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Development of Composite Panels with Innovative Thin Glass and Polycarbonate

Summary Report

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Starting Position

Glass expresses lightness and modernity. By rising glass surfaces of facades, requirements for safety and heat protection grow simultaneously. However, single glass panes do not fulfil the demands on these products. Thereby, further processing into laminated glass is necessary. A composite of ductile polycarbonate with brittle thin glass enables innovative composite panels which provides an alternative to conventional laminated safety glass.

Subject of the Research Project

At the beginning, the requirements and applications of a thin glass-polycarbonate composite panel are described. This is followed by a material selection for the components on technical and economic principles. A thin glass-polycarbonate composite panel consists of two outer thin glass panes and at least one inner polycarbonate sheet, laminated with polymeric interlayers. The interlayer is a thermoplastic polyurethane from SiLATEC Sicherheits- und Laminatglastechnik GmbH. The polycarbonate Lexan™ 9030 is produced by Sabic Deutschland AG. The thin float glass is Optiwhite™ from Pilkington Deutschland AG with a nominal thickness of 2.00 mm and the chemically strengthened thin glass is Leoflex™ from Asahi Glass Co., Ltd, with a nominal thickness of 0.85 mm. The combination of the impact-resistant and ductile polycarbonate with the hard and brittle thin glass enables the application as laminated safety glass and security glazing into account of the passive and active safety of glazing. Figure 1 shows a typical build-up of a thin glass-polycarbonate composite panel with the thin glass Leoflex.

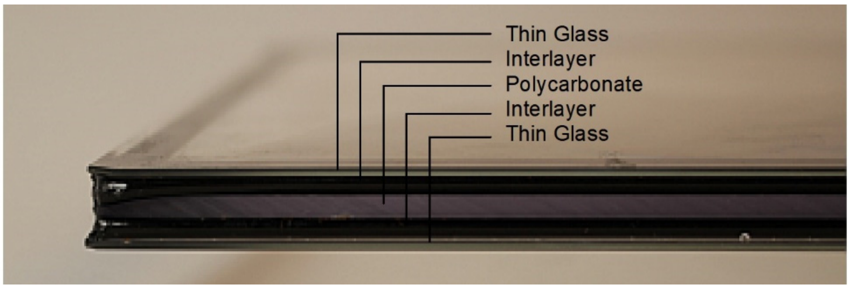

Figure 1 Thin glass-polycarbonate composite panel made of 2 x 0.85 mm thin glass, 2 x 2.00 mm interlayer and 2.00 mm polycarbonate.

In a second step, physical, optical and mechanical properties of the composite panel are determined. This results in dimensions of the cross-section for different stresses.

Experimental tests show a small splinter loss for the bonding strength of the interlayer with the ball drop test. Both glass panes of thin glass-polycarbonate composite panel made of the thin glass Optiwhite break. In contrast, by using thin glass Leoflex only the glass pane at the attack side break and no splinters are replaced. Figure 2 shows the fracture pattern of the attack side of a thin glass-polycarbonate composite panel with the thin glass Leoflex.

Figure 2 Fracture pattern of the attack side of a thin glass-polycarbonate-composite panel after the impact of the steel ball.

The test methods for a resistance against climatic stress with the test at high temperature, the test in humidity and the radiation test are successfully completed for the specimens with thin glass Optiwhite. Blisters, delamination or haze do not occur in the cross-section. The thin glass-polycarbonate composite panel with the thin glass Leoflex also passes the test at high temperature, in humidity and under radiation.

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The test with the axe for resistance against manual attack shows an optimization of laminated safety glass in terms of security by using a thin glass-polycarbonate composite panel. A classification as security glazing with the highest resistance class against manual attack P8B requires a composite panel of Optiwhite with a nominal thickness of 20.0 mm. By using the thin glass Leoflex in the laminate, the nominal thickness of security glazing P8B is reduced to 17.7 mm. The test with the axe on a thin glass-polycarbonate composite panel with the thin glass Optiwhite is given in Figure 3.

Figure 3 Test with the axe on a thin glass-polycarbonate composite panel with thin glass Optiwhite.

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The thin glass-polycarbonate composite panels show improved thermal protection compared to conventional glass due to a lower thermal conductivity of the two polymers of polycarbonate and polyurethane. At the same time, a high transmission in the visible spectral range is ensured and a protection against ultraviolet radiation is given. The thermal transmittance coefficient of the composite panel compared to glass and polycarbonate is shown in Figure 4.

