

## SHORT REPORT

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### Title

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Development of ultra-slim, energy-efficient facade and window systems with fibre-reinforced profiles (FRP) in combination with vacuum-insulated glass (VIG) for optimal thermal insulation

### Cause / starting position

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Due to the planned tightening of the Energy Saving Ordinance is need for development of the facade and window technology. This applies particularly to the insulating properties of frame sections and glazing. FRP profiles with optimal geometry and U-value in conjunction with vacuum-insulated-glasses are an optimal solution for this area. By reducing the gas heat conduction in the space of vacuum glasses to give good insulation properties.

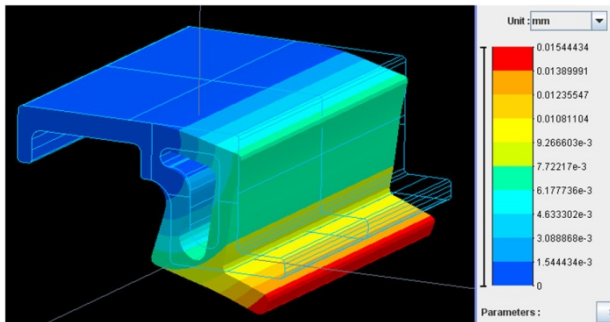


Figure 1: Simulation of the mechanical properties with FEM methods

### Subject of the research project

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The project case was based on the latest developments of cost-effective vacuum insulated glass (VIG) with very good U-values in conjunction with fibre-reinforced plastics (FRP) and a bonding technique. In this project, a slim and lightweight window system was developed, which is interesting due to its lightweight construction, in particular for the refurbishment of old buildings.

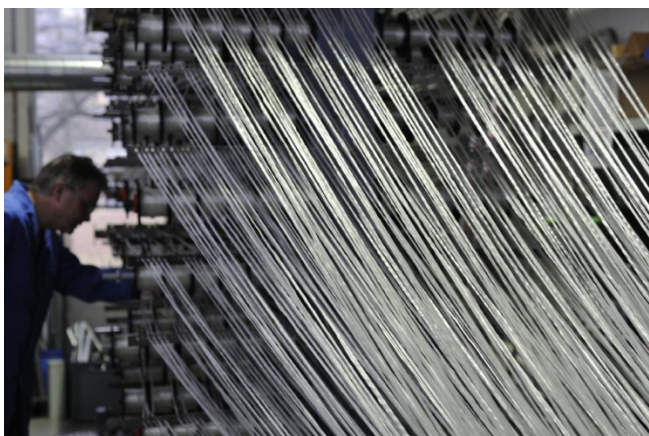


Figure 2: Pulling of the required glass fiber rovings

Developed within the project window frames have been checked and optimized using the finite element method for mechanical requirements against-over weight loads and wind loads. From the design data Pultrusion die were prepared and profiles were produced on a pilot scale. A final review of the profiles in various tensile and compression tests on defined strength properties revealed a substantial confirmation of the simulated characteristic values. The developed window profiles satisfies the required demands.

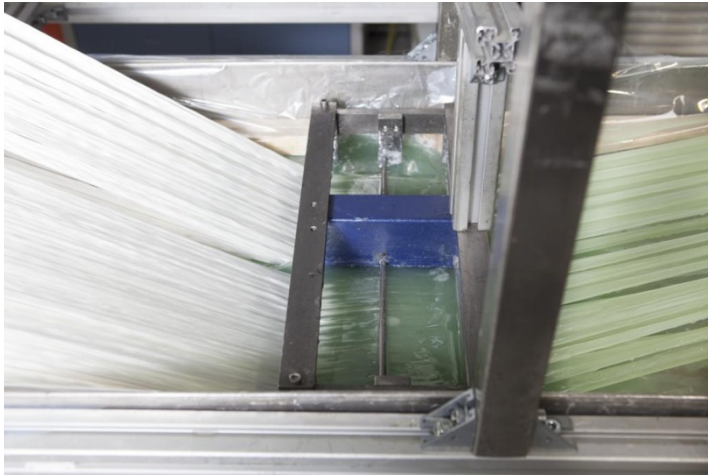


Figure 3: Impregnating the rovings with resin

The structural minimum requirements for fire protection have been studied and shown within the project. In accompanying research standard specimens are pultruded with different matrix systems and their mechanical properties are determined in tensile, flexural and impact strength test. Fire retardant pultrusion profiles for e.g. apply for rail vehicle construction gave lower strength characteristics. This was used in the simulation of the frame profiles to be taken into account.

