

The Italian National Guidelines for the fire safety of facades

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Abstract. Traditionally, the facades' design buildings were once only focused on architectural or aesthetic purposes (in addition, of course, of whether protective issues). Nowadays, thanks to the technological development of the construction works and the use of new types of materials, the facades' design should also address fire safety related aspects.

In Europe and especially in Italy – where the types of building façades are built with windows of small surface and natural stone coverings – the green building/sustainability movement has resulted in the development of new concepts in facade or curtain wall design that intended to enhance the energy efficiency of building façades. These new building surfaces are covered by extensive panelling fitted with insulating materials or by wide glass surfaces, capable of carry out the most diverse purposes including, just to name a few: energy reduction, climate comfort, recovery of electricity through photovoltaic panels that convert sunlight into electricity, large space for advertising purpose.

One of the main fire safety goal for a building design is to restrict the vertical fire spread so that the smoke and flames are limited to the fire origin floor. The new building façade and curtain wall topologies could overwhelms concerns for fire safety, therefore the Italian National fire service has released a Fire Code Guideline in order to address the fire safety design for an high rise building façade. This paper aims to show the guideline contents and the related fire safety façades concerns.

1. INTRODUCTION

Fire safety façades' major problems can be summarized as follows:

- Generally building horizontal fire resistant elements – slabs – and vertical elements – fire walls –, for both structural and aesthetic requirements, do not lay perpendicular to the building façade; in this case, once the façade is attacked by a fire, it can be a suitable way for fire spread to one or more building compartments;
- For buildings with facades having a ventilating function of air through natural or forced circulation within vertical cavity, the risk of fire spread to other zones of the construction work is very high;
- The materials and components that constitute the facade or the outer building coating, could easily propagate a fire;
- For firefighters or rescue personnel is often very difficult to carry out rescue and fighting operation through the facade, especially for high-rise buildings;
- For an outside observer, it is difficult, especially in the case of double-wall facades, recognize an outbreak of a fire;
- In case of fire the final collapse of the facade (panels, profiles, glasses) can be a source of danger to the exodus of occupants and rescue workers.

Definitely, one of the most frequent cases of fires of façades is the one that originates within a fire compartment [1]. In such a case, flames and hot gases go out from the fire compartment via cavities of wall/slabs openings and, through any vertical cavity of the façade, the fire propagates within the gaps that may exist between the head of the slabs and the facade (or between the head of a fire compartment wall and a facade), involving other compartments which belong to the same building and that initially were not affected by the fire, whether they grow in horizontal and vertical direction. Furthermore, it

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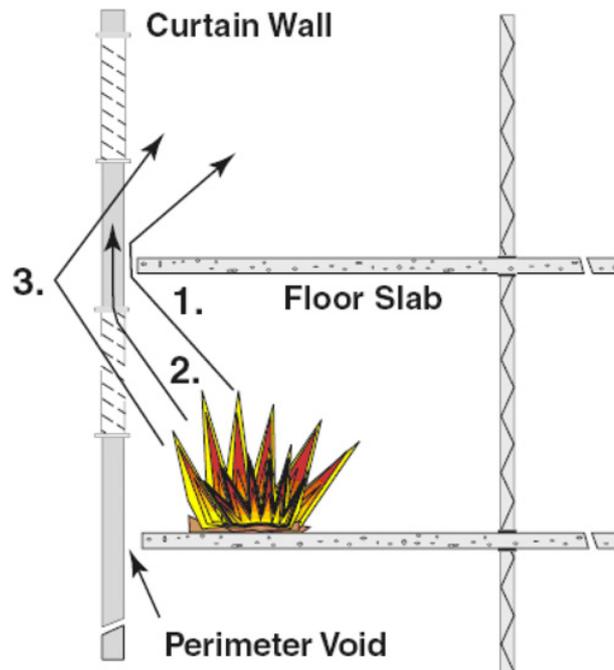


Figure 1. Façade main fire spread mechanisms.

should not be underestimated a fire that could be ignited a building façade starting from objects, like cars or waste containers [2, 3], which, given their proximity to construction, may involve the building right through the easy combustible façade elements.