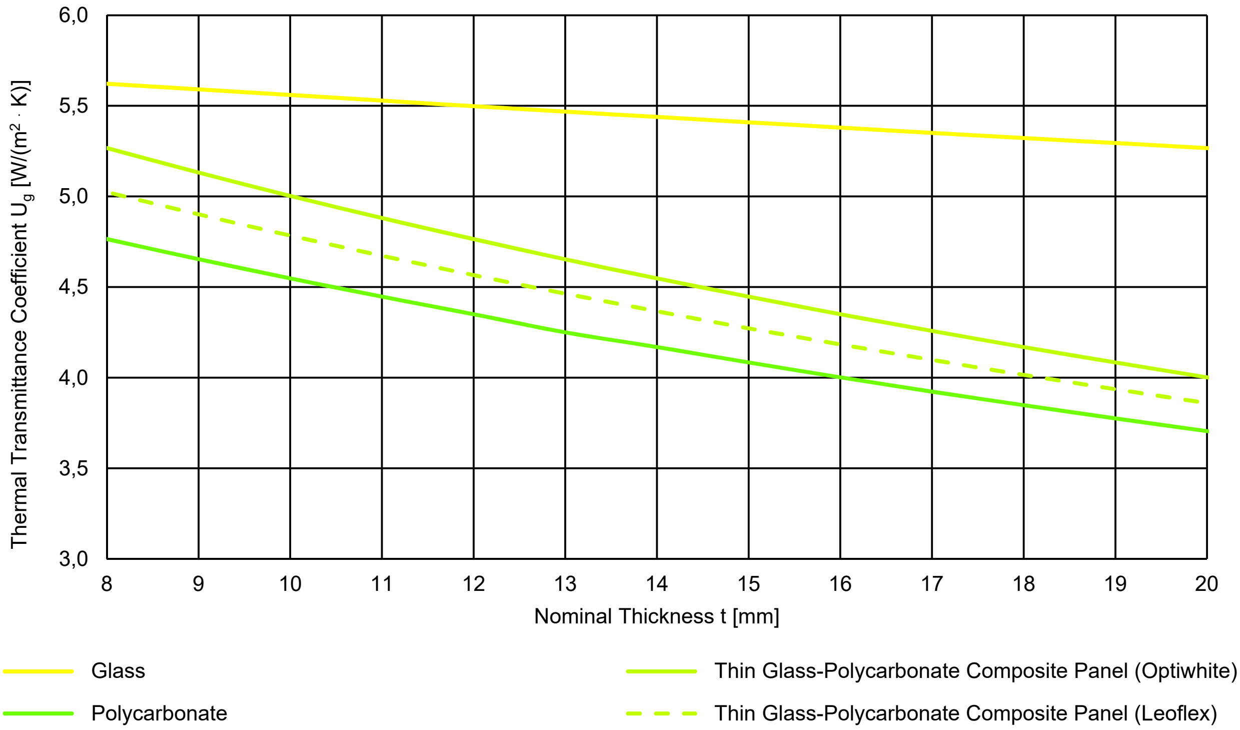

Figure 4 Thermal transmittance coefficient as U_G-value according to DIN EN 673 for a thin glass-polycarbonate composite panel in comparison to thin glass and polycarbonate depending on the nominal thickness.

Based on the four-point bending test for determining the strength of flat glass, the thin glass-polycarbonate composite panels are examined in view to the shear bond. This results in conclusions to the structural behaviour and post-breakage behaviour as well as the shear transfer of the laminate. Figure 5 shows a thin glass-polycarbonate composite panel during the measurements of the structural behaviour. A numerical geometrically non-linear study with the program SJ Mepla 4.0.6 describes the limit cases »no composite« and »full composite«. The »partial composite« is measured on specimens. In case of small nominal thicknesses of the composite panel, large deformations already occur under a low load of 300 N. A nonlinear structural behaviour with transverse stresses results. The bending stiffness of the polycarbonate sheet in conjunction with the glass splinters in the pressure zone ensures a sufficient post-breakage behaviour of the composite panel in the systematic destroyed state.

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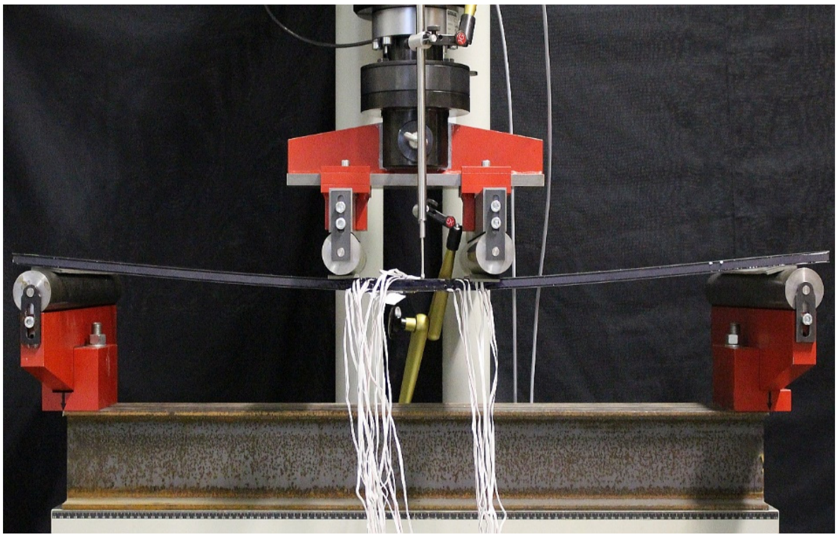

Figure 5 Four-point bending test for the structural behaviour of a thin glass-polycarbonate composite panel with the thin glass Leoflex.

Conclusion

The results of the development of composite panels made of thin glass and polycarbonate allows the production of an innovative laminate with a large field of application. As security glazing for the highest resistance class against manual attack, the laminate is up to 40 % thinner and up to 70 % lighter than common security glazing. Tests for durability are successfully completed. The structural behaviour shows a reduced participation of the thin glass by increasing polycarbonate sheet. The post-breakage behaviour in the systematic destroyed state is ensured with the ductile polycarbonate and the interconnection of the glass fragments in the pressure zone.