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SIGURNOST FASADA NA ZGRADAMA KAO SASTAVNI DIO PROJEKTA ODRŽIVE ZGRADE

Sažetak: Fasade predstavljaju jedan od najbržih puteva za širenje požara u zgradama, prvenstveno zbog neograničene opskrbe kisikom i vertikalnog položaja, ali i zbog današnjih projektnih zahtjeva koji se odnose na energetsku učinkovitost i estetski dojam. To dokazuju mnogi požari diljem svijeta s različitim posljedicama, posebno u visokim zgradama. Posljednji veliki požar u Grenfell Toweru, je imao za posljedicu najmanje 80 smrtnih slučajeva. U ovom radu je dan sažet prikaz problema koji se odnosi na širenje požara na fasadama i načinima dokaza ponašanje pojedinog fasadnog sustava u požaru. Poseban naglasak je stavljen je na raznolikost metoda ispitivanja, koje se trenutno koriste u Europskim zemljama.

Ključne riječi: požar, ponašanje fasade, visoke zgrade, metode ispitivanja

FIRE SAFETY OF BUILDING FAÇADES AN INTEGRAL PART OF SUSTAINABLE BUILDING DESIGN

Abstract: Façades are one of the fastest pathways for the fire spread in buildings, primarily because of unlimited supply of oxygen and verticality, but also because of the current requirements of the design related to energy efficiency and aesthetic appeal. This is proved by many fire incidents occurred around the world, especially in tall buildings. The Grenfell Tower fire, happened in 2017., being the latest major incident, resulted in at least 80 fatalities. This paper gives the overview of the problem related to fire spread across facades and means of its assessment. Special focus is given to diversity of testing methods, currently used in Europe.

Key words: fire, façade behaviour, tall buildings, test methods

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1. INTRODUCTION

Among different types of disasters, fire constitutes a significant threat to life and property particularly in urban areas. As the authors of this paper mentioned in their previous papers [1-4], examples of fires in different building types all over the world and especially in recent years are proof of an urgent need to start considering fire safety as an integral part of sustainable building design. Social community has responded to the threat of fire in buildings in many ways, including fire department intervention, insurance, building regulations, education on fire hazards, controls on the use of materials and products in buildings, and the design of buildings to resist the effects of fire.

Façades must fulfil the basic aspects like protection against fire, climatic influence and environmental pollution but also more and more stricter requirements related to reducing energy consumption in buildings. That is why new systems and materials for façades are developed. In this sustainable façade systems, the thickness of the insulation layer has been at least doubled, compared to former requirements, with a tendency of further increase. In that case, if combustible insulation materials (almost all organic materials shown in Fig. 1) are used, the risk of fire spread through façades have been increased.

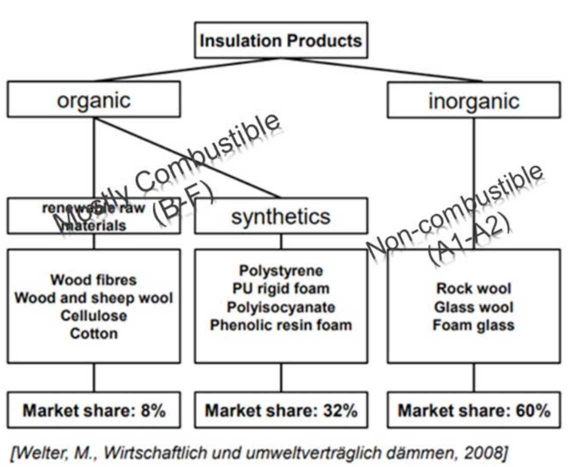

Figure 1 – Groups of thermal insulation materials [xxx]

Although the fires that have started and spread in buildings through combustible materials on façades are considered as relatively rare event, they can have considerable consequences both in terms of property damage and casualties (as presented in Table 1) [5].

In accordance to available literature, façade fires accounted for:

- 3 % of all structure fires
- 3% of civilian deaths and injures
- 8% of property damage
- 98 of façade fires occurring in building less than six stories high
- 42% of fires started on the façade surface
- 32% when the item first ignited was the façade covering

Review of fire incidents related to façade spread showed that they occurred in countries with poor regulatory controls or where construction was not in accordance to regulation [6].

