Contribution of fire barriers in preventing fire spread across façades – experimental testing performed by University of Zagreb

Marija Jelčić Rukavina[1], Ivana Banjad Pečur[2], Bojan Milovanović[3], Marina Bagarić[4]

[1] Assistant Professor, Faculty of Civil Engineering, University of Zagreb, Croatia, jmarija@grad.hr

[2] Professor, Faculty of Civil Engineering, University of Zagreb, Croatia, banjadi@grad.hr

[3] Assistant Professor, Faculty of Civil Engineering, University of Zagreb, Croatia, bmilovanovic@grad.hr

[4] PhD student, Faculty of Civil Engineering, University of Zagreb, Croatia, mbagaric@grad.hr

Keywords: fire safety of façades, fire barriers, large-scale testing, ETICS systems

Scope and objectives – To satisfy the requirements set for reducing energy consumption in buildings, the thickness of the insulation layers in façade systems has increased at least twofold, with a tendency of further increase. The insulation layers can be made of either inorganic non-combustible materials or organic combustible ones. In case of fire, application of combustible insulation materials in façade systems increases the risk of fire spread vertically across façade and to adjacent buildings. Due to special fire safety problems related to high-rise buildings (i.e. risk associated with vertical spread across façades, prolonged evacuation, rescue not possible from outside, etc.), in most European countries, only non-combustible materials for façade application are used. For the lower buildings, e.g. with height from 11 to 22 m, the use of combustible materials in façade systems is allowed in Republic of Croatia, but if interrupted with fire barriers [1]. A fire barrier represents a non-combustible material used to break up continuous combustible construction to delay fire spread from its one side to the other. Hereafter, results of large scale fire testing performed on EPS (expanded polystyrene) based ETICS (*External Thermal Insulation Contact Systems*) specimens with and without fire barriers are shown. In the absence of a harmonized EU standard for large scale façade fire testing, fire performance of ETICS system in presented tests was assessed according to standard BS 8414-1 [2].

Experimental testing set-up – Test specimens were L-shaped, 8 m high, with main test wall (main face), 2.6 m long, and return wall (wing), 1.5 m long. The L-shape of the specimen represents an internal corner of a building.

Composition of test specimens and their classification according to the reaction to fire properties, as declared by the manufacturer, is shown in Table 1. The only difference between test specimens was 20 cm high horizontal fire barrier made of non-combustible material (stone wool – SW) that was installed as lintel protection above the combustion chamber (representing opening) of test specimen denoted with TS_2 (Fig. 1a). The specimens of the same compositions were tested twice to assess repeatability of testing in outdoor conditions and comparability of obtained results.

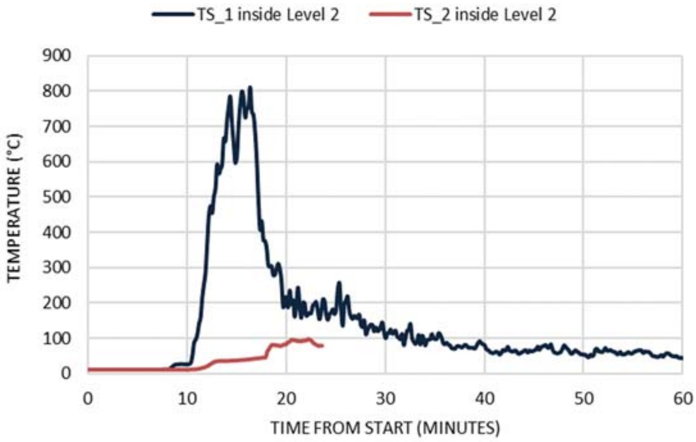
Table 1. Description of test specimens

Test specimen	Thermal insulation material and thickness	Render	Fixing method	Reaction to fire class [3]
TS_1	Expanded polystyrene (EPS) – 150 mm	Basic render reinforced with glass fibre mesh and final organic (acrylic) render – 5 mm	Adhesive and mechanical fixing	B-s2, d0
TS_2	Expanded polystyrene (EPS) – 150 mm + fire barrier 200 mm high; directly above combustion chamber			B-s2, d0 (A2-s1, d0 barrier)

