The impact of reinforcing profiles on the fire resistance of aluminium glazed partitions

Part 2.

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In this paper, the impact of using this type of additional profiles on the fire resistance of a glazed wall was analysed. The results of two walls with identical external dimensions and the same static scheme, made on the basis of the same glazing, from the same aluminium profiles have been compared, with additional reinforcing profiles applied in one of the tests. This article discusses the results obtained and the conclusions from the tests conducted.

Tests completed

Two fire resistance tests on glazed partitions with the same structural scheme and made of the same aluminium profiles and glazing were conducted. The only difference between the tested specimens was that one of the partitions was tested with additional reinforcing profiles. Both partitions had similar dimensions: 3000 x 3000 mm (width x height) and were made of aluminium profiles with dimensions of 46 x 78 mm (width x depth) – 4 mullions and 9 transoms connected to each other and fixed to the aerated concrete wall with a thickness of 240 mm on 3 sides (bottom, top and one of the vertical edges). One side was left unfixed to simulate the elements with greater widths.

The aluminium profiles were 3-chamber profiles, made of 2 elements connected to each other by means of a thermal separator made of polyamide reinforced with glass fibre. The central chamber of the profiles, between the two aluminium elements and thermal separator was filled with special cooling plate used for profile insulation. For one of the tests (designated as Test 2), the aluminium profiles were additionally reinforced with aluminium U-shaped profiles with dimensions of 40 x 50 x 2 mm (width x depth x thickness), which were screwed to the main profile by means of steel screws, and closed with aluminium masking bead.

In both tests the 6 areas formed between the profiles (transoms and mullions) were filled with the same type of special fire-resistant glazing, designed for elements with 30 minutes of fire integrity and insulation. The thickness of the glazing was 20 mm and the width x height of each pane was 933 x 1425 mm. The general view of both specimens is presented in Figure 5.

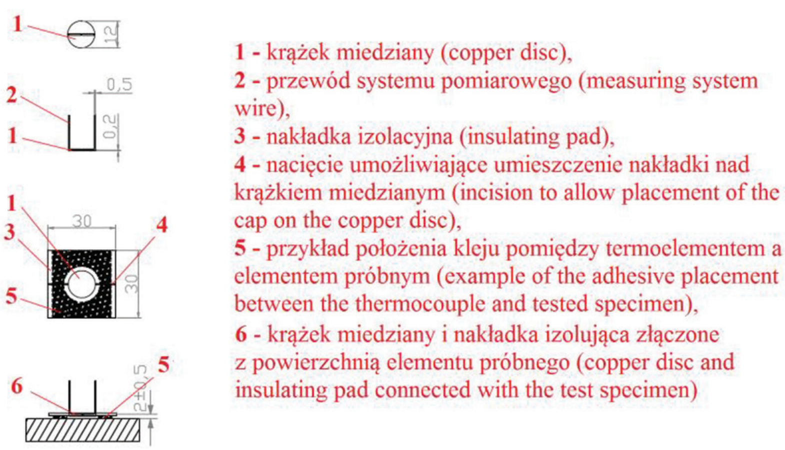

Fig. 3. Thermocouple diagram [61]

During the fire resistance tests, the performance criteria of integrity and insulation were verified. The integrity was checked by means of gap gauges and cotton pad previously described. The insulation was verified by means of thermocouples (diagram presented in Figure 3) placed in the specific locations of the test specimens: mullions (M1 – M4 in Figure 4), transoms (T1 – T4 in Figure 4) and junctions (J1 – J8 in Figure 4). Additionally, deflection of the partition was measured at specific locations (A – O in Figure 4) by means of laser and cable meters. The view of the unexposed surface of tested specimens during the tests are presented in fig. 5 and 6.

Test results

The general results of the fire integrity and insulation, as well as the mechanical behaviour (deflection caused by the impact of fire) of the tests, are presented in Table 2. The comparisons of temperature increases at each specific location are provided in Figures 7 – 11, and the comparison of deflections in the middle height of test specimens are presented in Figure 12.