Next Figure shows the main mechanisms of façade fire spread:

- 1) fire spreads through the hollow space between the slabs and the internal façade side ;
- 2) fire spreads within the façade' cavity (through facade ventilation chambers);
- 3) fire spreads from façade windows.

For the new types of façades, that are often equipped with large glass surfaces, a fire scenario is a severe safety issue to address to, since a fire could spread either among building compartments and outside the building itself.

As a direct consequence of a fire, it must be taken into account also the risk related to the falling of façade components or pieces that could collapse during the fire exposure, such as fragile parts like glass elements. This risk could affect both the escape of the building occupants and the rescue team actions.

In order to limit the aforementioned risks in case of an outbreak of a façade fire, the following safety goals should be achieved:

- A. Reduce the occurrences of fire of a facade and its spread within the building, due to a fire that could have both internal and external origin;
- B. Reduce, in case of an outbreak of a fire, the falling of facade pieces (fragments of glass or other broken or burnt facade components) that may affect the safe exodus of the building occupants and the rescue and fighting operations of rescue teams and fire brigades.

2. FAÇADE FIRE SAFETY REQUIREMENTS

This section discusses the most appropriate fire protection measures in order to achieve the above general fire safety performances of a building façade. In order to achieve the first fire safety requirement – safety

goal A listed in the previous section – the following two aspects have to be taken into account. The first safety aspect is related to the fire compartment requirements among the façade elements – both horizontal and vertical ones – and the building fire compartments. The second safety requirements is related to the ignition and combustibility performance of the materials that constitute the façades, therefore to the choice of a material/component with a proper reaction to fire rating.

The fire compartment requirements can be addressed by means of technical solutions, like proper building structural interruptions or by placing in the space between the outer covering and the building a fire resistant element. It is very important that the separation between floors and protection of the joint system between the exterior wall and slab edge is assured in order to decrease the fire spreading, both in horizontal and vertical direction.

The façades vulnerability to fire could be also reduced if the fire load within building compartments is maintained at modest levels. Moreover, in order to address the aspects related to the choice of façade materials (especially insulating ones), which is also aimed to reduce the fire spread risk, there is obviously the need to ensure adequate fire performances and therefore a proper class or level of “reaction to fire” must be adopted for the façade materials [4].

In fact, the most used façades are built with a series of layers of materials that increase insulating and sound absorbing performances without any considerations of combustibility and participation to fire tendency. Expanded Polystyrene (EPS) is the most used foamed plastic used in external façade insulation systems today, even though it has a very low reaction to fire rating: class E or F according to the European classification EN 13501-1 [5]. For this reason, often, an ignition of a façade becomes a severe problem for the protection of people and property.

Furthermore, if a fire starts at road level – i.e. a burning car or a waste container –, and ignites a nearby building façade covered or completely built up by combustible materials, taking into account the vertical position of the fuel and the unlimited presence of oxidizer quantity (the oxygen in the atmosphere), the fire façade could become a real huge torch. In order to reduce the vulnerability of the overall cover building system, the lightweight, high insulation and sound absorbing materials used in the construction of a facade must have a proper reaction to fire performance.

As well established, fire protection for buildings relies on both passive and active measures. Among fire protection measures, the installation of automatic fire suppression system – like sprinkler –, could represent a viable solution in order to limit the fire propagation risk.

The second façade fire safety requirement – safety goal B in the previous section – concerns the choice of the solutions that could prevent the risk of falling glass parts or pieces of other façade fragile objects in case of fire. This safety requirement appears more complex, mainly because it is impossible or at least very difficult to foresee the size and geometry of the façade that could collapse when exposed to fire. Neither could be affordable a façade built up with fire-resistant glazed elements and fitted with connections which are also fire resistant, in order to prevent their rupture or falling risk, without considering also the fact that these same elements, when are broken by a fire, allow the removal of smoke and heat from the compartments affected by the fire. In other words, restrict the falling risk of burning or fire broken façade elements can be only modestly related to the choice of the materials that constitute the façade. The mitigation of façade falling parts is mainly linked to the identification of all those measures capable to ensure the protection of the building safety escape routes, even those used by rescue teams and firefighters.