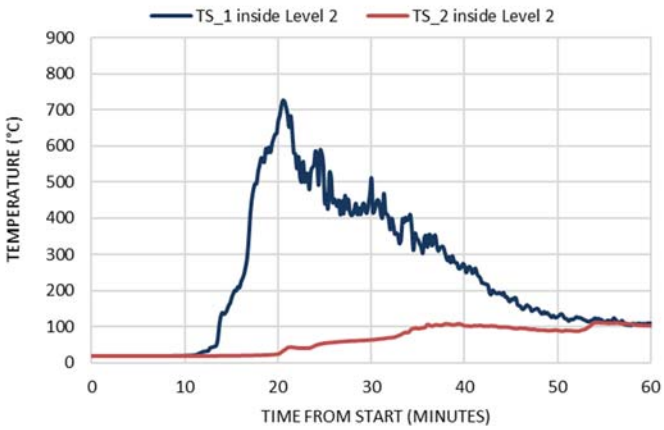
Fig.1. a) dimensions of fire barrier installed above combustion chamber of test specimen TS_2, b) position scheme of thermocouples embedded in both specimens, TS_1 and TS_2 [4]

Developed temperature profiles - To monitor evolution of temperatures during testing, external thermocouples were embedded on the main face of the façade and on the wing, both at Level 1 (2.5 m from combustion chamber) and Level 2 (5 m from combustion chamber) in accordance with BS 8414-1. Internal thermocouples were embedded at Level 2, on the main face of the façade and on the wing (Fig. 1b).

Analysis of average temperatures, developed during both tests within thermal insulation layer, shows that test specimen TS_2 has considerably lower temperatures compared to test specimen TS_1. Obviously, fire barrier has limited the fire development within the insulation material in test specimen TS_2 where, at Level 2, the temperatures remained below or around 100°C. The adverse effect occurred in specimen TS_1, i.e. the thermal insulation in this specimen was caught by fire where temperature peak rose above 700°C (Fig. 2).



a)



b)

Fig.2. Average temperature within thermal insulation layer at Level 2 on main façade during a) first testing, b) second testing

Visual appearances - Figs. 3-8 present the pattern of behaviour of two façade systems during second testing. As it can be seen from figures, only the glass fibre mesh and finishing render was left of test specimen TS_1, while the entire thermal insulation burned up in less than 40 min after the start of fire. At test specimen TS_2, once the fire propagated over the fire barrier above the combustion chamber, the thermal insulation started to melt and burning droplets were released and felt around the specimen. The thermal insulation melted only partially at this test specimen.

Effectiveness of fire barriers - Non-combustible stone wool fire barriers if positioned above the window opening can delay the fire spread of EPS ETICS in case of a fully developed fire impinging on the façade. Therefore, in systems like the ones tested, a non-combustible fire barrier can possibly be used as passive fire protection. The fact that the system with the fire barrier allowed considerable fire spread, although later in the test, shows that the safety margin of these types of systems are limited. They should therefore not be used on buildings such as high rise buildings and buildings where occupants need additional time to escape such as hospitals, kindergartens and nursing homes.

Fig. 3. Start of the test

Fig. 4. 9 min from the start

Fig. 5. 19 min from the start

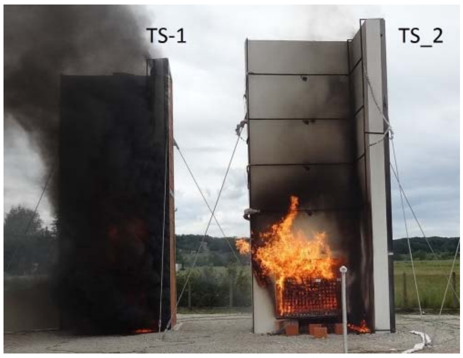


Fig.6. 28 min from the start

Fig. 7. 37 min from the start

Fig. 8. 57 min from the start

References

[1] M. Jelcic Rukavina, M. Carevic, I. Banjad Pecur, Fire protection of façades - The national guidelines for design and execution, University of Zagreb, Faculty of Civil Engineers, 2017.

[2] BS 8414-1 Fire performance of external cladding systems. Test methods for non –loadbearing external cladding systems applied to the face of building.

[3] HRN EN 13501 – 1 Fire classification of construction products and building elements -- Part 1: Classification using data from reaction to fire tests (EN 13501-1:2007+A1:2009)

[4] D. Bjegovic, I. Banjad Pecur, B. Milovanovic, M. Jelcic Rukavina, M. Alagusic, Comparative full-scale fire performance testing of ETICS systems, Građevinar, vol. 68, no. 5, pp. 357–369, 2016. doi: https://doi.org/10.14256/ JCE.1347.2015