Discussion

The results presented in Table 2. indicate that for elements with additional reinforcement profiles (Test No 2), fire integrity and insulation are maintained for a shorter period of time than in walls without them, which is an opposite phenomenon to the one expected. The explanation for this may be the nature of the load to which the wall is subjected in the fire resistance test. It is assumed that the loss of insulation mainly corresponds to the level of deformation of the

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elements of the structure, which at the connection points and discontinuities cause gaps. The course of the wall deflection graph indicates that the load caused by the temperature gradient is dominant in the initial phase of the test. Since generally it can be assumed that the value of the bending moment originating from such a load is proportional to:

$$M \sim \frac{\alpha_t \, \Delta t \, E \, h^3}{h}$$

Where:
αt – coefficient of thermal expansion of the material
Δt – temperature difference
E – Young's modulus
h – profile depth

While the deformation in the mullion is proportional to:

$$\varepsilon = \frac{M}{WE} \sim \frac{M}{E \, h^2}$$

Where:
W – bending strength indicator

The deformation should therefore be proportional to:

$$\varepsilon \sim \alpha_t \, \Delta t$$

This means that it should depend only on the type of material and duration of the test (the resulting temperature difference).

On the other hand, the bending moment under an evenly distributed load is proportional to:

$$M \sim q l^2$$

and deflection to:

$$u \sim \frac{q \, l^4}{E \, h^3}$$

This results in:

$$\varepsilon \sim \frac{hu}{l^2}$$

It is a dependence according to experience, which means that it predicts higher fire integrity for the investigated cases in the first test (Table 2.).

Conclusions

Generally the fire resistance of the aluminium glazed partitions depends on multiple factors, such as: the type of glass used, the size of the glass panes, the pane aspect ratio and the method of mounting the glazing as well as the the type of frame profiles used, insulating fillers inside the profiles and the degree to which the profile chambers are filled. Even a slight change in the structure of the element can significantly reduce its fire resistance. For this reason, determining the actual fire resistance class of an alu-

