

Large glazing in curtain walls – study on impact of fixing methods on fire resistance

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Abstract. Paper presents curtain walls fire resistance tests results comparison. Considered tests specimens were of similar system solution regarding profiles material, shape, dimension and insulation, glass pane family group and dimensions and glazing arrangement, fixing of framing system (anchoring) but differ in glazing fixing method. Collected study material allowed reliable comparison of glazing fixing method impact on whole construction fire resistance. Comparison was made for curtain walls glazed with glass panes fixed in standard way (by means of pressure plates with covering profiles) and for curtain walls with structural glazing (fixed by means of steel clamps and structural silicone).

1. INTRODUCTION

Glazed curtain walls play essential role in modern building industry. Ease of installation and aesthetic effect of the final provides great popularity of this type of solutions, especially in a tall [25] and high-rise [24] buildings. This external cover of the building, which consists of vertical and horizontal structural members, connected together and fixed to the floor supporting structure has to fulfil the basic aspects like climatic and environmental influence as well as those connected with protection against burglary and fire. Facing up these problems is a huge challenge for both designers and contractors, especially in case of the increasingly popular buildings with great floor to floor distance [19] and facades with large glass panes [14, 15].

According to the regulations of many countries curtain walls, as a non-loadbearing part of the building, should be designed and constructed in a way that in case of fire it will limit the spread of fire inside the building, ensure the safety of rescue team and allow the evacuation of users. Facades should for a specific period of time prevent development of fire between the adjacent floors of the building, between the adjacent objects, and in specific cases also between the adjacent rooms in the building (connection of the curtain wall with inner wall of the building). Moreover, its fixing shall be made in a way that prevents falling of the parts of element during the rescue team activities and evacuation of the users [6, 9, 21, 23].

Requirements listed above quite often results in necessity of use the curtain walls with specific fire resistance class. In order to ensure the insulation and reduce the adverse impact of thermal effects, those constructions are equipped with special accessories such as intumescent gaskets [12], profile insulation inserts [8] and obviously fire resistant glazing [16, 18]. However, even a vast knowledge

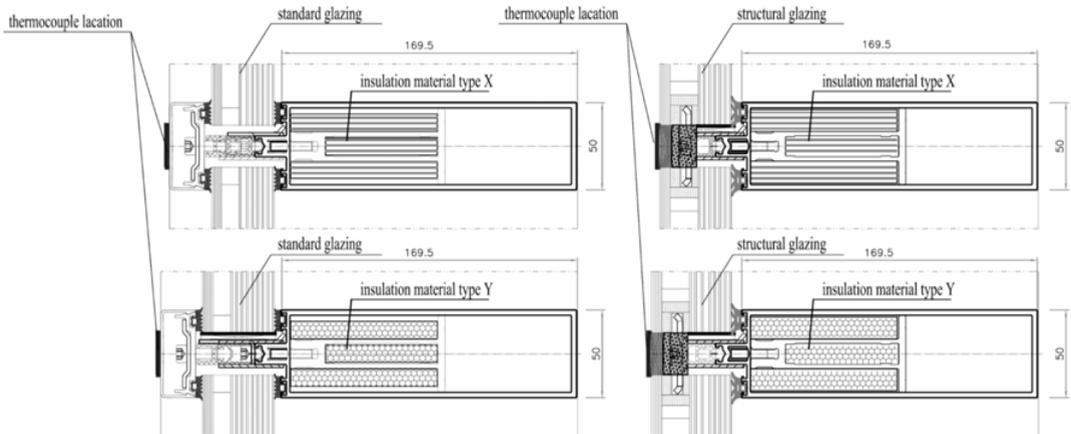


Figure 1. Transoms cross – section, construction details and thermocouples location.

of systems, used solutions and the behaviour of glazed curtain walls in fire conditions isn't enough to calculate or assess its fire resistance class, therefore the only way to determine this characteristic is to perform the fire resistance test. The European methodology of fire testing, as well as detailed information regarding the selection of appropriate test specimens, has been widely discussed in the existing papers [1, 10, 11, 13, 22]. Curtain walls as an external cover of the building can be exposed for the fire inside as well as outside the object and that's why two different methods of heating and test specimen configuration depending on the side of fire exposure (external or internal) are given in the testing procedure. The impact of the side of exposure on fire resistance of glazed curtain walls is presented in papers [17, 20].

