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A EUROPEAN FRAMEWORK TO ENSURE FIRE SAFETY IN TALLER BUILDINGS

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ABSTRACT

The Modern Building Alliance presents a framework which proposes a comprehensive and structured list of elements for consideration by Member States in their regulatory approach to ensure fire safety in high and mid-rise buildings. This framework fits with the EU subsidiarity principle and aids in structuring the exchange of information and best practices between Member States within the European Fire Information Exchange Platform (FIEP) established by the EU Commission in October 2017. A holistic approach enables consideration of, not only the building design and construction but also technical installations and fire safety management throughout the lifetime of the building, including clarification of the roles and responsibilities in the value chain. For façade system components, the use of large scale testing of the system is recommended as a starting point, complemented by clear information about the systems and applications in which products may be used. This paper also identifies the role of product manufacturers and of EU standards. The ultimate goal of such a framework is to provide a clear basis to Member state regulators and the construction sector, allowing identification of gaps and best practices for fire safety.

1 INTRODUCTION

The Modern Building Alliance gathers different trade associations and companies representing the plastics industry in the construction sector with the mission to support the EU in ensuring safe and sustainable construction. Plastics (thermoplastics and thermosets) are widely used in construction applications because of their properties contributing to energy efficient and sustainable buildings, from window frames and durable pipes to state-of-the-art insulation solutions. Ensuring fire safety is a prerequisite to deliver the maximum benefits of polymer products with regard to performance and sustainability. It's a driving force behind product design and manufacturing and a joint responsibility of the whole value chain involved in building and construction. Fire safe buildings need construction materials and products to be approved, installed and maintained responsibly and in accordance with all regulations. Indeed, many major fire incidents have in common a lack of compliance with regulations or standards [1]. It also became apparent that in some countries regulations might not be clear, and roles and responsibilities are not explicitly described [2] leaving room for interpretation and errors. Another factor is that it may not be clear how to assess the performance of a system, since different components are produced by various manufacturers, while the system assembly can be made by a third party. This system then may not comply with the appropriate regulation or there is a lack of evaluation of the system performance. Added to that is the fact that many EU countries have adopted a different large scale façade testing method with a variety of national criteria that are more or less adapted to specific building contexts. For example in the UK BS8414 [3] is a large scale test with a corner but no window opening, whereas the French test LEPIR2 [4] is also large scale but without a corner and with a window opening, and the German test DIN 4102-20 is a large scale test, but with a lower fire load than the former two tests. Combining all these aspects will potentially result in a situation where unsuitable products are used in a building either by predesign, or due to replacement of components in the field without substantiated evidence and a clear view on the impact on the performance of the system as a whole. In many cases these choices are made to reduce time or cost. As part of a successful fire safety strategy, the installation of active and passive fire protection measures is also crucial to detect a fire in an early stage, prevent fire spread and to ensure compartmentation and safe evacuation routes for occupants. In addition to construction and installation aspects, problems with the organisation and maintenance of the building, for instance blocked evacuation doors, sprinkler valves shut off, or covered smoke detectors or dysfunctional alarms are frequently seen. A lack of redundancy in the fire safety design can jeopardise the overall fire safety strategy if one aspect is failing. In the proposed framework, the three identified key aspects Building, Installation and Organisation (BIO) are investigated in order to provide a clear foundation to Member State (MS) regulators and the construction sector, allowing identification of gaps and best practices for fire safety. The regulatory framework for buildings, installations and organisation is defined at national (or regional) level and MS must also ensure proper enforcement and compliance. The EU is providing the set of necessary standards to assess and report the performance of products and systems, allowing MS to define application-specific performance requirements. Finally, the roles and responsibilities in the value chain are discussed.

2 A HOLISTIC APPROACH TO ENSURE FIRE SAFETY IN BUILDINGS

2.1 Buildings

The definition of building categories in national regulations is influenced by many local factors. Some countries have developed different regulatory requirements for example for small, mid height and high rise buildings, other countries have specific requirements only for normal and for high rise buildings. For instance, the height limit for high rise buildings is 22 m in Germany, 18m in the UK and 28m in France. In addition, regulatory requirements in many countries depend on the type of use of buildings (i.e. residential buildings, offices, schools, and hospitals), which can be justified. Height limits do not need to be harmonised but should be defined locally in relationship with the adequate evacuation and intervention strategy, notably the available fire-fighting equipment. A European harmonisation of typologies definitions would be highly complex and bring little benefits but we recommend to each Member State (MS) to define its regulatory safety requirements based on the height and size of a building as well as on its type of use, as is done in some MS.

