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Understanding the dynamic response of windshields and architectural glazing

Ghent University, Composites research group is seeking companies and research institutes interested in cooperation on the characterization of window glass under dynamic loading.

Safety glazing is all around us. Whether it is the windshield of a car, a thermally toughened glass door, a laminated glass balustrade or a window retrofitted with safety film. Various international standards describe how to obtain the qualification as 'safety glass' for each application.

Yet, the general understanding of the glass components' response to dynamic loads, such as impact and blast, can still be improved, particularly in the post-fractured state. This knowledge will enable further optimization of products for each specific application.

Goal

Developing validated numerical models will allow to asses impact resistance of different concepts of safety glass (facades) without the need for many large–scale tests.

Experimental

Testing facilities at UGent Composites research group

- Dynamic Mechanical Analysis (DMA): rheological properties (time- and temperature dependence) of interlayer polymers, silicones and rubbers.
- Dynamic tensile test bench (max. 20 m/s): enables to map out stress-strain curves of materials at high strain rates, such as occurring in an impact event.
- Small-scale drop weight: designed in-house and extensively instrumented for maximal gain of impact test data. Clamping frame and impactor can easily be adapted for different test pieces.
- Double tire pendulum impactor: 'human impact' test according to *EN 12600: Glass in building - Pendulum test - Impact test method and classification for flat glass*
- Steel Ball Drop Tower: up to 6m drop height; according to *EN356: Glass in building – Security Glazing – Testing and qualification of resistance against manual attack*
- Bird Strike Testing Chamber; only independent bird strike testing equipment in Europe. For example, a helicopter windshield can be tested.
- Explosive blast chamber (small-scale shock tubes available) and arena air-blast facilities, in cooperation with the Belgian Royal Military Academy.

Fig. 1: Small- scale drop weight. Force sensor, accelerometer and magnetic strips for displacement measurement on impactor; strain gauges and high speed imaging (up to 250000 fps, from sides and bottom) can be applied to test piece.

Digital Image Correlation (DIC)

This technique is applied to photographic images of a test specimen to track its deformation. A speckle pattern is commonly applied to the specimen's surface. Thus, effectively, a measurement of strain and strain rate over a complete surface can be realized. Using 2 (high-speed) cameras, 3-dimensional deformation can be mapped out.

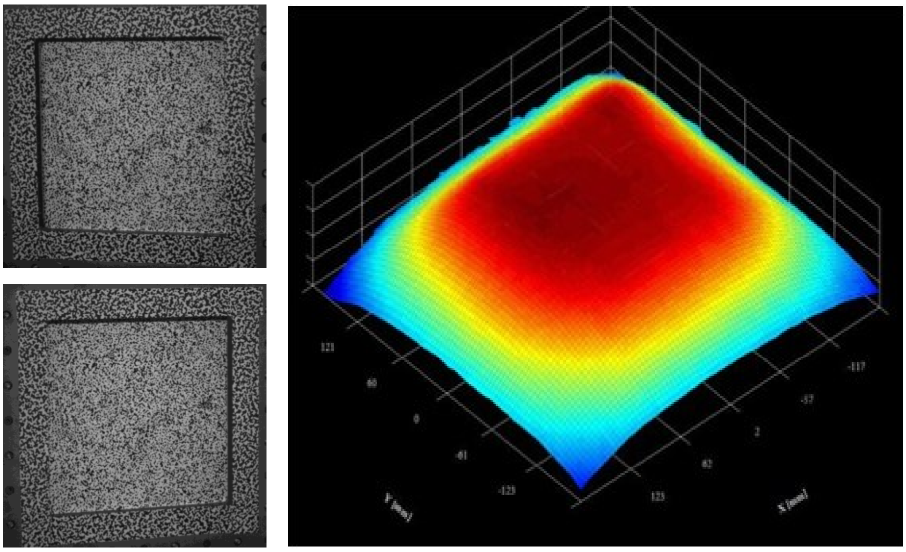

Fig. 2: Digital Image Correlation of glass panel under 20g C4 explosive blast load: high-speed camera images from 2 angles (left), 3D deformation of processed data (right)

Simulations

Facilities and software

The research group owns a number of powerful workstations for numerical analysis. Access to the University's central High Performance Cluster (tier-1 supercomputing system) is available.

Profound experience with numerical simulation methods is present in the department, in particular with following commercial software packages: ABAQUS, iSight, LS-DYNA, Matlab and more.