Table 1 – A summary of recent major façade fire incidents [5]

Building	Location	Year	Description	Damage
Grenfell Tower (24 stories)	London, UK	2017	Fire started at 4th floor and spread rapidly through the external cladding which consisted of ACM panels with PE core	79 dead 70 injured
The Address Downtown Dubai (302m tall)	Dubai, UAE	2016	Fire started the parking level while the construction works were ongoing	16 minor injuries
Marina torch (352 m)	Dubai, UAE	2015 & 2017	Fire started in the 52nd floor and spread quickly due to high winds	No injuries
Tamweel Tower (160 m tall)	Dubai, UAE	2012	A fire ignited which burned two separate broad vertical bands of exterior cladding from ground to roof level. ACM panels with PE core	Repair works have begun after 3 years
Saif Belhasa Building (13 stories)	Dubai, UAE	2012	Fire started at the 4th floor and spread rapidly to the roof level. Cladding consisted of ACM panels with PE core	9 flats destroyed 2 injured Debris damadged 5 vehicles
16 Storey apartment building	Baku, Azerbaijan	2015	Rapid fire spread along the cladding which were fitted after a renovation. 'Polyurethane panels' according to reports.	17 dead 60 injured
Lacrosse Building	Melbourne, Australia	2014	Fire started on the 6th floor and Fast-running flames soon ignited external wall cladding and aided by combustible material located within the wall structure quickly spread to the top of the building	No injuries
18 storey building	Roubaix, France	2012	Dramatic upwards spread of the fire from its origin to the top of the 18-floor building, apparently fuelled by its highly flammable outer cladding	1 dead 1 injured
28 storey building	Shanghai, China	2010	Building was undergoing renovations which involved installing energy saving insulation. Fire was believed to have spread on polyurethane insulation to external walls	53 dead 90 injured
Monte Carlo Hotel (32 stories)	Las Vegas, US	2008	Fire was burning along the combustible components of the building's arhitectural trim and the exterior insulation and finish system which consists of a layer of expanded polystyrene foam adhered to gypsum sheathing	13 minor injuries
Marco Polo Apartments (36 stories)	Honolulu, US	2017	Fire started on the 26th floor and blaze rapidly spread higher. The building did not have a sprinkler system	3 dead 12 injured

2. MECHANISMS OF FIRE SPREAD

There are three typical scenarios of fire spread over façades (as shown Fig. 1):

1. Spread of the external fire onto combustible façade by radiation from the neighbouring, separate building,
2. Spread of the external fire onto combustible façade from the source of fire located next to the façade, with the consequence of radiation or direct exposure to fire (litter on the balcony, improperly discarded cigarettes, parked cars etc.),

3. An internal fire that has started in a space inside a building spreads through openings in the façade (windows, doors etc.) onto higher or lower floors.

If there is no fast intervention (either by firefighters or by a sprinkler system) a fire in an indoor space can develop to flashover phase, when the flame is most likely to come out through the openings on the façade (windows or doors). By the time glass on the openings cracks and a fire breaks outside, flames can reach up to 5 metres above the edge of the opening regardless of the façade system and the type of material used (Figs. 2 and 3), which is both influenced by a façade system and by airflow speed.

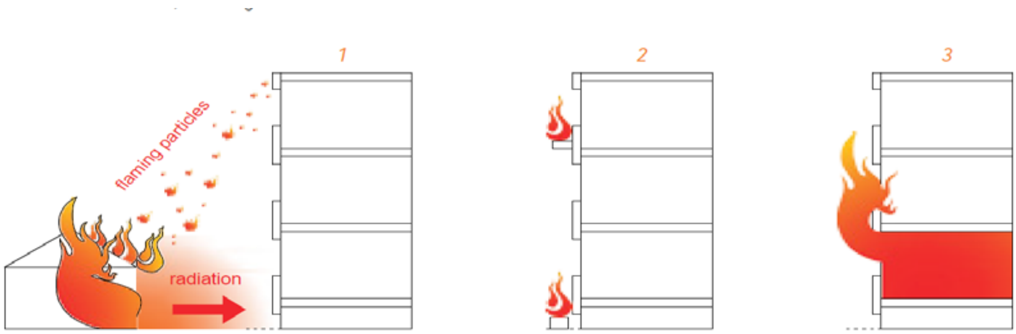

Figure 2 – Three typical scenarios of fire spread across façades [7]