Regulatory requirements can be different for all these types of buildings, with performances defined by the fire safety strategy for evacuation, compartmentation, and fire-fighting. In addition to requirements regarding reaction and resistance to fire of the installed products, there should therefore be precision regarding the protective measures implemented, such as ease of evacuation (single stairs, protected or not…) and access for fire fighters. It is necessary that there is sufficient time to evacuate everyone from the building or to safe areas within the building. These safe areas are intended to assure the safety of occupants while the fire is active and while firefighting operations are ongoing. The most common safe areas are the stairwells and other escape routes, which need to remain isolated from fire and smoke. While such considerations are easier to integrate in new constructions, it must also be addressed for existing buildings, particularly when considering a renovation. Older buildings may not have appropriate escape routes and fire-fighting access. If these cannot be improved during a renovation it may be worthwhile considering installing fire doors, sprinklers or even demolition to build a new construction instead of conducting an extensive renovation.

Redundancies are necessary for all safety systems. Typical approaches are ventilated lobbies that create a buffer zone between areas with combustible products and the stairs, or creating a pressure differential between the lobbies and the stairs, preventing smoke from entering the stairs. Another common form of redundancy is to prevent fire or smoke from escaping the sector of the building where the fire originated. This is achieved by means of fire and smoke compartmentation preventing or delaying the progression of a fire. It is important to note that robustness and redundancies are more crucial for high rise buildings than for less tall structures because of the ease of evacuation of the latter. Additionally, for high rise buildings the evolution of a fire as it scales up becomes extremely complex [5] and the performance of both fire safety measures and the fire brigade is stretched.

For tall buildings it is critically important to avoid fast fire spread along the façade cladding or insulation system, which potentially would bypass internal compartmentation. The performance of a façade cladding system cannot be assessed based only on reaction to fire classifications of the products applied because the performance of the façade system depends on a number of factors:

- The combination of different products in a façade cladding system leads to a different fire performance than for the single products.
- Even if only non-combustible products are applied, the geometry (i.e. ventilation gaps, windows detailing) can play an important role in fire spread [6].
- Fire barriers have been developed for different types of façade systems (ventilated façade systems, ETICS, cavity walls). Small scale tests alone are not sufficient to prove the effectiveness of these barriers.

Therefore it is essential to use large scale tests as the basis for requirements for all façade systems for tall buildings– regardless of combustibility of individual components –considering all elements of a façade system. Together with the results of the test it is of utmost importance, that the tested system is described exactly and unambiguously regarding the properties of the tested materials, products and assembly. Harmonised product standards or harmonized technical specifications are needed to define what has to be reported. If for a façade cladding/insulation system, the fire performance has been verified with such a large scale test, it is necessary to make sure, that installed façade systems still meet the defined performance criteria, but on the other hand it is not feasible to perform large scale tests for every small variation of a façade system, like change of thickness of the insulation or other components. Hence, clear rules are needed for the extended application of the large scale test results of systems to assure maintenance of the fire performance with defined changes. For instance, using intermediate scale testing such as ISO 13785 to test most significant variations can be part of this process[7]. The fire safety community should be developing such guidelines. As fire regulations are in most cases developed to be robust and fit for all solutions, the safety margins of the latter are implicit and cannot easily be quantified, and this sometimes can bring an unnecessary burden for the construction sector. This is often the case for high rise buildings. Member States (MS) should therefore also consider being open to fire safety engineering solutions which can more easily quantify the safety level of their solutions and their safety margins.

2.2 Installations (in MS regulatory framework)

The fire safety concept and strategy for a building can only work, if the installations relevant for fire safety are in place, undamaged and working well. The most important technical installations are:

- Smoke and CO detectors and alarm systems are an absolute must. For larger buildings it is essential to have a sufficient number of smoke detectors in every compartment and connected alarms which make sure that occupants who are still far away from the fire as well as fire brigades are alerted immediately.
- Fire suppression installations, including sprinklers can be very effective in many situations, such as high rise buildings or large assembly buildings, as they assure that starting fires grow slowly or remain small and the consequences of fires are limited.
- Smoke dampers and smoke ventilation systems can be required to keep escape routes free of smoke.
- For the fire brigades it is important, especially important in high rise buildings that all necessary installations are in place to support the fire-fighting strategy as: adequate water supply, building plans with information on gas and electricity supply.