Fire resistance of glazed curtain walls depends on many factors of the system solution to name only: profile material and shape, type of insulation inserts used, type of glazing and glazing fixing method, (especially important in case of large glass panes). Study on impact of latter factor mentioned on fire resistance is the main topic of this paper.

2. FIRE RESISTANCE TESTS

Four test specimens of glazed aluminium curtain walls in full configuration, were tested in the Fire Testing Laboratory of Building Research Institute (ITB) in Pionki. All tests were performed on straight curtain wall type B (in accordance with EN 1364-3 [3]) in full configuration, with internal fire exposure heated under the standard fire curve. All four curtain walls had the same framing system fixing (anchoring system). Two test specimens were tested with glass panes fixed standard way (by means of pressure plates with covering profiles), and two with structural glazing (fixed by means of steel clamps and structural silicone). All tested specimens were of the same transom – mullion structure with aluminium profiles sections of:

- 165×50 mm (mullions, Fig. 2),
- 169,5 × 50 mm (transoms, Fig 1).

Dimension of exposed surface of tested specimens was 3350 × 4500 mm (width × height). General view of tested specimens is presented in Fig. 3 (drawing), 4, 5 (photos). In performed fire resistant tests two types of insulations inserts (X, Y) were used in profiles and two types of glass panes (in terms of fire resistant glass pane) in glazing units, each type for pair of tests. Test specimens details specification

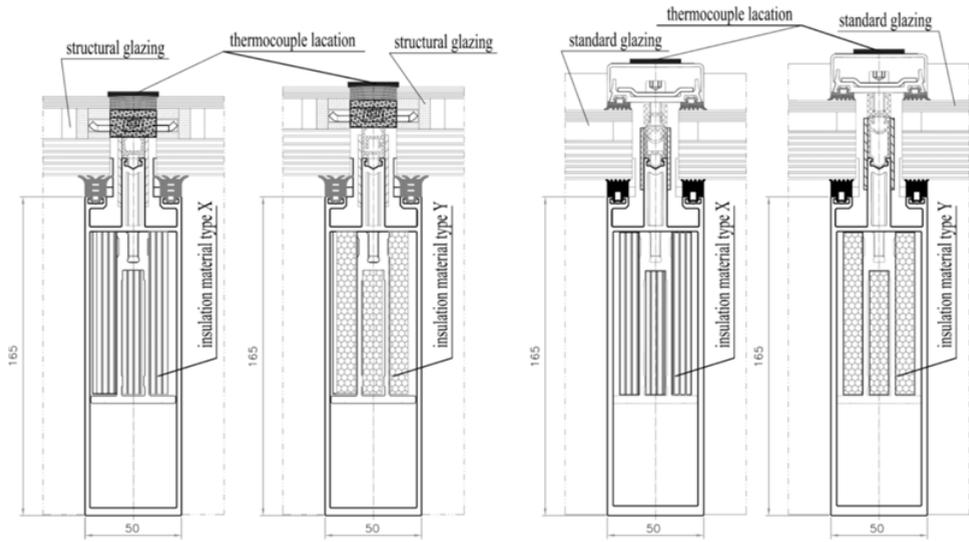


Figure 2. Mullions cross – section, construction details and thermocouples location.

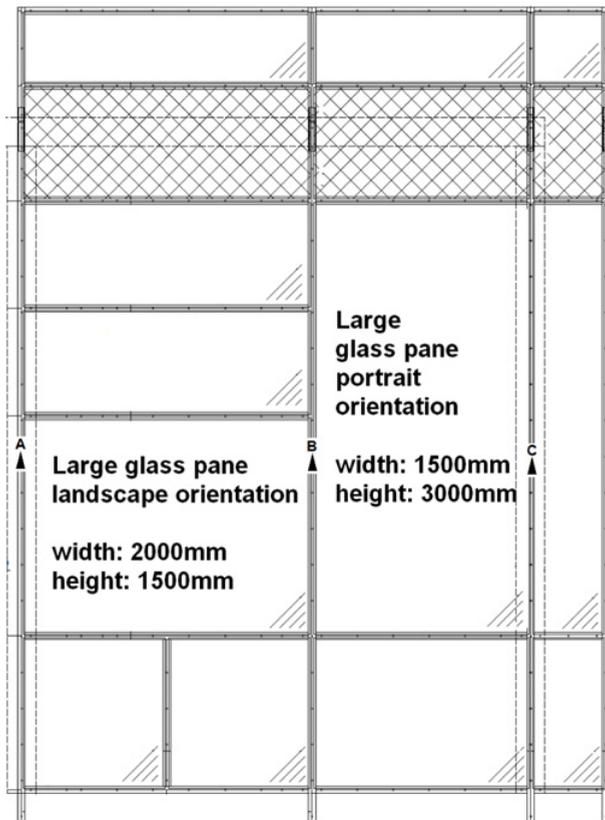


Figure 3. General view of tested specimens (with location of points of deformation measurements).