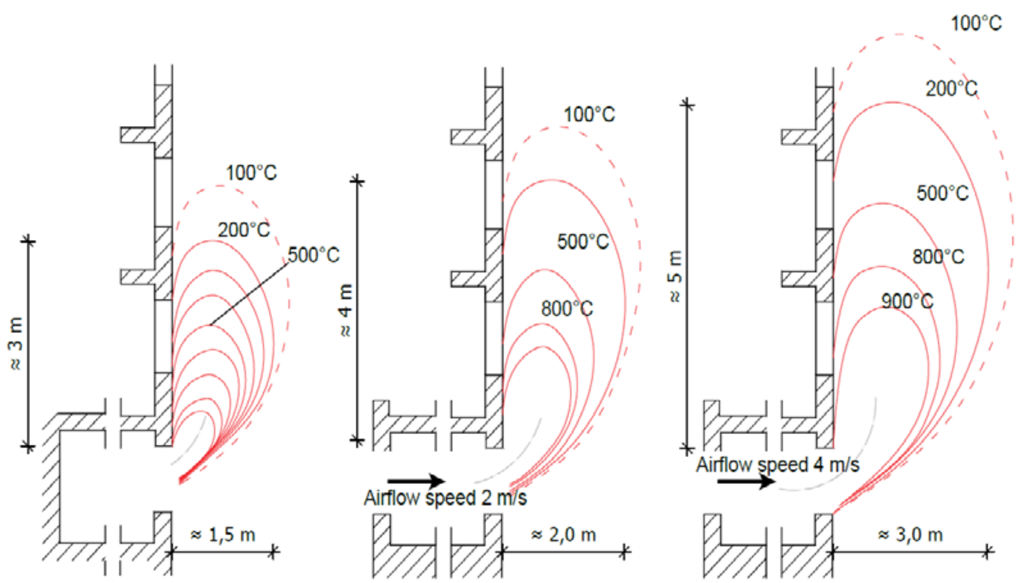

Figure 3 – Flame heights with marked temperatures across façade depending on airflow [7]

The existence of cavities in a façade (which are part of façade systems, e.g. ventilated ones, or the ones formed by parts of the façade delaminating during fire). If fire enters a cavity, due to the chimney (stack) effect, it can be extended five to ten times from its initial length, regardless of the properties of the material facing the ventilated layer. If fire barriers are not used, the described effect will cause fast vertical fire spread, which can be "hidden" below the cladding on the façade, as it was the case in Grenfell Tower disaster.

The research in this area has shown that the danger of fire spread along the façade is higher if fire is spread from the interior space compared to fire occurred outdoor. That is why a large-scale testing of façades, which are used in some European countries as it will be shown later, is based on exposing façade to simulated fire occurred in an enclosed space after the flashover phase.

3. ASSESSMENT OF THE FIRE PERFORMANCE OF FAÇADES

To implement specific actions towards façade fire prevention, the following objectives should be met: protection against fire spreading along the façade, maintaining fire compartmentation, protection against falling objects; protection against fire spread between windows, reaction to fire and fire resistance requirements for the external wall etc.

The objectives can be satisfied using **prescriptive fire protection legislation requirements, standard fire façade tests or performance-based design methodologies**.

Prescriptive requirements are based on satisfying the following key issues: reaction to fire requirements for façade assemblies and materials, fire barrier requirements, horizontal separation distance of buildings, vertical separation distances of openings between successive storeys, requirements for sprinkler protection etc.

Concerning standard fire façade tests, due to date, there is no harmonised European methodology for testing and evaluating the fire performance of façade systems. In some European countries, building fire safety design regulation suggest specific requirements regarding the fire resistance (defined in accordance EN 13501-2) and reaction to fire (defined in accordance EN 13501-1) rating for façade systems and materials, even though the European classification system on reaction to fire behaviour has been developed specifically for materials used for wall and ceiling interior finish. It has to be highlighted that the SBI test, which Euro classes are based on, requires heat output of 30kW.