3. THE NEW ITALIAN GUIDELINE FOR “FIRE SAFETY REQUIREMENTS OF BUILDINGS FACADES”

In 2010, the Ministry of Interior, by means of the Italian National Fire Services, issued a first technical note (Circular Letter No. 5643 of 31.3.2010) where, in the annex, was presented the first edition of the guideline for fire safety of façade. This original normative document was developed by a proper

working group and approved by the Italian Scientific Technical Central Committee of the Italian National Fire Services.

For the first time in Italy, the document dealt with the fire design of building facades, highlighting the technical difficulties related to this specific technical building external covering solutions.

Moreover, the 2010 Act stipulated that, after two years of experimentation, based on the comments received from the users, the technical guideline would be updated. It was then recently issued a new Technical Guide (which replaces the previous one) that, thanks to the contributions of both the Industry facades and the practitioners who deal specifically with this subject, is now the best national normative document in the specific area.

The new guideline was issued by the Ministry of Interior Circular Letter n. 5043 of April 15, 2013, where the Italian National Fire Services recommends to use the new standard, as a “Voluntary Fire Code” and, as it was stated in the 2010 issue, the field of application is restricted to buildings whose fire height is greater than 12 metres. This section reports the main technical contents of the Guideline.

3.1 The new definitions introduced

The document, like the previous one, is rather articulate due to the complexity of the technical topic discussed. The novelty introduced, compared to the first version, are tailored to fire safety concerns of facades, both by typological features and material choices, in order to ensure a better formal lay-out of the document, especially in relation to the specific performance based characteristics required.

The Guideline first section points out the facades safety requirements illustrated in the previous Section 2: reduce the occurrences of fire of a facade and its spread within the building, due to a fire that could be both internal and external origin and limit the falling of facade pieces (fragments of glass or other broken or burnt facade components) that may affect the safe exodus of the building occupants and the rescue and fighting operations. Soon After, the Guideline introduces a classification of these types of constructive elements that appears more articulated than in the previous version but certainly more functional to the purposes of the Guideline itself. The definition paragraph of the Guideline states that a facade is defined as a “*set of components that build up a closing-system materials, items, accessories etc.- designed, assembled and installed in order to build the outer covering, vertical or near-vertical, of a building*”. Furthermore, it introduces the following definitions which distinguish the major categories of facades:

- a) Single skin or simple facade, where layers and functional elements are assembled continuously without gaps among the layers. Are considered as “single layer” perforated elements such as bricks, concrete blocks, glass-room, etc.”
- b) Double-skin Facades: “facade of multilayer type, in which the layers and/or functional elements are separated by a cavity or air gap (called” air corridor “or” intermediate space”). They can be ventilated and not-ventilated, with matt or glazed glass walls.

The guideline clarifies that from the point of view of fire safety, a double skin not ventilated facade is comparable to a simple facade. These facades are divided in two categories according to whether they are accessible or not accessible. The double skin non-accessible facades, where the ventilation of the cavity is controllable by fan and/or openings, show a cavity width ranging from 5 to 10 cm, while the accessible ones have a cavity width greater than 60 cm, as the one represented in Figure 2.

According to the Italian Guideline, if an accessible double skin facade has a cavity width greater than 120 cm the two walls are considered as two independent facade systems. This type of facade is generally composed of a glass outer wall and an inner wall that can be with or without windows, made by matt or glazed glass or by a curtain wall. The internal space between the two walls is arranged in order to allow the entrance and passage of maintenance personnel.

The guide states, also, the definition for Curtain wall, that is a “*structural independent building covering, usually fixed to the slab heads and walls*”; a curtain wall includes frames, panels, glazed surfaces, sealing, fastening systems, joints and sealing membranes. In order to take into account the

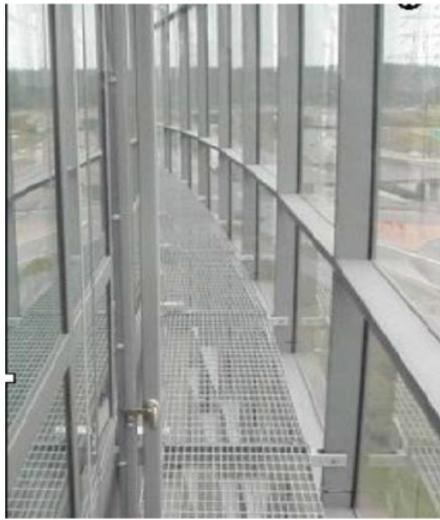


Figure 2. An accessible double skin façade.

possibility that the outer walls of the building could be equipped with venting systems able to dispose smokes and heat in case of fire, the Guide distinguishes the “open walls” from the “closed walls”. An open wall must have at least the 50% of its surface covered by windows/panels with automatic opening systems (that operate in case of fire) or by low melting panels, i.e. materials that at 200 ° C break and fall down. On the contrary, closed wall is defined as an external wall that does not meet the criteria of open walls.

