DEVELOPMENT OF STRUCTURAL CONNNECTION JOINTS FOR ADHESIVELY BONDED GLASS–PLASTIC-COMPOSITE PANELS

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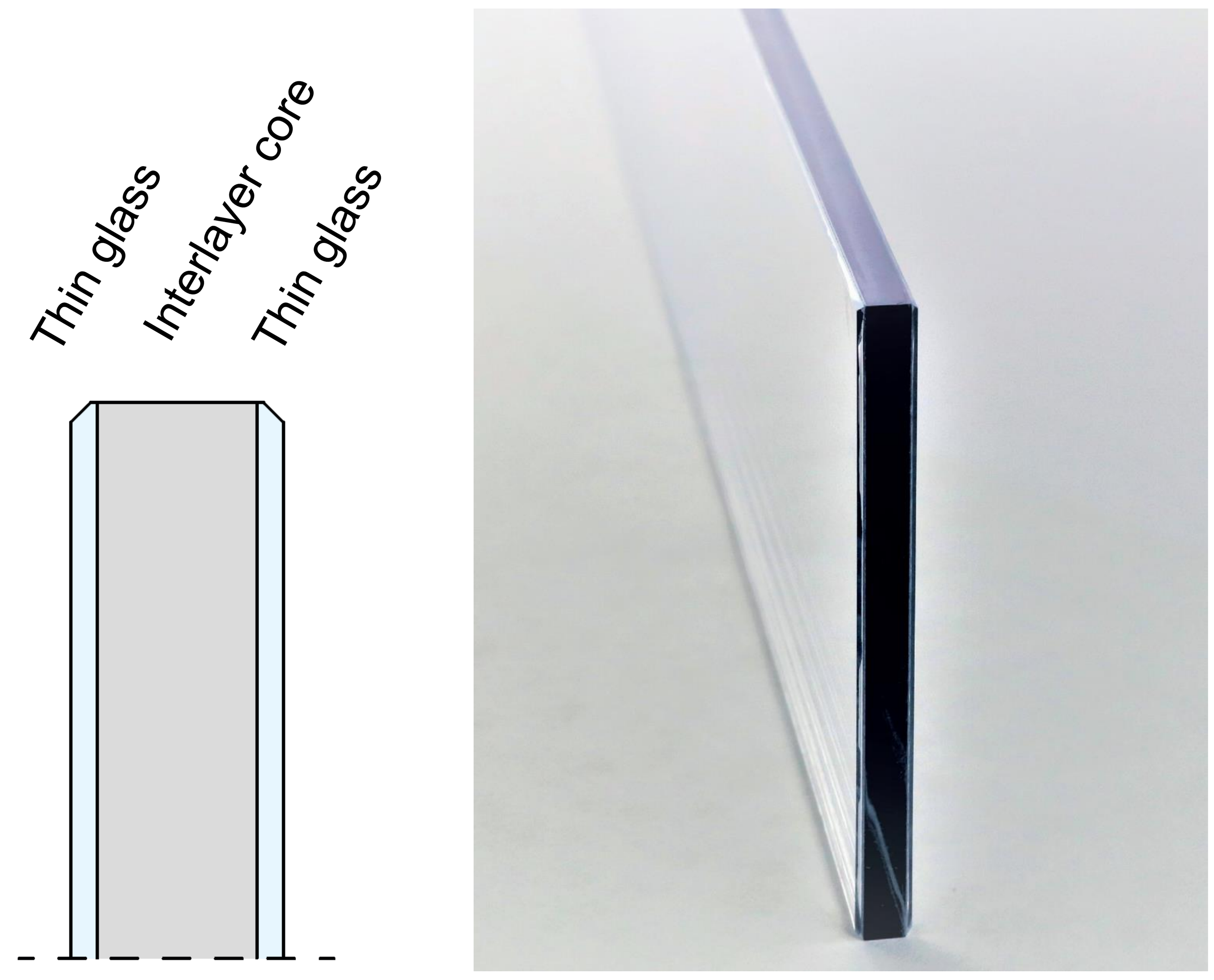


Figure 1: Glass–plastic-composite panel structure (build-up and view)

Motivation

All-glass systems such as mobile glass partition walls and glass doors set high requirements for transparency, lightness and durability. The interconnection between the panels is conventionally performed by eye-catching fittings and clamping details. Innovative glass–plastic-composite panels (Figure 1) consist of adhesively bonded thin glass cover layers by a thick polymer Polymethylmethacrylate (PMMA) interlayer core. The composites show high-performance load-bearing behaviour, durability and exhibit full transparency at low self-weight. Additionally, the novel composite assembly allows for a direct connection into the mechanically processed PMMA interlayer core.