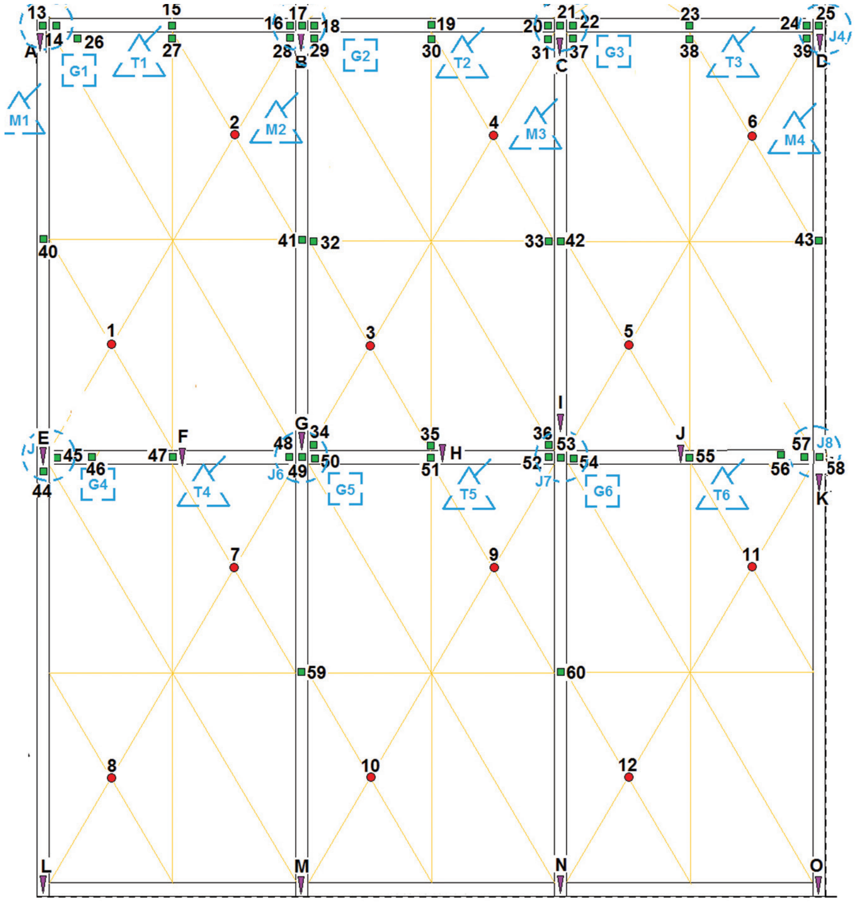

Fig. 4. Thermocouple arrangement and location of deformation measurements

Table 2. Comparison of test results

Parameter	Test results	
	No 1 (without reinforcing profiles)	No 2 (with reinforcing profiles)
Fire integrity, min	60	46
Sustained flaming, min	60	47
Gap 6 mm (on a length of 150 mm), min	60	62
Gap 25 mm, min	60	62
Cotton pad ignition, min	60	46
Fire insulation, min	48	41
Exceeding the average temp, min	53	45
Exceeding the maximum temp, min	48	41
Exceeding the average temp, glass panes, min	48	41
Exceeding the maximum temp, profiles, min	61	54
Max deflection (mullion), mm	112.38	52.49
Max deflection (mullion) / height of specimen	0.03746	0.01750
$\frac{h*u}{l^2}$ *)	0.00099	0.00105
The time of max deformation appear, min	2.5	3.0
Max deflection mullion 1 (fixed edge), mm	13,96	5,87
Max deflection mullion 1 / height of specimen	0.00465	0.00196
Max deflection mullion 2 (2 from the fixed edge.), mm	101.01	52.49
Max deflection mullion 2 / height of specimen	0,03367	0,01750
Max deflection mullion 3 (3 from the fixed edge.), mm	112.38	52.11
Max deflection mullion 3 / height of specimen	0.03746	0.01737
Max deflection mullion 4 (free edge), mm	43.79	12.59
Max deflection mullion 4 / height of specimen	0.01460	0.00420

*) h – profile depth, u – deflection, l – height of the wall

Fig. 5. The view of the unexposed surface of tested specimen No. 1 during the fire resistance test

Fig. 6. The view of the unexposed surface of tested specimen No. 2 during the fire resistance test

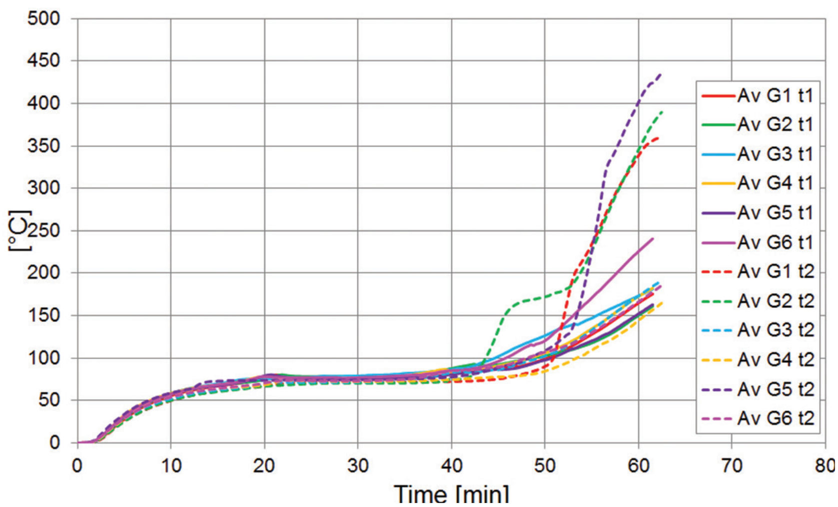

Fig. 7. Comparison of average temperature increases on glass panes (solid line – partition without reinforcing profiles, dashed line – partition with reinforcing profiles)