The fire safety concept of a building needs to verify, that the safety level can be met with these installations and that they have been tested, installed and inspected correctly.

2.3 Organisation (in MS regulatory framework) for the building maintenance and renovation process

All the requirements mentioned hereafter are not specifically defined in a legal framework; however they should be taken into account when a building is planned.

- To guarantee the safety of people in a high rise building in case of a fire, it is necessary to implement an adapted fire safety strategy. This is a concept by which various measures are taken to guarantee a societally accepted adequate level of safety for people. However, these objectives are not easily quantifiable and further analysis is needed.
- For new construction and renovation, it is necessary to provide verification that the systems and products installed correspond to the systems designed (quality control, trained/accredited installers, definition of responsibilities…). This is valid for all building components, products and installations. It starts from the market surveillance of construction products that must be organized in MSs and extends to fire inspection of installations. Non-compliant electrical components or incorrectly installed fire doors are examples of possible concerns. Fire inspections can be categorized into three types, (1) inspections of newly constructed buildings, (2) inspections of existing buildings undergoing renovations, and (3) inspections of existing buildings for routine safety checks [8]. Lack of inspection or negligent inspection practices can result in casualties and fire loss. In 2006, an assessment of the U.S. fire service found that 25.2% of responding fire departments reported that no one conducts fire-code inspections within their communities. As a result, it was estimated that 20.3 million people, or 7% of the US population, live in communities where no one conducts fire-code inspections [8].
- It is important to clearly define fire safety responsibilities, emergency procedures and emergency training for buildings where appropriate (e.g. hospitals, schools, public buildings).
- The organization of the fire brigades and adequate fire-fighting equipment should also be seen as part of the whole fire safety framework. It is not necessarily the same equipment that is needed for tackling fires in high rise buildings and in rural areas.
- For existing buildings regular control is needed, to make sure that all parts and installations of a building are still in place, undamaged and functioning correctly. Escape routes need to be free from obstructions and in no case to be blocked. All installations require regular maintenance and control, and occupants should be aware of the fire safety measures as well as evacuation plans.
- In high rise buildings, evacuation is often only made from the level where the fire takes place and from adjacent levels, while occupants on other levels can remain in place. This strategy is named "stay put". In case of a façade fire, where the fire has spread vertically and spread over more than two floors, this strategy is jeopardised, especially if stairs are unprotected. That is often the case of old buildings that do not have to comply with current regulations. Hence, reflection should be made on whether occupants should be told or not to evacuate the building in case of a façade fire. As mentioned earlier, the performance of the façade in case of a fire is only one of many factors impacting the safety of occupants. It is important that the fire does not enter the building; that fire detection is adequate; and that safe escape ways are provided. All the elements together contribute to the level of safety. This has been

demonstrated in a number of fire incidents (some are listed in [7]) where all occupants were able to evacuate safely regardless of the façade fire spread.

- For façade systems it is especially important to ensure that the complete build-up corresponds to the system tested and approved.
- Finally, it is also important to consider the social factors in the analysis of fire statistics and to get more detailed knowledge about the relevant type of risk factors, who dies in fires and why. In Norway, it was shown for a sampled population that 39 % of all fatal fires are caused by open fires, and 34 % of these are caused by smoking. Additionally, other risk factors were systematically identified such as substance abuse, mental illness, and alcoholic influence [9]. Estonia recently shared information during the Fire Information Exchange Platform (FIEP) on their recent successful initiatives on fire safety, demonstrating the large potential for improvements thanks to well-targeted prevention measures focusing on the benefits of smoke detectors, the risk of smoking and open fires, and the danger of obstructing escape routes by providing relevant public awareness, home visits and media campaigns, child education. This targeted campaign resulted in a reduction of 50% of domestic fires in ten years.

To achieve all the objectives aforementioned, this is necessary to:

- organize control of existing buildings (maintenance and modifications);
- have accredited professionals performing the roles related to fire safety of the building (e.g. fire fighter, fire safety manager, maintenance); and
- mandate fire brigades to work on prevention (safety checks, awareness campaigns, evacuation plans).