Table 1. Test specimens.

Test specimen	Glass pane fixing method	Type of fire resistant glass pane	Type/ application of glazing unit	Type of insulation inserts
1	Standard	1	Standard glazing (C)	X
2	Standard	2	Standard glazing (C)	Y
3	Structural	1	Structural glazing (S)	X
4	Structural	2	Structural glazing (S)	Y

**Figure 4.** The view of the unexposed surface of the test specimen during the test (structural glass pane fixing).

is presented in Table 1. Dimensions of the glass panes were (width x height):

- 1500 × 3000 mm – for portrait orientation,
- 2000 × 1500 mm – for landscape orientation.

Glazing units manufactured using fire resistant glass pane of type 1, specification and composition:

- thickness of 34 mm [20 mm fire glass, 8 mm steel frame and 6 mm toughened glass]; (C),
- thickness of 42 mm [20 mm fire glass, 16 mm steel frame and 6 mm toughened glass]; (S).

Glazing units manufactured using fire resistant glass pane of type 2, specification and composition:

- thickness of 39 mm [25 mm fire glass, 8 mm steel frame and 6 mm toughened glass], (C),
- thickness of 47 mm [25 mm fire glass, 16 mm steel frame and 6 mm toughened glass] (S).

The insulation inserts type 1 were made of gypsum plasterboards and insulation inserts type 2 were made of special cooling plates.



Figure 5. The view of the unexposed surface of the test specimen during the test (standard glass pane fixing).

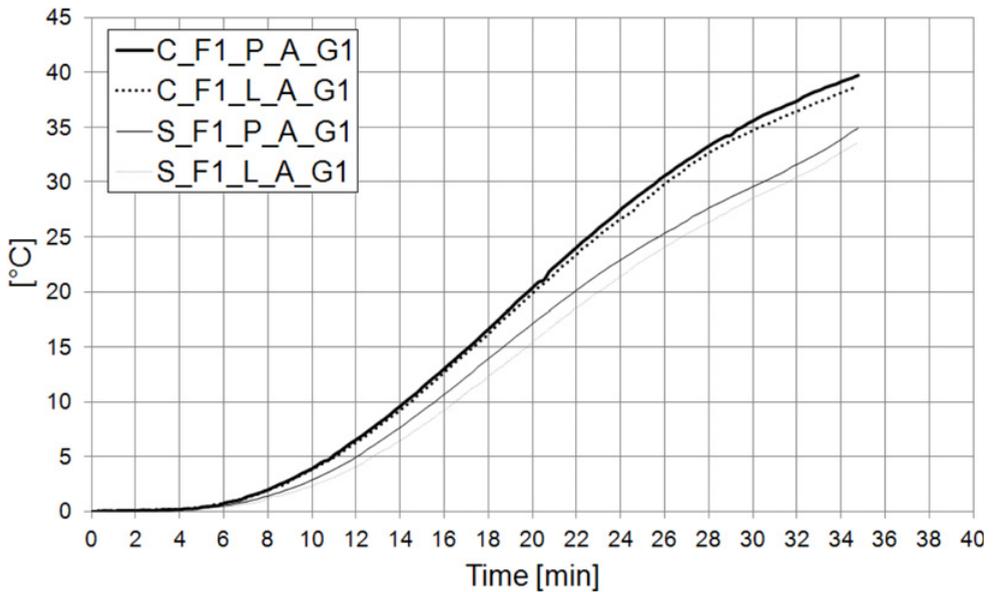


Figure 6. Comparison of average temperature rise on the glass panes (C_F1_P_A_G1 – glass pane type 1, standard fixing method, portrait orientation; C_F1_L_A_G1 – glass pane type 1 standard fixing method, landscape orientation; S_F1_P_A_G1 – glass pane type 1, structural fixing method, portrait orientation; S_F1_L_A_G1 – glass pane type 1 structural fixing method, landscape orientation).