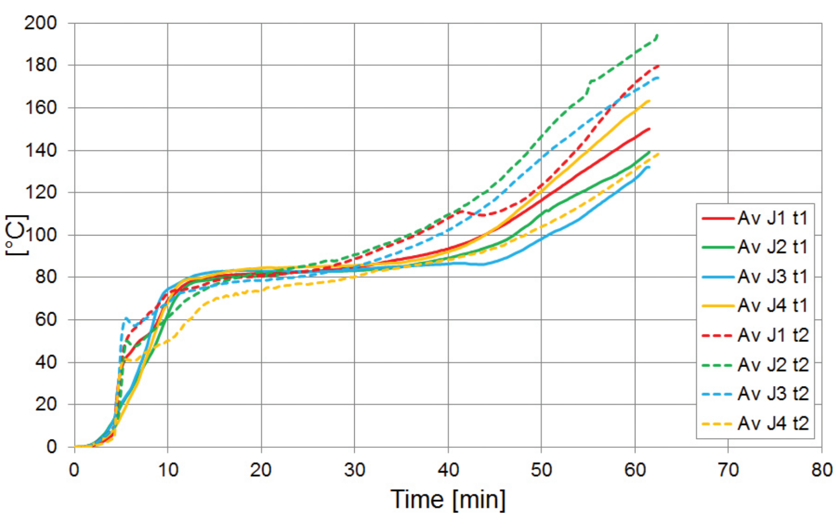

Fig. 8. Comparison of average temperature increases on mullions (solid line – partition without reinforcing profiles, dashed line – partition with reinforcing profiles)

minium glazed partition is only possible on the basis of results from fire resistance tests performed on the test specimens.

The one important conclusion from the tests described in the paper is that profile reinforcement has no significant influence on the insulation properties of the partition wall. There are no repeatable differences between the registered temperature increases and the course of the graphs is quite similar for both tests.

In the case of fire integrity, the test results indicate that the use of reinforcing profiles in this case caused its lowering, which could be influenced by greater deformations described in the previous point. However, it is unclear what caused greater deformations in the profile with a theoretically greater strength. Moreover, the origin of the phenomenon, which could cause an evenly distributed load in the fire resistance test, is also unclear. It should be mentioned that the deformations could also correspond to second-order effects related to the axial force in the wall coming from its own weight and material loss (melting of the aluminium profiles); however due to the low relative value of the deflection u / L about 1/100, this seems unlikely. It is also possible that this phenomenon was accidental, and will be not confirmed following further tests.

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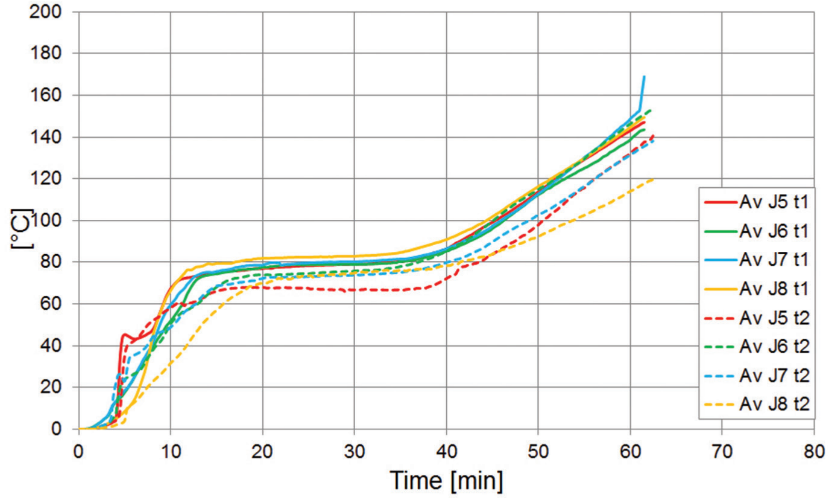

Fig. 9. Comparison of average temperature increases on transoms (solid line – partition without reinforcing profiles, dashed line – partition with reinforcing profiles)