Thanks to an improved knowledge, better engineering, and appropriate regulations, fire deaths are at their lowest level in many parts of the world. In the last decades, we have seen a reduction in the number of fires across Europe that is a result of the setup and the improvement of fire safety regulations. However, tragic fires still occur. By analysing the conditions that led to these regrettable incidents, it has become clear that there were systematically breaches of one or several existing regulations. In many cases, compliance with fire safety regulations would have avoided the ignition, propagation and the extensive loss of life. That is why fire inspections are important in buildings throughout the lifecycle of a building.

3 ROLES AND RESPONSIBILITIES IN THE VALUE CHAIN

3.1 The role of Europe and Member States

Fire safety is generally regulated nationally by Member State (MS) regulators. Buildings across MSs differ based on construction traditions in different regions and societies which influence fire strategies. A simple example is the difference between the buildings in Mediterranean and Scandinavian regions. Not only are weather conditions different, but so too are the choice of construction products and local preferences. Fire safety regulations are also historically influenced by the firefighters' means of intervention and the means of egress of a building's residents. Because of the subsidiarity principle, the EU must only act where there is clearer added value, particularly for the single market. For these reasons, the European Union is not able to impose a single set of fire regulations. Hence, the European Union needs to maintain room for local needs and local regulations, while construction products that are able to travel across borders, are therefore regulated at EU level. MSs should therefore remain free to design their fire safety regulations by taking into account the local specificities in terms of building design solutions, materials, use patterns and climate. The EU should therefore continue to respect the subsidiarity principle in order to have effective fire safety strategies. Conversely, harmonised practices in MSs facilitate the circulation of construction products in the European market. This is typically done through adequate European harmonised standards that are referenced in MSs' regulatory framework. These standards ensure that products from all European countries are tested and classified identically. The description of the products, as well as the classes and levels for different properties, are defined in these standards in a way, which allow MSs to define their appropriate safety levels on that basis. The rules for CE marking and AVCP (Attestation and Verification of Constancy of Performance) are defined strictly at the European level and controlled by appropriate national market surveillance by MSs. On this basis, MSs are able to define regulatory requirements so that the intended safety level is met. In addition, it is important that MSs ensure that the systems and products installed correspond to the systems designed. To achieve this, not only quality control of the applied products is necessary – it is key that they are installed correctly. Therefore during construction works responsibilities have to be defined clearly and for critical installations only trained craftsmen should perform the task.

Reaction and resistance to fire tests that have been developed for CE marking are usually small and medium-scale. The European classification criteria have been linked to the performance of a large variety of construction products. All tests, regardless of their size, have to consider the fire scenario in which the construction product is burning. A benefit of small-scale tests is that the cost of these tests is limited. They facilitate development of new products and allow even SMEs to test and market their products while respecting fire safety standards. A façade fire scenario has been left aside in this harmonisation process in the past due to the complexity of the problem. There is a broad agreement that only a larger scale test, simulating exposure of a realistic façade construction to a realistic fire source, is needed to assess the fire performance of such a façade construction. The European Commission is currently preparing a decision on how and where a harmonised test method will be developed under the Construction Products Regulation. The EC facade study [10] proposes to incorporate DIN 4102-20 and BS8414 [3] or a new one based on both former tests. The plastics industry supports the harmonisation of large-scale fire tests for (insulated) façade constructions and calls for standardisation bodies to be mandated to finalise and validate the method developed by the European Organisation for Technical Assessment, which incorporates the most common used test methods in MSs. This would also benefit the development of a harmonised test method for kits involving thermal insulation of buildings such as External Thermal Insulation Composite Systems (ETICS) which are not yet available and so national provisions still apply [11]. Ideally, a large scale test is necessary to assess fire safety of the complete construction. While this test and classification system is being prepared, urgent clarification is needed on how and for which types of products it will be applied.

In many cases the single components for façade systems are tested and classified regarding their fire performance separately or sometimes as a kit e.g. in ETICS. In case a façade comprises of single products sold separately but the complete façade system is assembled by the company doing the construction or renovation of the building, it might not have been tested appropriately as the responsibility is not well defined. Already today an ETICS system can be approved and CE marked as a system, based on an EOTA Guideline. But there are no product standards for other façade cladding systems.