Novel glass construction with glass–plastic-composite panels utilize the low panel self-weight and require small as well as unobtrusive connections to fulfil the desired maximum transparency. Therefore, integrated structural connection joints with transparent structural adhesives are under development and tested with a focus on applications in all-glass systems for the building industry.

Connection Design

The adhesive connection joint was designed for a minimized size and directly integrated into the PMMA interlayer core using transparent adhesives. Thus, the increased fracture toughness of the PMMA compared to glass provides improved resistance to fracture and a reduction in glass stress concentrations.

Figure 2 provides an overview of the component design with associated dimensions. The stainless-steel insert consists of an exterior block serving as a representation of connection hardware with an insert tab that is adhesively bonded to the milled PMMA interlayer core. The adhesive joint was designed with a gap of 0.5–1 mm for the application of structural adhesives.

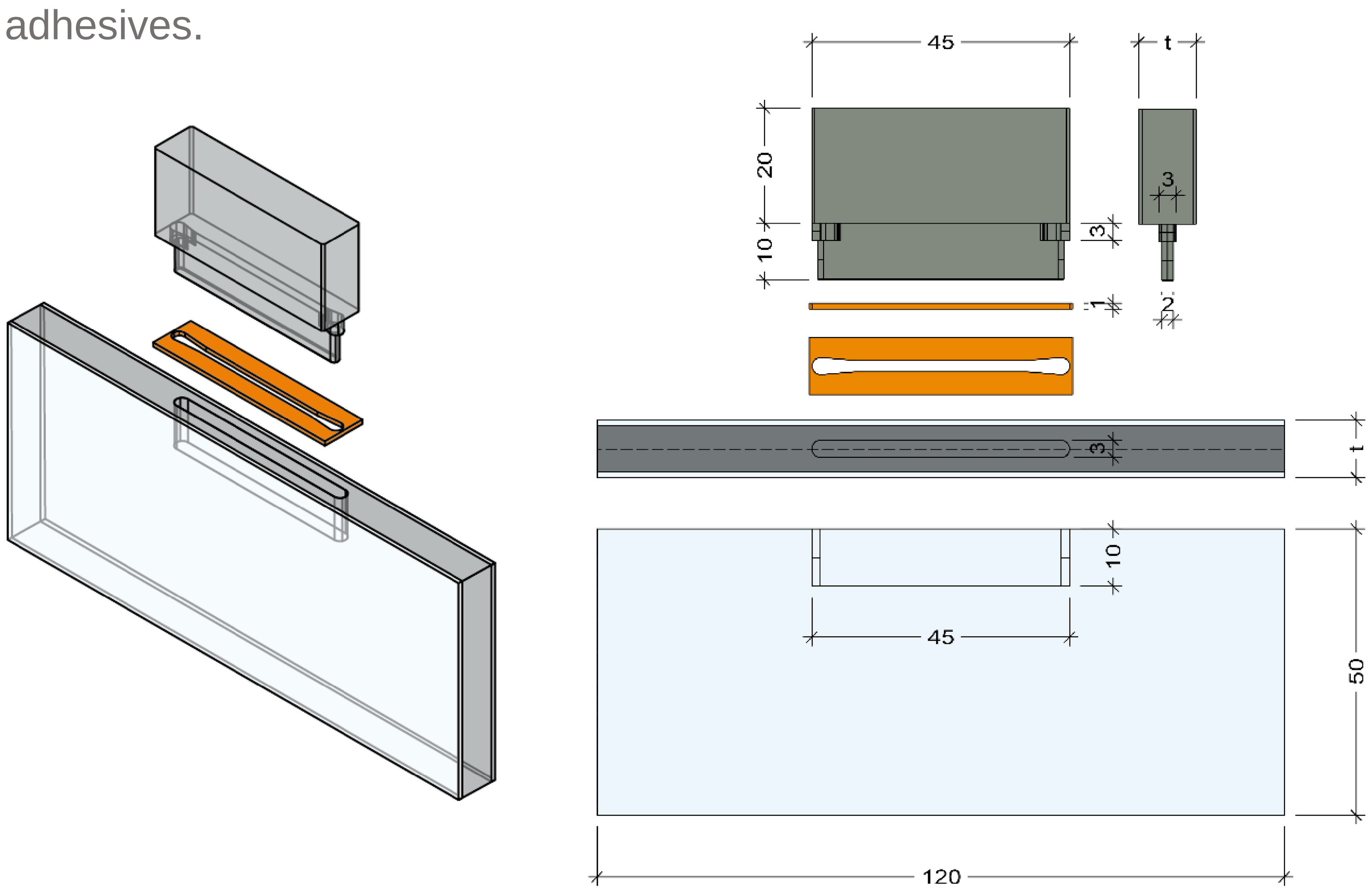


Figure 2: Connection design of the structural connection joint

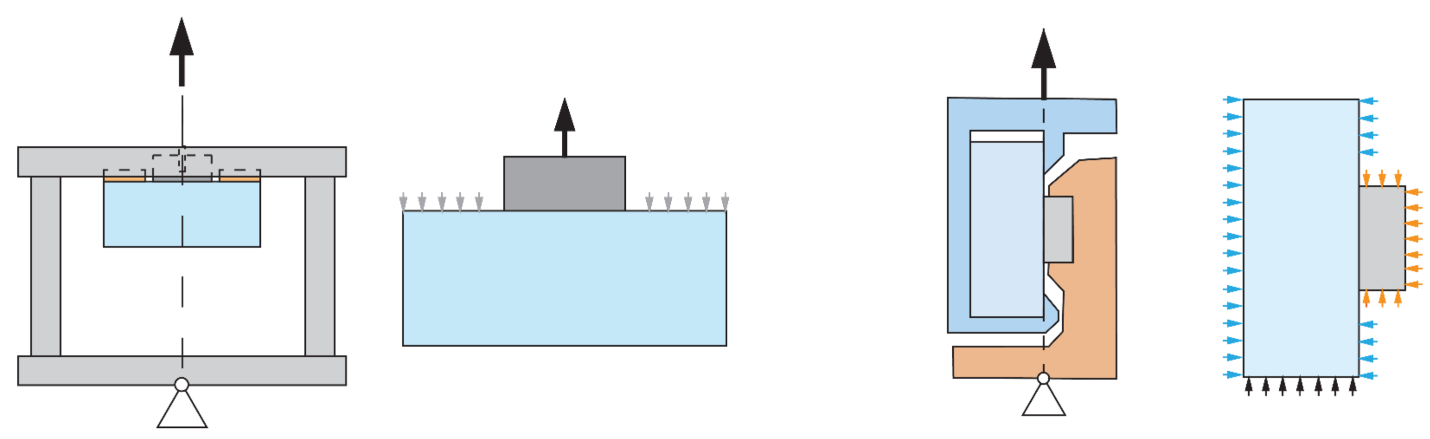
Adhesive Selection + Experimental Testing

A preliminary study of 14 structural adhesives, consisting of polyurethanes, acrylates, epoxides and silicones, was conducted to assess compatibility with the desired adhesive joint. To compliment the desire for a less obtrusive connection, a colourless transparent appearance was a crucial initial parameter in assessing the success of the adhesive. Other parameters included viscosity, applicability for small gap sizes of 0,5–1 mm, adhesion, shrinkage and imperfections after application. A reduced pool of viable adhesives was tested in UV-ageing and climate testing to assess long-term aesthetic stability.