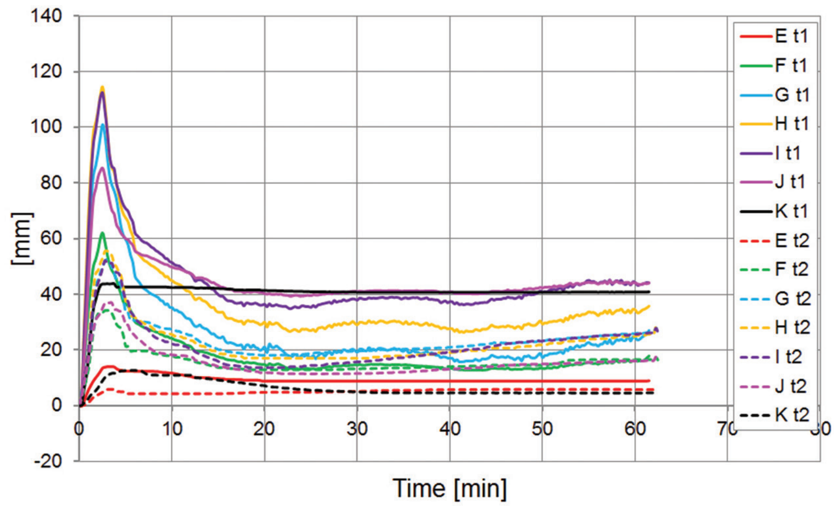

Fig. 10. Comparison of average temperature increases on junctions (solid line – partition without reinforcing profiles, dashed line – partition with reinforcing profiles)

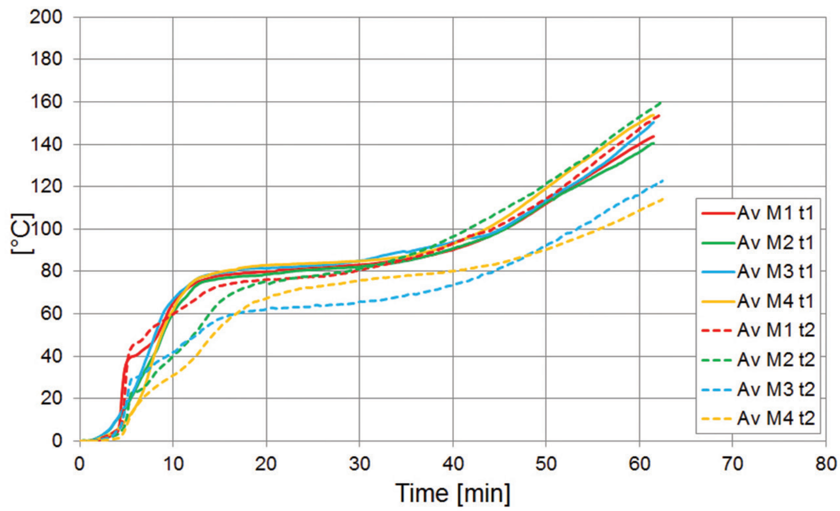

Fig. 11. Comparison of average temperature increases on junctions (solid line – partition without reinforcing profiles, dashed line – partition with reinforcing profiles)

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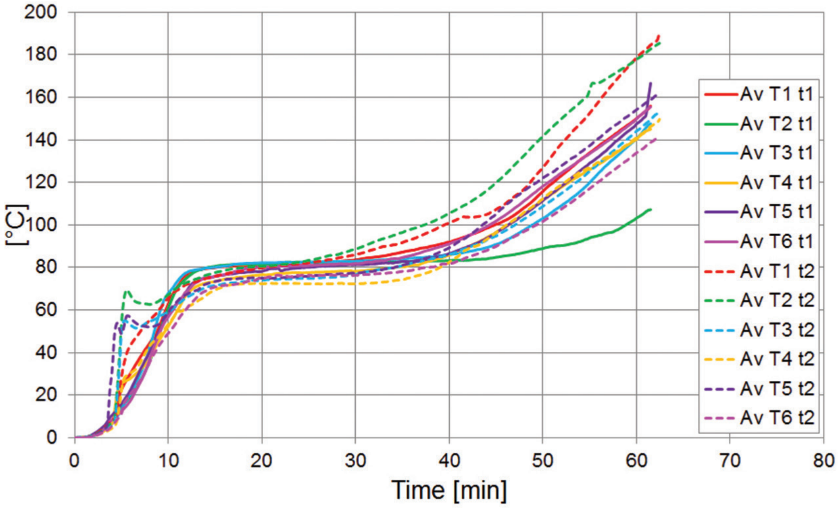

