.

[10] NBN 713-020:1968+A1:1982+A2:1985+A3:1995 Fire fighting. Fire performance of building materials and products. Fire resistance of building materials (with erratum).

[11] Royal Decree of 7 July 1994 stipulating the Basic Standards for fire and explosion prevention with which all new buildings must comply. Brussels, SPF Home Affairs, Belgian Official Gazette (BOG) of 26 April 1995 (+ erratum BOG 19/3/1996) and its modifications of 4/4/1996 (BOG 20/4/1996), of 18/12/1996 (BOG 31/12/1996), of 19/12/1997 (BOG 30/12/1997), of 4/4/2003 (BOG 5/5/2003), of 13/6/2007 (BOG 18/7/2007) + erratum (BOG 17/8/2007), of 18/9/2008 (BOG 16/10/2008), of 1/3/2009 (BOG 15/7/2009) + erratum (BOG 4/2/2011) and of 12/7/2012 (BOG 21/9/2012) + erratum (BOG 10/1/2014) and of 7/12/2016 (BOG 18/01/2017).

[12] Regulation (EU) no. 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC. Brussels, Official Journal of the European Union, no. L88/5, 4 April 2011.

[13] Maîtriser la qualité des produits et systèmes de construction (Monitoring the quality of building products and systems). Brussels, BBRI , Monograph, no. 13, 2008.

[14] NBN S 21-204 (1982) Fire protection in buildings. School buildings. General requirements and fire reaction.

[15] STS 71-2 Systèmes d'isolation extérieure des façades (External facade insulation systems). Brussels, FPS Economy, division Quality and Innovation, Spécifications techniques unifiées (Coordinated Technical Specifications), draft, 2017.

[16] Conception et mise en œuvre de bâtiments industriels conformes aux exigences de sécurité contre l'incendie (Design and execution of industrial buildings in compliance with fire safety requirements). Brussels, BBRI, Technical Information Note, no. 256, 2016.

[17] Obturation résistant au feu des traversées de parois résistant au feu. Prescriptions et mise en œuvre (Fire-resistant sealing and stopping of service installations penetrating fire-resistant walls. Requirements and installation). Brussels, BBRI, Technical Information Note, no. 254, 2015.

[18] L'application de systèmes de peinture intumescente sur structures en acier (Application of intumescent paint systems on steel structures). Brussels, BBRI, Technical Information Note, no. 238, 2010.

[19] Le placement des portes résistant au feu (Installation of fire-resistant doors). Brussels, BBRI, Technical Information Note, no. 234, 2008.

[20] L'entretien des portes résistant au feu (Maintenance of fire-resistant doors). Brussels, BBRI, Technical Information Note, no. 226, 2002.

[21] Circulaire relative au rapport de prévention incendie et à la mission d'avis par les zones de secours (Circular regarding the fire prevention report) (FPS Home Affairs, 1/12/2016) et arrêté ministériel fixant le modèle de rapport de prévention incendie (FPS Home Affairs, 1/12/2016).

[22] Decision of the European Commission of 8 February 2000 regarding the classification of reaction-to-fire characteristics for building products. (2000/147/EG).

[23] Réduire le risqué de propagation de l'incendie via les façades-rideaux (Limiting fire spread via a curtain facade). Brussels, CSTC-Contact, no. 3, 2013.

[24] Les ETICS et la sécurité incendie des façades (ETICS and the fire safety of facades). Brussels, CSTC-Contact, no. 2, 2017.

[25] Konstruktive Ausbildung von Maßnahmen zur Verbesserung des Brandverhaltens von als „schwerentflammbar" einzustufenden Wärmedämmverbundsystemen mit EPS-Dämmstoff. Deutsches Institut für Bautechnik DIBT, 05/2015.

[26] Arrêté du 24 mai 2010 portant approbation de diverses dispositions complétant et modifiant le règlement de sécurité contre les risques d'incendie et de panique dans les établissements recevant du public. Instruction Technique 249 relative aux façades, 2010.

[27] Protection contre l'incendie des façades béton ou maçonnerie revêtues de systèmes d'isolation thermique extérieure par enduit sur polystyrène expansé (ETICS-EPS). Paris, ministère de l'Intérieur, Guide de Préconisations, April 2016.

[28] Enduits sur isolation extérieure (ETICS) (Rendering on outside insulation (ETICS)). Brussels, BBRI, Technical Information Note, no. 257, 2016.

[29] Les revêtements de façade en bois et en panneaux à base de bois (Facade claddings in wood and wood-based panelling). Brussels, BBRI, Technical Information Note, no. 243, 2011.

[30] Commission delegated regulation 2016/364 on the classification of reaction-to-fire performance of construction products pursuant to regulation (EU) no. 305/2011 of the European Parliament and of the Council.

[31] Sécurité incendie des façades. Conception et mise en œuvre des façades-rideaux (acier et aluminium) (Fire safety of facades. Design and construction of curtain walls (steel and aluminium)). Brussels, BBRI, Technical Information Note, no. 282, 2022.

[32] Sécurité incendie des façades-rideaux : une NIT pour tout savoir (A TIN on the fire safety of curtain facades). Brussels, Les Dossiers du CSTC 2022/02.07, 2022.

Responsible publisher: Olivier Vandooren
BBRI, Rue du Lombard 42, 1000 Brussels

D/2022/0611/05

bbri.be
Researches • Develops • Informs

Belgian Building Research Institute

Researches • Develops • Informs

Primarily financed through the membership fees of some 95,000 Belgian companies, representing almost all of the construction trades, the BBRI has been considered the leading scientific and technical institute for over 55 years, contributing directly to the improvement of quality and productivity.

Research and Innovation

The introduction of innovative techniques is vital for the survival of an industry. Oriented by the construction professionals, contractors and experts sitting on the Technical Committees, the Institutes's research activities are closely aligned to the day-to-day needs of the sector.

With the help of various official bodies, the BBRI encourages companies to innovate, by offering advice in various fields that is tailored to the current challenges.

Development, standardisation, certification and approval

At the request of public or private players, the BBRI also works on various development projects under contract. Actively collaborating in the activities of the standardisation institutes – on the national (NBN), European (CEN) and international (ISO) levels – as well as in those of bodies such as the Belgian Union for Technical Approval in Construction (UBAtc), the Institute is ideally placed to gain insight into the construction sector, and thus to better respond to the future needs of the various construction trades.

Dissemination of knowledge and support to companies

The BBRI makes extensive use of information technology in order to efficiently share the results of its work with all companies of the sector. Its website, adapted to the diverse needs of construction professionals, contains the publications of the Institute as well as more than 1,000 construction standards.

Personalised training and technical assistance contribute to the Institute's commitment to disseminating information. Alongside some 750 information sessions and thematic conferences involving the BBRI's engineers, over 18,000 advice notices are issued each year by the Technical Advice Division.

Registered office
Rue du Lombard 42, B-1000 Bruxelles
Tel. 02/502 66 90
Fax 02/502 81 80
Email: info@bbri.be
Website: www.cstc.be

Offices
Lozenberg 7, B-1932 Sint-Stevens-Woluwe
Tel. 02/716 42 11
Fax 02/725 32 12
- Technical advice – Publications
- Management – Quality – Information technology
- Development – Valorisation
- Technical approvals – Standardisation

Testing Station
Avenue Pierre Holoffe 21, B-1342 Limelette
Tel. 02/655 77 11
Fax 02/653 07 29
- Research and innovation
- Training
- Library

Brussels Greenbizz
Rue Dieudonné Lefèvre 17, B-1020 Bruxelles
Tel. 02/233 81 00