Laminated Glass as a Structural Building Material

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I. Introduction

In order to increase the post-failure behaviour of load-bearing, transparent glass elements, almost always laminated glass is used. Recently, SentryGlas® (SG) was developed as a stiffer and stronger alternative for the existing and most frequently used interlayer material Polyvinyl Butyral (PVB). Because SentryGlas® is a relatively new and complex visco-elastic material, there exists only little knowledge of its exact material properties. This PhD-research tries to improve this through a combination of an experimental, a theoretical and a numerical approach.

II. Structural Glass

It took until the early nineties of the previous century until some courageous engineers dared to use the brittle material glass - before in buildings only used as an infill panel - as a load bearing element like beams or columns. Ever since, the application of structural glass boomed and it became the subject of many research around the world. Thanks to an increased insights in the material behaviour and enhanced safety concepts, full transparent structures are within the reach of every architect (with a wealthy client).

Figure 1. Cold bended glass bridge at Glasstec 2008, Düsseldorf.

Figure 2. Detail of the full-glass Apple cube, New York City.

III. Laminated glass

In most cases, laminated glass is used to improve the brittle behaviour of monolithic glass. For this, several glass sheets are connected across their entire surface to a weaker, but less brittle interlayer. Then, if the element is subjected to an impact, this latter material can absorb the energy, preventing all glass sheets to break instantaneously. Additionally, the glass fragments remain bonded to this interlayer, preventing them to fall down.

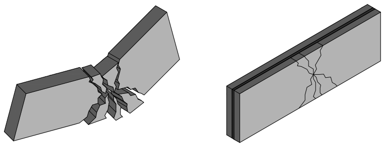

Figure 3. Post-failure behaviour of laminated glass.

Because of the increasing demand for structural glass and the important influence of the interlayer on the mechanical behaviour (strength and stiffness) of this kind of composite elements, a new interlayer was developed recently. This ionomer material is much stronger and stiffer than most common interlayer materials so it can decrease the necessary thickness of laminated glass elements or increase the structural possibilities. Unfortunately, the exact material properties of this new material are jet relatively unknown. Therefore, the actual possibilities can not be taken into account completely.

IV. Experimental Research

To gain a better insight in this material, bending and torsion test series were executed on glass/SentryGlas® laminates in a closed chamber with controlled temperature and air-humidity.

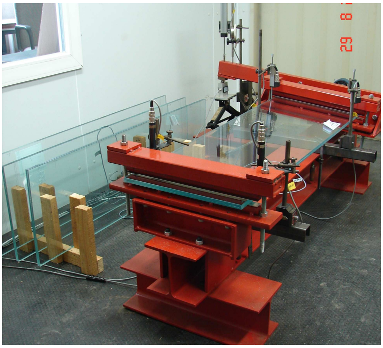

Figure 4. Experimental test setup: torsion.

Figure 5. Experimental test setup: bending.

V. Discussion

Tests at different temperatures clearly showed the visco-elastic behaviour of the interlayer. During the experiments, the stiffness of the laminates decreased significantly with increasing temperature and decreasing load duration. Also the importance of the span for bending and the composition of the laminate for torsion to the proportional stiffness of the laminate was indicated.

A thorough comparison between the torsion and bending results, complemented with an extensive FEM analyse, should result in a safe and applicable material model for the SG interlayer. With this, also other loading conditions than pure torsion or three-point bending should be examined. This way, it can be verified if these two simplified loading conditions are appropriate for a full experimental analyses of new interlayer materials.

Acknowledgements

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References

[1] Dieter Callewaert, Didier Delincé, Jan Belis and Rudy Van Impe, *Temperature-dependent Behaviour of Glass/Ionomer Laminates: Preliminary Test Results*, Proceedings of Challenging Glass – Conference on Architectural and Structural Applications of Glass (pp. 431-437), Delft, 2008.

[2] Dieter Callewaert, Jonathan Depaepe, Kenneth De Vogel, Jan Belis, Didier Delincé and Rudy Van Impe, *Influence of Temperature and Load Duration on Glass/Ionomer Laminate: Torsion and Bending Stiffness*, Proceedings of ISAAG2008 (pp. 51-63), München, 2008.