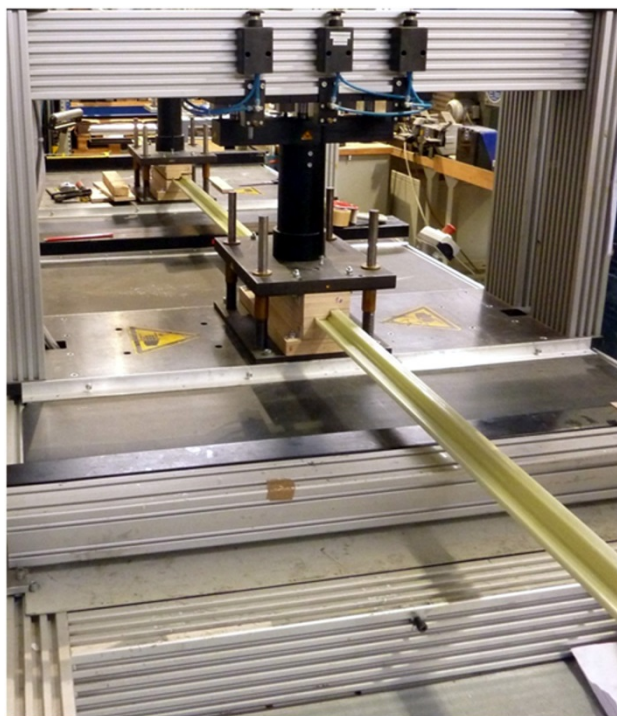


Figure 4: Pulling of the cured window profiles

From the custom built profiles demonstrators were produced and constructed to a Fair module. The window system developed in the project ULTRASLIM could be first presented publicly at the fair in Munich BAU2013. The positive feedback also showed that quite a demand for slim VIG windows exists, contrary to what large window manufacturer indicate.



Figure 5: Fair exhibition module with ULTRASLIM Demonstrator

A still-standing problem is the lack of national technical approval to VIG window pane in Germany. Pilkington from Spacia, the manufacturer of the VIG window pane employed in ULTRASLIM window, by his own admission has an interest, further optimize the VIG and to gain a technical approval in Germany. The flexible ULTRASLIM window system is suitable to take new and advanced VIG panes. So only a cost-effective replacement of the window pane is approximately needed to improve the U-value, while sash, frame and building connection are maintained.

The integration of an "Euro-groove" in the pultruded frame structure allows different opening mechanisms. However, further demands on the technical space are required for the mechanical actuation of latches and fasteners, as well as of possible corner drives. The transfer of condensate and rainwater shall also be investigated.



Figure 6: Detail from ULTRASLIM parallel opening window

## Conclusion

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The aim of the project was to develop a lean and energy efficient facade and window profile with integrated Vacuum insulation glass. The developed window frame profiles were checked and optimized by FE methods. The Pultrusion dies were made and profiles were produced in the pilot plant scale. A review of the profiles in various stress and compression tests with regard to defined mechanical properties showed a significant confirmation of the simulated characteristics. From the produced profiles demonstrators were manufactured and built to an exhibition module that could be presented at the fair BAU2013 for the first time.

## Basic data

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Short title:	ULTRASLIM
Researcher / : project management	Dipl.-Ing. Ralf Bäumer, Faserinstitut Bremen e.V. (SF1, PM) Dipl.-Ing. Sebastian Seidelmann, FH Dortmund, FB Architektur
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