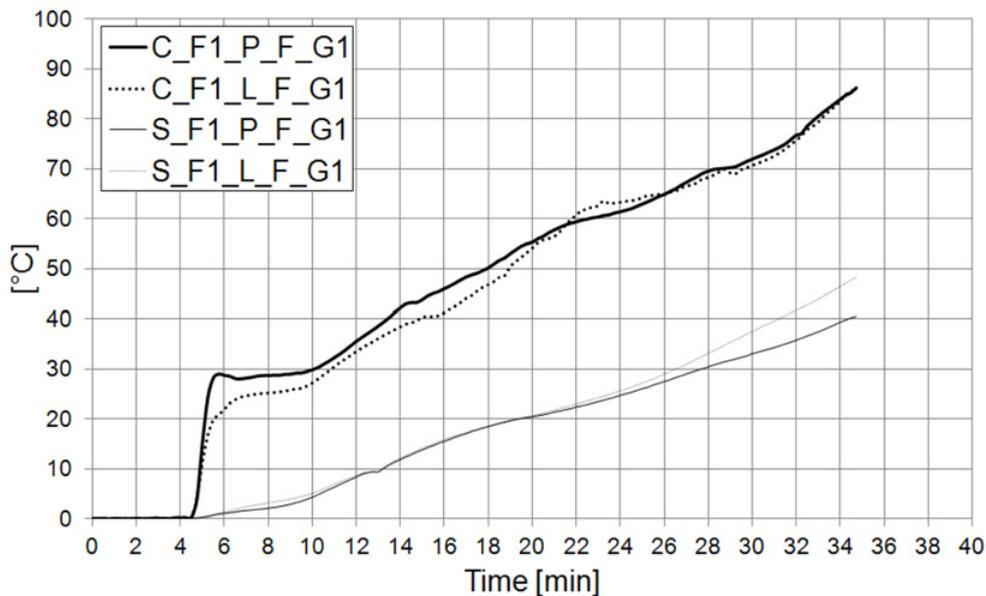


Figure 7. Comparison of average temperature rise on the framing (C_F1_P_F_G1 – glass pane type 1, standard fixing method, portrait orientation; C_F1_L_F_G1 – glass pane type 1 standard fixing method, landscape orientation; S_F1_P_F_G1 – glass pane type 1, structural fixing method, portrait orientation; S_F1_L_F_G1 – glass pane type 1 structural fixing method, landscape orientation).

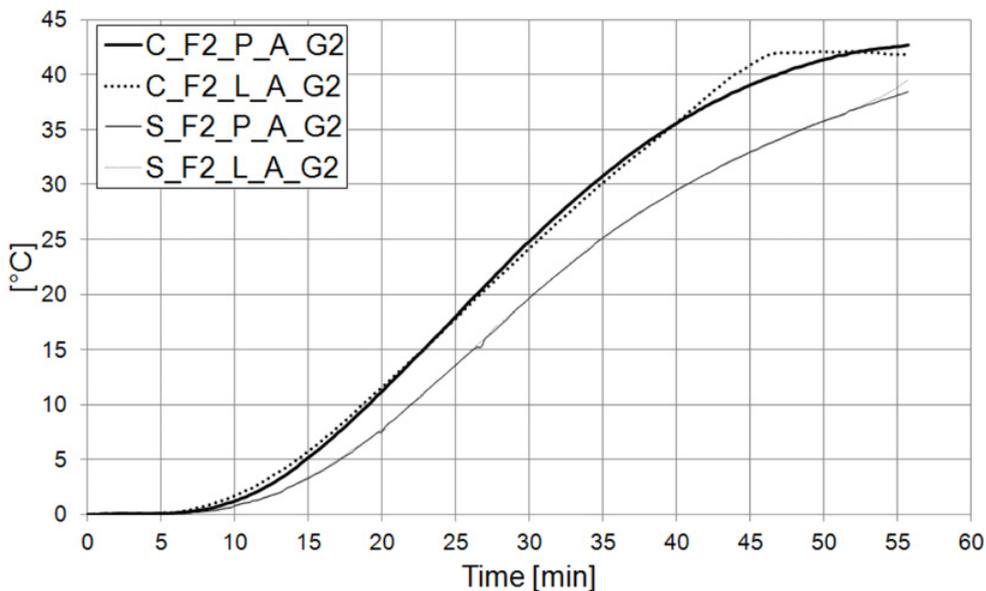


Figure 8. Comparison of average temperature rise on the glass panes (C_F2_P_A_G2 – glass pane type 2, standard fixing method, portrait orientation; C_F2_L_A_G2 – glass pane type 2 standard fixing method, landscape orientation; S_F2_P_A_G2 – glass pane type 2, structural fixing method, portrait orientation; S_F2_L_A_G2 – glass pane type 2 structural fixing method, landscape orientation).