Fig. 12. Comparison of deformations in the middle height of test specimens (solid line – partition without reinforcing profiles, dashed line – partition with reinforcing profiles)

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PRAWIDŁOWY SPOSÓB CYTOWANIA
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Abstract: The inner walls of a building, which do not constitute its structure and therefore do not have loadbearing properties, are called partition walls. The main task of this type of element is the separation of rooms in a building, which is why they should be designed and constructed in a way that ensures, among others, compliance with fire safety requirements, including those related to fire resistance. There are many types of fire-resistant partition walls both on the European and global construction market, among which the most impressive effect is achieved by those using glass elements in their structure. These include aluminium glazed partitions, which are the subject of this paper. These structures are usually made of special fire-resistant glass positioned in three chamber profiles, made of two aluminium sections, connected by a thermal break, usually made of glass fibre reinforced polyamide. The chambers created in this way are filled with special insulating inserts, and the degree of filling depends on the expected fire resistance class, which is determined by an appropriate test. Large wall-height profiles of this type are usually further reinforced by screwing to them additional, special aluminium profiles. In this paper, the impact of using this type of additional profiles on the fire resistance of a glazed wall was analysed. The results of two walls with identical external dimensions and the same static scheme, made on the basis of the same glazing, from the same aluminium profiles have been compared, with additional reinforcing profiles applied in one of the tests. This article discusses the results obtained and the conclusions from the tests conducted.

Keywords: fire safety, fire engineering, fire resistance, fire integrity, fire insulation, aluminium profiles, aluminium glazed partition systems, glass panes.

Streszczenie: WPŁYW PROFILI WZMACNIAJĄCYCH NA ODPORNOŚĆ OGNIOWĄ ALUMINIOWYCH PRZEGRÓD PRZESZKLONYCH. Ściany wewnętrzne budynku, które nie stanowią jego konstrukcji, a tym samym nie mają właściwości nośnych, nazywane są ścianami działowymi. Głównym zadaniem tego typu elementów jest wydzielenie pomieszczeń w budynku, dlatego należy je projektować i wykonywać w sposób zapewniający m.in. zachowanie wymagań bezpieczeństwa pożarowego, w tym w zakresie odporności ogniowej. Na europejskim, a także światowym rynku budowlanym istnieje wiele rodzajów przeciwpożarowych ścianek działowych, z których najbardziej spektakularny efekt osiągają te, które wykorzystują w swojej konstrukcji elementy szklane. Należą do nich przeszklone przegrody aluminiowe które są przedmiotem niniejszego artykułu. Konstrukcje te są zwykle wykonane ze specjalnego szkła odpornego na działanie ognia, umieszczonego w trójkomorowych profilach, składających się z dwóch profili aluminiowych, połączonych przekładką termiczną, najczęściej z poliamidu wzmocnionego włóknem szklanym. Powstałe w ten sposób komory wypełnione są specjalnymi wkładami izolacyjnymi, a stopień wypełnienia uzależniony jest od oczekiwanej klasy odporności ogniowej, która jest określana odpowiednim badaniem. Tego typu profile o dużej wysokości ścian są zwykle dodatkowo wzmacniane poprzez przykręcenie do nich dodatkowych, specjalnych profili aluminiowych. W artykule przeanalizowano wpływ zastosowania tego typu dodatkowych profili na odporność ogniową przeszklonej ściany. Porównano wyniki dwóch ścian o identycznych wymiarach zewnętrznych i tym samym schemacie statycznym, wykonanych na podstawie tego samego schematu oszklenia, z tych samych profili aluminiowych, z dodatkowymi profilami wzmacniającymi zastosowanymi w jednym z badań. W artykule omówiono uzyskane wyniki oraz wnioski z przeprowadzonych badań.

Słowa kluczowe: bezpieczeństwo przeciwpożarowe, inżynieria przeciwpożarowa, odporność ogniowa, szczelność ogniowa, izolacja ogniowa, profile aluminiowe, aluminiowe przeszklone systemy ścian działowych, przeszklenia.