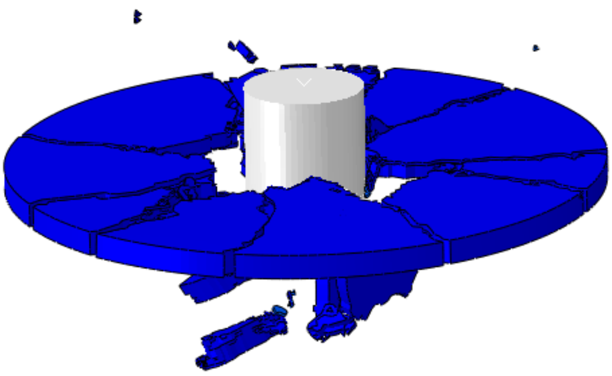

Fig. 3: Dynamic cracking simulation of small monolithic glass plate in impact by drop weight

Glass-related simulation

Past and current glass research at the research group centers around the dynamic, and more specifically post-fractured, mechanical response of structural glazing. In this work, experiments and numerical simulations go hand in hand. E.g.: interlayer-to-glass adhesion testing results in a force-displacement relation. This data can then be used to validate a numerical model with advanced material modelling, so as to extract the delamination stresses and energy dissipation.

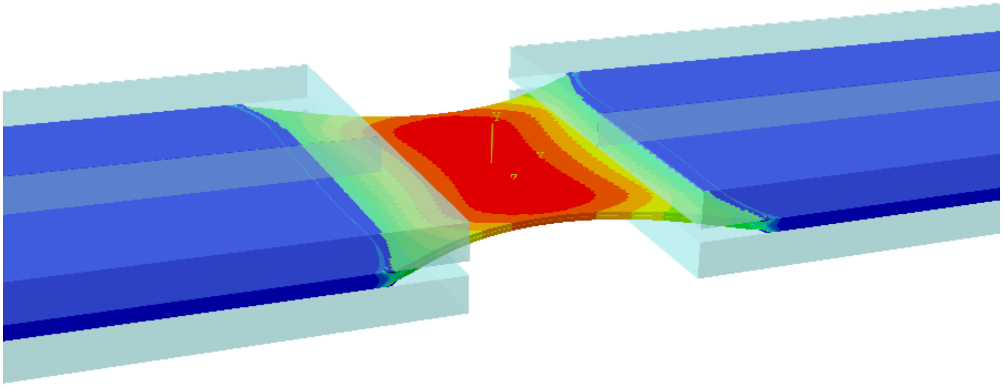

Fig. 4: Simulation of debonding with cohesive zone elements for a PVB-laminated glass in through-cracked tensile test

Moreover, detailed failure analysis for safety window film was performed and a framework for constitutive modelling of polymer interlayer has been developed. Research on fracture simulation of laminated glass is ongoing.

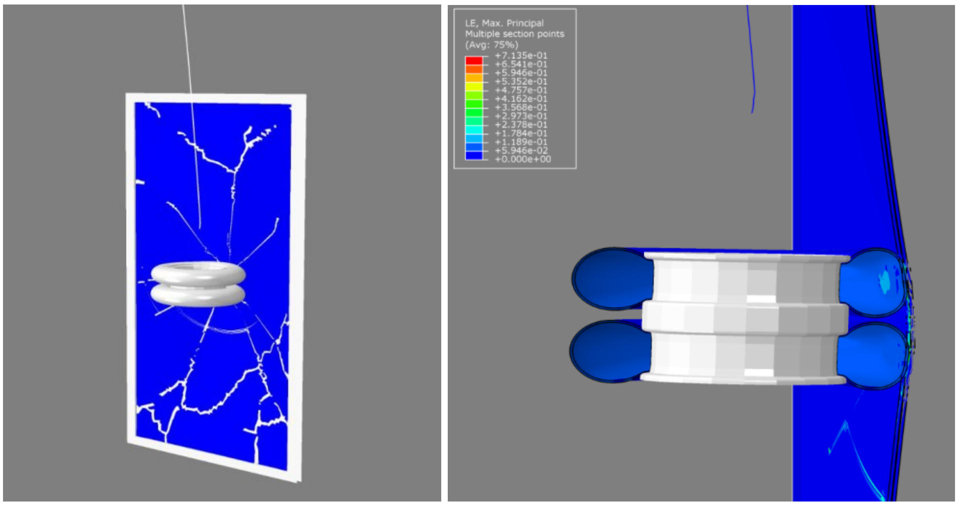

Fig. 5: Detailed simulation of double tire pendulum impact on laminated glass

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Department of Materials Science & Engineering

Contact

Ilse Christiaens, PhD Technology Transfer Officer Technologiepark 903 9052 Zwijnaarde Belgium M: +32 487 46 97 78 T: +32 9 331 04 19 Ilse.Christiaens@UGent.be	**prof. Wim Van Paepegem** Department of Materials Science and Engineering Technologiepark 903 9052 Zwijnaarde Belgium Wim.VanPaepegem@UGent.be site: www.composites.ugent.be

ir. Joren Pelfrene Doctoral researcher Technologiepark 903 9052 Zwijnaarde Belgium Joren.Pelfrene@UGent.be +32 9 331 04 25	**ir. Sam Van Dam** Doctoral researcher Technologiepark 903 9052 Zwijnaarde Belgium Sam.VanDam@UGent.be +32 9 331 04 25