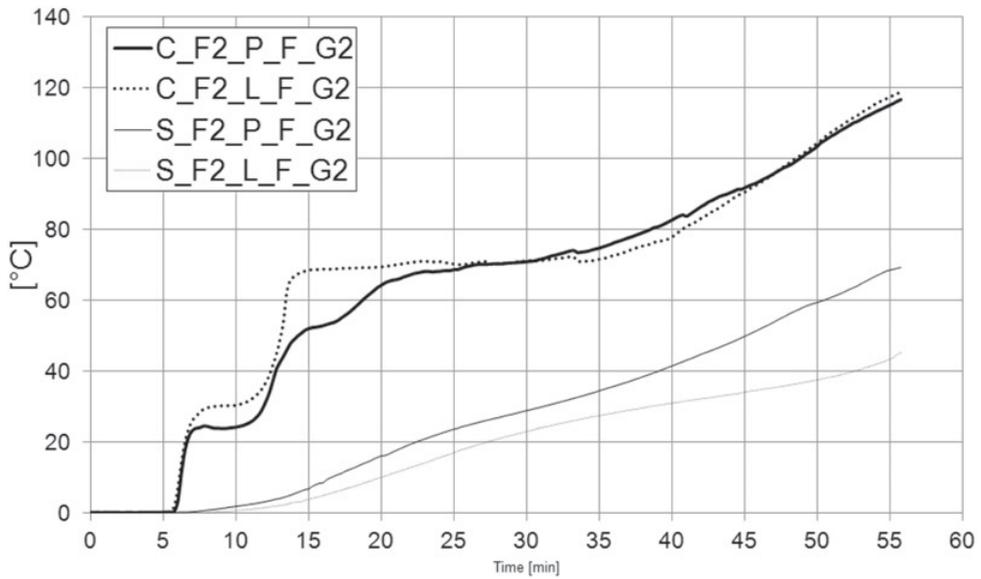


Figure 9. Comparison of average temperature rise on the framing (C_F2_P_F_G2 – glass pane type 2, standard fixing method, portrait orientation; C_F2_L_F_G2– glass pane type 2 standard fixing method, landscape orientation; S_F2_P_F_G2 – glass pane type 2, structural fixing method, portrait orientation; S_F2_L_F_G2 – glass pane type 2 structural fixing method, landscape orientation).

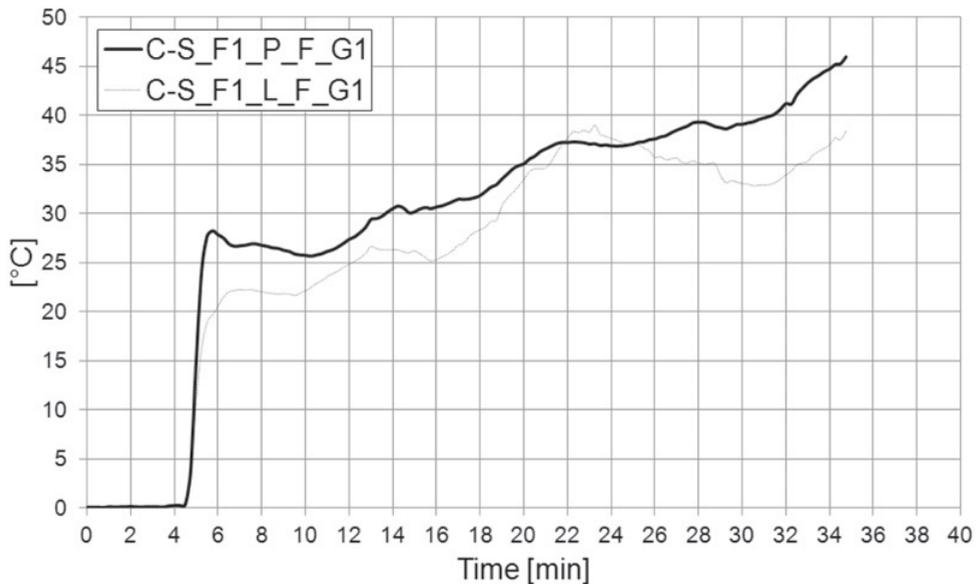


Figure 10. Differences between the average temperature rises on the unexposed surface of glass pane framing elements (C-S_F1_P_F_G1 – glass pane type 1, portrait orientation; C-S_F1_L_F_G1 – glass pane type 1, landscape orientation).