Eventually, in order to address both the various construction technologies adopted for the façades and European requirements of the Construction Products Directive and the new Construction Products Regulation (CPR), the Guideline reports a last definition that covers the so-called “Kit”, as following:

“KIT” means a construction product placed on the market by a single manufacturer as a set of at least two separate components that need to be put together to be incorporated in the construction works [6].

3.2 Fire resistance and fire compartment requirements

As a general rule, the Guideline establishes that if each building fire compartment has a fire load less than 200 MJ/m², it is not required any Fire Resistant performance for the façade. In other words, it is not necessary any measure connected to fire resistance if the elements of the façade are part of a fire compartment with a modest specific fire load (less than 200 MJ/m²) or, where these building compartments, regardless of the amount of the fire, are protected by an automatic fire extinguish system (i.e. sprinkler). It is interesting to note that the value of the fire load equal to 200 MJ/m² corresponds, according to the Decree of the Ministry of Interior 9 March 2007 [7] (see table in 3.3 p. to. of the Decree), to a class of fire resistance of 15 minutes (this class refers to structural elements exposed to a standard fire inside the building). Actually, a façade is exposed to a less severe external fire curve, therefore the predicted value of the fire load compartment fire appears largely justified.

In order to achieve an adequate fire compartment building organisation, for simple skin façades or curtain walls the fire resistant band rule is pointed out. Bands of fire-resistant construction at regular intervals running up the façades are requested in the areas of intersection between elements

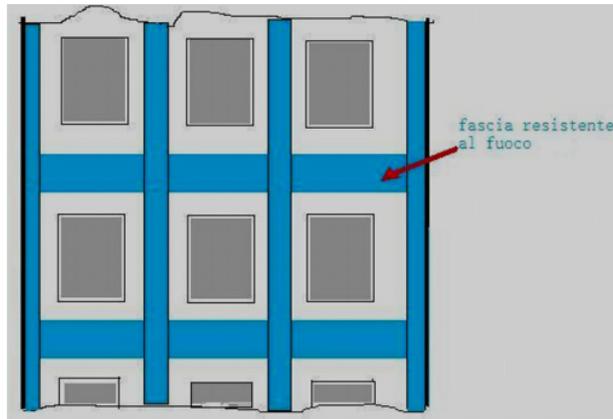


Figure 3. Façade whit bands of fire resistant material.

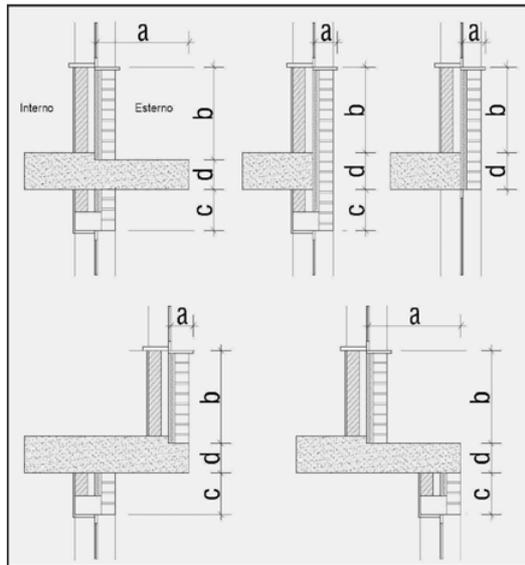


Figure 4. Fire Resistant Band applied to horizontal intersection.

of compartments (wall or slabs) of the building and the external covering façade. The Fire Resistant band rating should at least E60-ef (external fire) classified. As an example, next Figure shows a façade where the bands of fire resistant construction are highlighted.