Based on the aforementioned evaluation criteria 3 structural adhesives with varying stiffnesses were selected for mechanical testing:

- 2-C epoxy (Huntsman Araldite® 2020) – E = 2468 N/mm^2
- UV curing acrylate (DELO® Photobond ® GB368) – E = 900 N/mm^2
- 2-C polyurethane (technicoll® 9430-1) – E = 25 N/mm^2

The connections for glass–plastic-composite panels were experimentally tested with the final adhesive selection. Five test specimens each test series in thicknesses of t = 8 and 12 mm with 1 mm annealed thin glass (ANG) were tested for short term load-bearing behaviour under pure tensile and pure shear force in custom made test rigs.



Summary + Conclusions

The tested connection joints showed significant differences in their load-bearing behaviour that was mainly dependent on the flexibility and strength of the adhesive. The more stiff adhesive connections with epoxy and acrylate showed substrate failure and exceled in connection application. The final failure of the stiff adhesive connections highly exceeds the initial glass defect and leads to desirable ductility. The flexible polyurethane adhesive displayed the lowest connection performance with early cohesive as well as adhesive failure at insufficient load levels. The thicker build-up showed higher resistance to initial glass defect due to lower glass stresses. In conclusion, the designed connections provide suitable levels of force transfer given the size of connections and show ductility offered by the polymeric PMMA interlayer core. This allows for a suitable hardware design in all-glass systems. Further investigations examine the connection performance using panels with stronger glass faces made of chemically strengthened glass (CSG).

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