In 2017, the European Commission announced a new initiative to enhance fire safety cooperation across EU MSs. Under the leadership of the Commission's DG GROW, the Fire Information Exchange Platform (FIEP) gathers MS authorities and stakeholders from civil society and industry. The FIEP aims to facilitate the exchange of information between the competent MS authorities and other stakeholders, allowing them to benefit from lessons learned and best practice regarding fire safety. It is expected to enhance the capabilities of MS authorities to fulfil their tasks in full knowledge of the advantages and disadvantages of the regulatory choices they have to make. The following areas have been identified by FIEP members for further cooperation:

1. Common terminology and fire statistics
2. The application of fire prevention principles
3. The regulatory approach for new products, including high-rise buildings
4. Exchange of experience from fire accidents
5. Fire engineering approach in building regulations

The FIEP might assist in several of the above points. Sharing best practice between MSs and key stakeholders can create a better understanding of how countries already using large scale façade testing consider variations between the tested constructions and the final details of the construction. A lack of accessible, comparable statistical data is one of the critical issues which have hampered efforts to protect European citizens. While many MSs have introduced initiatives to improve fire safety nationally, the results of these are often not shared effectively and the influence of changes to the system is often unknown. This means successful projects cannot easily be replicated in other countries and it makes it difficult to learn from initiatives that are not as successful as desired. With regard to the work stream on fire statistics, the European Commission announced that it will benefit from the pilot project on fire safety statistics voted by the European Parliament in September 2018. This will help to complement other pioneering work already done in gathering EU-wide data [12,13].

3.2 The role of the product manufacturers

Product manufacturers have direct roles, contributing to fire safety of buildings:

- Contribute to the development of robust product standards
- Have their products classified and labelled according to these standards and to have adequate quality control
- Present unambiguous and clear information about their product performance and general use guidelines
- For façade system components, conduct large scale system testing and provide clear information about the systems and possible applications of the products.
- Contribute to training of designers and installers
- Manufacturers cannot be held liable for a product that has been misused or installed in its actual application in a way that is not compliant with regulation. Hence the role and responsibility of the value chain should be clarified.

Product manufacturers are also contributing via industry association activities:

- To show leadership on fire safety and contribute to their National building fire regulation developments and reviews
- To participate in the FIEP workstream, set up by the European Commission
- To propose solutions to improve fire safety in the EU

3.3 The role of other stakeholders

During planning and construction of new buildings and renovation measures, various stakeholders can and should contribute to fire safety. The contributions of architects and fire safety engineers are needed to develop a holistic fire safety plan for the complete building. Firefighters should be included in the approval process for the planned construction. They should also take a role in inspection of buildings in use, to make sure that fire prevention and detection measures are working and evacuation routes have not been obstructed. There is currently no common agreement on what is the competency required from these professionals or on competency verification approaches that should be used [2], to guarantee that those involved in the design, construction, regulatory approval, hand-over and maintenance of the building components and installations can deliver societally acceptable levels of safety [14]. The complexity of building systems and the quality of regulatory approval should be recognised.

4 CONCLUSIONS

- In this paper we have listed a number of important aspects separated into three categories: Building, Installation, Organisation, which should be considered when developing and reviewing the building regulations of a country. While fire safety regulations remain a Member States' competence, structuring the key aspects in such a framework can facilitate the exchange of information between Member States.
- Even if sometimes regulations have been robust over the last decades, they need to be reviewed systematically to make sure that they are still relevant and proportionate regarding current practices and the impact on the construction sector. More importantly, regulators should consider feasible solutions applied to old buildings. Often these building do not fall under new or amended fire safety regulations but are more prone to fire events simply due to lack of maintenance.
- The roles and responsibilities of National regulators, the European institutions and product manufacturers have been presented. However, the connections between other stakeholders of the value chain needs further clarification in each country to ensure that objectives are reached and that gaps are identified.
- The Fire Information Exchange Platform (FIEP) was set up by the European Commission and gathers Member State authorities together in order to facilitate the exchange of information between the these authorities and other stakeholders. The EC intends the platform to be used to promote best practices across Europe.
- MBA calls upon Member States to ensure the strict enforcement of existing regulations and standards.
- As fire regulations are most of the time developed to be robust and fit for all solutions, the safety margins of the latter are implicit and cannot easily be quantified, which sometimes can bring unnecessary burden for the construction sector. Member States should also consider being open to fire safety engineering solutions which can more easily quantify the safety level of their solution and their safety margins.

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