The basic concept is to assure an useful fire compartment organisation along the building façade, both in horizontal and vertical direction, by means of fire resistant bands not less than a meter width or height. This fire safety solution was firstly suggested by the following Belgian technical report: “*Proposition de modification de l’arrêté royal du 7 Juillet 1994 en matière de spécification techniques pour les façades*” edition 3.2 – 15/10/2006 [8].

Furthermore, the Guideline annex contains two useful explanation diagrams, in order to explain a correct fire resistant band placement. The Diagram B (see Figure 4) refers to horizontal slabs of a width “a” equal to or greater than 0.6 m, joined to the slab that could be a continuous parapet height “b” on the upper floor, connected to the attic or a continuous lintel height “c”, connected to the attic. The sum

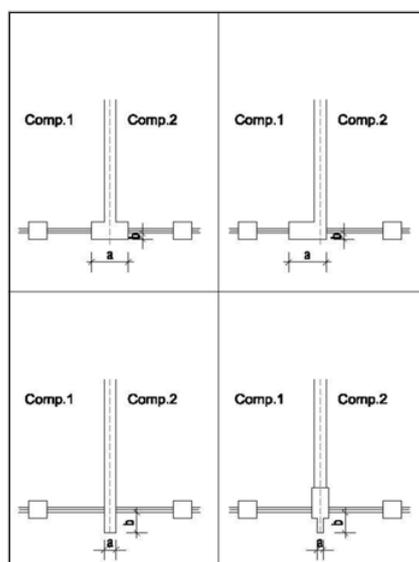


Figure 5. Fire Resistant Band applied to vertical intersection.

of the dimensions a , b , c and d (thickness of the slab) is equal or superior to a meter while each of the values a , b or c may optionally be equal to 0. In the same manner, it is possible to extract the rule of the band in the case of the intersection of the façade with vertical compartment elements (fire walls) as represented in Figure 5.

For vertical intersections, the band having one or more fire-resistant building elements must be formed by a projection of depth “ b ” with respect to the outer surface of the facade and width “ a ”; even in this case, as well as in the previous one, the sum of the linear band width ($2b$) must be equal to or greater than one meter.

In the following, for each type of the facades considered in the Guideline the fire resistance requirements are reported.

For Curtain wall, that are connected but not anchored to the head of the fire walls or slabs, the link zone represents a significantly vulnerable element, therefore it is requested that this junction components must have a fire resistance class not less than EI60 ISO 834 curve fire attack [9].

For non-accessible double skins ventilated facades that have an external closed wall, if the cavity is provided for each window and/or door and at slab intersection of non-combustible elements, the inner wall is considered as simple façades. Furthermore, no slab horizontal fire stop elements are required if the cavity is built up of material classified at least Bs3d0 reaction to fire performance or if the internal wall has, for the entire height and for all storeys, EI30 fire resistance performance.

For non-accessible double skins ventilated facades that have an external open wall, the inner wall must possess the same fire resistance requirements of a simple façade, only if the cavity is built up of material classified at least Bs3d0 reaction to fire performance or if the internal wall has, for the entire height and for all storeys, EI30 fire resistance performance.

For accessible double skins ventilated facades that have an external closed wall, if the cavity is interrupted by fire stops or slabs EI 60 rated for each storey, the external and internal wall can be considered as a simple façade. Fire stops or fire resistant slabs can have openings to allow air circulation inside the cavity but only if these openings are provided by automatic closing devices having fire resistance requirement not less than E60. The latter measure preserves the fire compartment between storeys.

For accessible double skins ventilated façades that have an external closed wall and the cavity is not interrupted by fire resistant elements in correspondence of each floor, the internal wall must have a fire resistance performance not less than EW30 (i →). Furthermore, if the internal wall is a curtain wall, the joint element to the slabs and walls must have a fire resistance performance not less than EI 60. If an accessible double skins ventilated façade has an external open wall, the internal wall must be considered as single façade. In fact, in this case of an “open” external wall, the fire safety measures can be requested to the internal wall in order to limit fire spread, therefore they are considered as simple façades.