On the other hand, some European countries, as countries worldwide as well, early recognised the limitations of the reaction to fire testing and developed their national testing methods based on large or medium scale as shown in Table 2. 12 different test methods have been identified to presently be used across Europe. The main parameters that these tests addressed were: flame spread – vertical and horizontal, surface and within the system, fire spread from one room to another (above), joints, windows, detailing around window openings, smouldering, falling parts and burning debris/droplets, smoke, heat, fire from inside, fire from outside, damage to the system (assessed after the test).

More than 20 years ago when CEN got a mandate from European Commission to develop a harmonised European method but failed at that time. In 2016, European Commission made an invitation to tender (tender ref 531/PP/GRO/IMA/16/1133/9108) on this topic with the aim to develop a European approach to: assess the fire performance of façades where all aforementioned parameters will be included, define all relevant details and classify façades. For that purpose, the BS 8414 series and DIN 4102-20 should be used as a basis. Project group with members from RISE (Sweden), BRE (UK), BAM (Germany), EMI (Hungary) and Efectis (France) with large group of subcontractors were included in the project. In June 2018, the consortium made the final document [8] where two approaches were proposed. The first one, called *"proposed method"* where BS 8414 series and DIN 4102-20 should be used with some additional requirements (for example, falling parts), or new method *"alternative method"* which include new developed large and medium scale methods. All details of these two approaches can be found in the aforementioned document. The next step, towards development a new harmonised testing method, is put to European countries to make consensus which method or which approach should be used. After that, round robin test (RRT) should take place, which leads to the conclusion that certain time (at least two or three years) is needed for harmonised method to be prepared and ready for use.

Table 2 – Overview of fire façade testing methods [8]

No.	Test methods	Countries using the test method	Scale
1.	PN-B-02867:2013	Poland	Medium scale
2.	BS 8414-1:2015 and BS 8414-2:2015	UK, Republic of Ireland	Large scale
3.	DIN 4102-20	Switzerland, Germany	Medium scale
4.	ÖNorm B 3800-5	Switzerland, Austria	Medium scale
5.	Prüfbestimmung für Aussenwandbekleidungs systeme	Switzerland/ Lichtenstein	Large scale
6.	Technical regulation A 2.2.1.5	Germany	Large scale
7.	Lepir 2	France	Large scale
8.	MSZ 14800-6:2009	Hungary	Large scale
9.	SP Fire 105	Sweden, Norway, Denmark	Large scale
10.	Engineering guidance 16 (unofficial test method)	Finland	Large scale
11.	ISO 13785-2: 2002	Slovakia	Large scale
12.	ISO 13785-1: 2002	Czech Republic	Medium scale

Performance-based design approaches, based on the use of numerical simulation tools, are gradually starting to be implemented worldwide. It is to be highlighted that recent advances in computational power and development of accurate numerical models have resulted in significant improvements in prediction accuracy which will certainly promote the usage of these tools.

Republic of Croatia belongs to this group of countries where the requirements for façades are based on the Euro classes. Due research, where the authors of this paper were involved, in [1,3], showing that SBI testing cannot represent behaviour of façades in real fire situation (especially issues related to flaming droplets and smoke emission), the regulations prescribe for certain buildings (with high > 11m, < 22 m) also construction of fire barriers at certain positions of building, especially at the border of the fire compartments, which can slow down fire spread until firefighter intervention. Details of these requirements can be found in [7].

4. CONCLUSION

In this paper, overview of problem concerning the fire safety of building façades is given. Many fires recently happened and spread through façades, have shown that these fires are low-events, but the resulting consequences in terms of property loss and occupant safety can be devastating. The Grenfell Tower disaster is certainly the incident with the greatest loss of life attributed to façade fires, but also wake-up call to most of the world to deal with this problem. This and other fires, with the same mechanism of spreading, showed the importance of an urgent need to start considering fire safety as an integral part of sustainable building design.

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