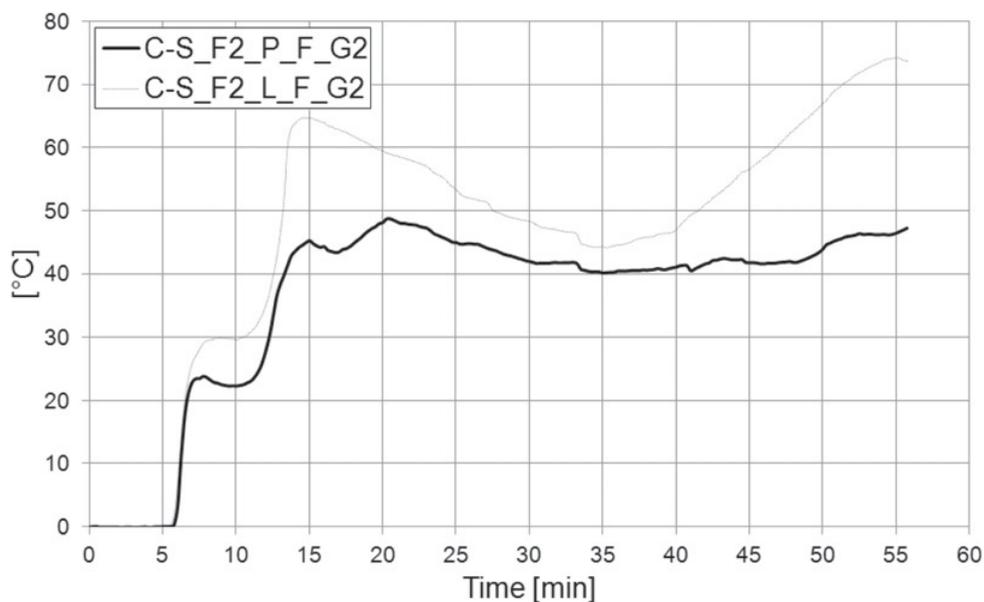


Figure 11. Differences between the average temperature rises on the unexposed surface of glass pane framing elements (C-S_F2_P_F_G2 – glass pane type 2, portrait orientation; C-S_F2_L_F_G2 – glass pane type 2, landscape orientation).

3. INSTRUMENTATION AND TESTS RESULTS

The comparison was made for average temperature rises on unexposed surface of largest glass panes (in portrait and landscape orientation) and its framing – aluminium covering profiles in case of standard glass pane fixing and fireproof silicone in case of structural glass pane fixing. The temperature rise on unexposed surface of the test specimens was measured with surface thermocouples type K specified in EN 1363-1:2012 [1]. Places of temperature rises measurements were arranged in accordance with EN 1364-3:2014 [2].

Comparison of average temperature rise on the glass panes is presented in Fig. 6 (glazing type 1) and Fig. 8 (glazing type 2). Comparison of average temperature rise on the framing is presented in Fig. 7 (glazing type 1) and Fig. 9 (glazing type 2). Figures 10 and 11 present the differences between the average temperature rises on the unexposed surface of glass pane framing elements.

4. DISCUSSION

Glazing units for curtain walls with structural glazing have improved insulation compared to the solution with standard glazing presumably due to their construction – wider frame provides larger gap of air, thus improves insulation in case of internal heating, Figs. 6, 8. Also framing system designed for curtain walls with structural glazing have improved insulation compared to the solution with standard glazing. Appropriately applied silicone fuge is a perfect sealing for all framing joints, but entails greater risk of installation errors which are much easier to avoid in case of using standard fixing system with pressure plates and covering profiles, Figs. 7, 9. Behaviour of both types of curtain walls (in terms of glazing fixing method) during the fire resistant tests were similar – there are no significant differences in test elements (deflection difference of max. about 25 mm for the elements height of 4500 mm cannot be