3.3 Reaction to fire requirements

Fire spread risk is well addressed if the façade elements and components have a good reaction to fire performances. Thermal and sound insulation characteristics of façades are often obtained employing combustible materials. Therefore, the Guideline focuses on façade materials and elements that, in case of fire, could be directly hit by flames and, due to their good combustibility performances, can support the fire propagation of a fire within the façade and the building itself. In fact, it is requested that for façade combustible materials, the reaction to fire rating must be class 1 according to the Italian classification or class B-s3-d0 according to the Commission Decision of 8 February 2000 [10].

For insulating combustible materials, excluding the materials that lay around windows or doors for a 60 cm clearance zone, the reaction to fire requested could be as follow:

- insulating internal material C-s2-d0 classified, covered by an external layer A2 rated;
- insulating internal material E classified, covered by a 15 mm width layer A1 rated.

The latter exception is also valid for the first 3 meter façade band starting from the grounds.

In addition, gaskets, sealants and sealing materials must ensure the same reaction to fire requirements indicated for insulating combustible materials, if they lay on a total surface greater than the 10% of the total façade surface. All other façade components that are placed on a total surface greater than the 40% of the entire façade, must have the same reaction to fire requirements indicated for insulating combustible materials. For glass items is not required any reaction to fire performance.

Eventually, if metallic elements (brackets, bolts, screws, etc.) or building service plants, subject to reach temperatures above 150 ° C, pass through insulating combustible materials that do not meet the aforementioned reaction to fire requirements, it will be necessary to separate these items from direct contact to insulation combustible materials.

4. FIRE RESISTANT DESIGN AND TESTING OF FAÇADES

According to European and Italian standards, in order to determine the Resistance to fire performance of a construction element it is possible to do fire test and to asses the extended applications of results, or carry out a design method or a calculation using the Eurocodes (recalled by the Italian decree 16.02.2007).

The Guideline requires that if a test method is chosen in order to asses the fire resistance of a façade, the following codes must be used:

- EN 1364-1 Fire resistance tests for non-loadbearing elements Walls, if it is a masonry type façade slab supported;
- EN 1364-4 Fire resistance tests for non-loadbearing elements, Curtain walling. Part configuration;
- EN 1364-3 Fire resistance tests for non-loadbearing elements, Curtain walling. Full configuration (complete assembly);
- EN 1366-4 Fire resistance tests for service installations, Linear joint seals, when a façade presents linear filling configurations.

The Guidelines states also that only for façade that are made by concrete heavy elements, like stones or brick walls (these materials are little deformable at high temperature), it is possible to calculate the

fire resistance rating using the method listed in the Decree of the Ministry of Interior 16/02/2007 [11]. It is also highlighted that a EI60 wall satisfies also the EI60 - ef requisite.

At this time, for façade made of lightweight type materials there are not available any Fire resistant calculations or simplified tables methods.

5. SAFETY OF ESCAPE OCCUPANTS AND RESCUE TEAMS

The Italian Guideline for façade fire safety points out both the safety in case of escape for occupants and the safety for rescue teams. These two safety goals are compromised by the falling risk of facade fragile or burning parts. The falling of fragile and burning façade parts, requires that the structural elements, both of facades and building, always made of steel or aluminium that have very low resistance to fire performances, must be designed and put in place taking into account the action in case of fire. For that reason, the Guideline requires for facades made of fragile materials that in case of fire could break and falling down in non-minute pieces, that the design of the escape strategy for the occupant have to be designed in order to protect the safety exit routes by falling pieces. It is also requested that Firefighter Brigades could easily reach the building and approach the façade in case of fire. The latter Guideline prescription requires that a proper free area must be reserved for Firefighters Engine and Ladder traks nearby the building. In addition, the reserved Fire Brigade area must be also protected by falling façade parts risk. At last, the Guideline forbids the use of cavities or cavity in double-skin facades as an occupants escape route.

6. CONCLUSION

The fire safety of the facades is a new theme in Italy. The Technical Guidance, which today addresses in detail the topic, is well integrated in the national standards and fire codes affecting national Fire Prevention.

The choice of suitable materials for their “reaction to fire”, the requirements of “fire resistance and fire compartment strategy” of the elements of the facade, along with measures related to “exodus of the occupants and the safety of rescue teams” make up the “hinge design” of this technical document. This legislative instrument is, however, necessarily intended to be an evolving nature code that could be updated in relation to the development of knowledge in this area, an area that is of interest now in all the world.

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