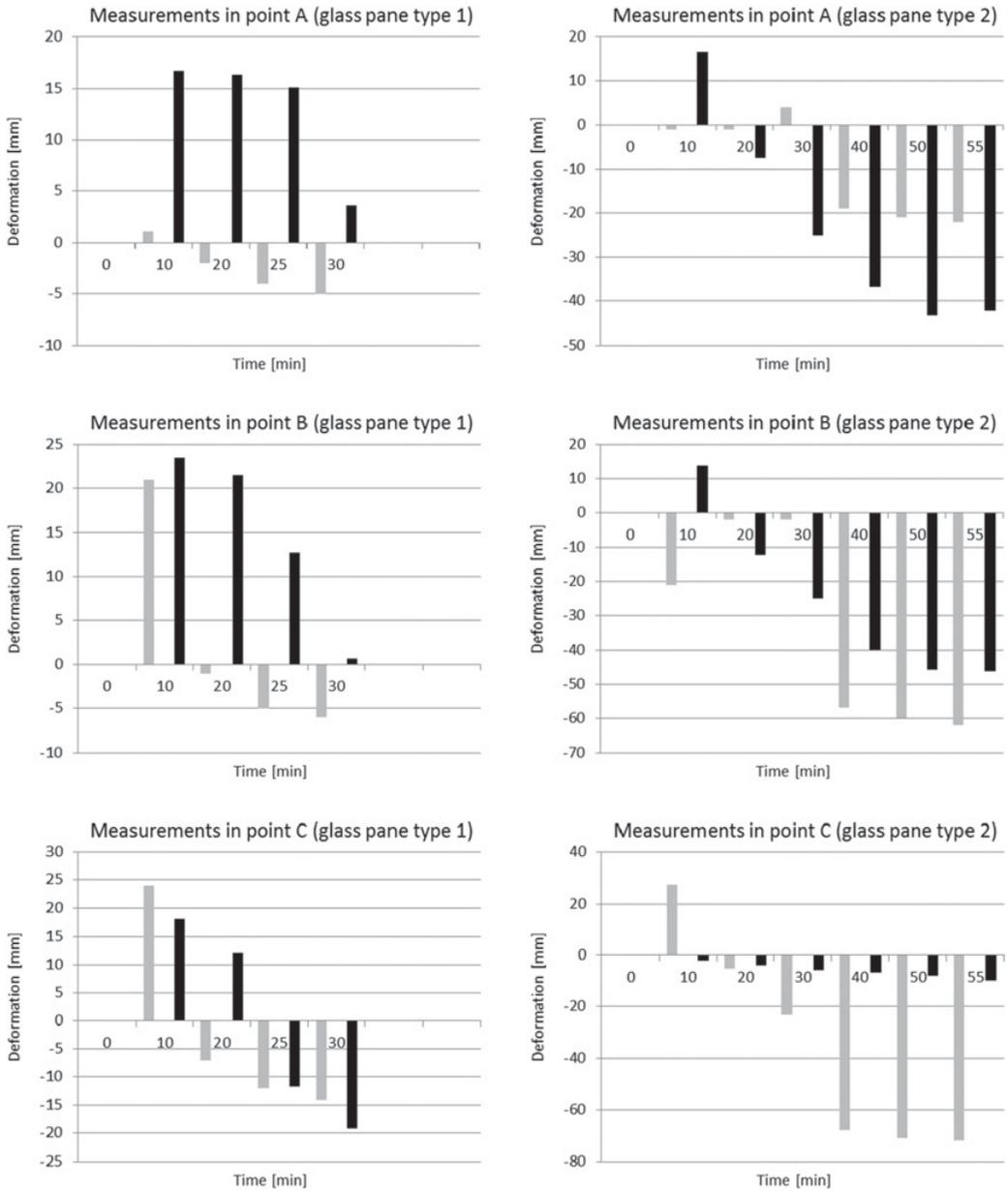


Figure 12. Deformation comparison (grey colour – curatin wall with standard glazing; black colour – curatin wall with structural glazing).

considered as large), Fig. 12. Perhaps fixing of framing system (anchoring) method could cause greater impact on the deflections [26]. According to EN 1364-3:2014 [3] test results of specified pressure plate fixing system (standard fixing system) are applicable to other solutions only with minor changes [5, 7]. Glazing unit can be exchanged for one with wider steel frame, but without additional fire test it is not possible to expand field of direct application. A relatively new method of structural glazing fixing is not yet analysed in Standard [3].

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