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Program

Monday, January 10th
10:30–12:30 Company visit at Acrosoma, Lokeren
12:30–13:00 Travel to conference center “Het Pand”, Ghent
13:00–13:30 Lunch & opening/introduction SAMPE BENELUX
13:30–14:00 Introduction sponsors
14:00–14:45 Keynote by Stein Janssens (ASCO)
14:45–15:00 Coffee & Tea Break

First Student Session
15:00–15:20 Nicolas Lammens
15:20–15:40 Unai Balda Irurzun
15:40–16:00 Sjoerd Hooning
16:00–16:20 Coffee & Tea Break

Second Student Session
16:20–16:40 Carlos Fuentes
16:40–17:00 Samuele De Guido
17:00–17:20 Joachim Vanwalleghem
17:20–17:40 Coffee & Tea Break

Third Student Session
17:40–18:00 Uli Sachs
18:00–18:20 Svetlana Verbruggen
18:20–18:40 Oksana Shishkina
18:40–19:15 Closure, drink & jury consult
19:15–21:15 Dinner & announcements of winners
22:00— Evenining activity at the “Monastrie”
Sponsors of the 9th SAMPE Benelux Student Event

The student event is sponsored by a number of companies:

- Kok & Van Engelen [www.kve.nl](http://www.kve.nl)
- Airborne [www.airbornecomposites.com](http://www.airbornecomposites.com)
- Composite Technology Centre (CTC) [www.ctcgroup.nl](http://www.ctcgroup.nl)
- Ten Cate Advanced Composites [www.tencate.com](http://www.tencate.com)
- SABCA [www.sabca.be](http://www.sabca.be)
- ASCO [www.asco.be](http://www.asco.be)

The SAMPE Benelux Board thanks the support of these companies. It would not have been possible to organise this event without their support.

The organisation also acknowledges Acrosoma for arranging a visit to their facilities in Lokeren ([www.acrosoma.com/](http://www.acrosoma.com/)) and keynote speaker Alexander Verhuizen from ASCO ([www.asco.be](http://www.asco.be)).
Composite Structures

Design, development and manufacturing of composite structures and components is the main pursuit of KVE Composites Group.

Innovation and performance

Our customers are looking for product innovations and enhanced product performance, and the use of fiber reinforced components makes this possible. The flexible and innovative mindset of KVE ensures that solutions are found for virtually every design and manufacturing challenge.

Markets

KVE serves all markets where composite structures are bringing advantages. Examples are the aerospace industry, medical technology, defense systems and high performance machine construction. But also other industries like automotive, sustainable energy and civil engineering are finding their way to KVE Composites Group.

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Extensive knowledge and experience is employed in the design and development of structures, technical products and systems using composites. All steps in the product realization process, ranging from conceptual design to series manufacturing, are executed by KVE Composites Group, whether as advisor or as turnkey project manager.

Manufacturing

Manufacturing of composites structures and components is offered from our well equipped facilities in The Hague Ypenburg. KVE Composites Group uses the best suited manufacturing process, ranging from vacuum infusion, resin transfer moulding, compression moulding to prepreg/autoclaving.

Aircraft Components MRO

KVE Composites Repair b.v. offers repair services for composites and metal bonded aircraft components from our EASA Part 145 approved composites repair facilities in Maastricht Airport.

KVE Induct

Developed at the KVE labs, the induction welding technology for carbon fiber reinforced thermoplastics is now being used for the manufacturing of aircraft components. It is an example of a very successful innovation in aerospace assembly technology.

Research

Research and Technology Development supports our engineering and manufacturing services, keeping KVE Composites Group at the forefront of the composites industry. We also have access to a large, international network of information from specialized companies, research organizations and universities, enabling us to integrate the right technology for the right problem.

Employment

KVE Composites Group is continuously looking forward to meet motivated people to further strengthen our team. Please contact us when you are interested to work in a high tech environment.
Composite Technology Centre (CTC) is an independent, international supplier of custom made designs, technology and on-site support and training to the composites industry in general with the aim of a leading position for these services in the wind industry. CTC’s focus is on structural applications of composites.

The services provided by CTC are grouped around 4 core activities:

1. **Design**
   - Loads calculation
   - Aerodynamic design
   - Structure design
   - Lightning protection
   - Repair plan
   - Choice of main materials
   - 2D and 3D modelling
   - Production drawings, incl. assemblies, laminate plan and parts

2. **Materials & Processes**
   - Material specifications (resin, foam, core, inserts and other parts)
   - Specification process windows
   - Selection of materials
   - Research into the applicability of new (combinations) of materials and/or processes

3. **Production & Technology Transfer**
   - Factory lay-out and logistical plan (new or implemented in existing situation)
   - Specification of equipment
   - Selection of equipment
   - Manuals and working instructions
   - QA/QC system related to production
   - Training
   - Prototyping (on-site or in-house)
   - On-site implementation
   - Damage inspection and repair
   - Helpdesk (solving non-conformities, efficiency improvement, etc.)
   - Manufacture of composite moulds

4. **Testing & Certification**
   - Test plan (materials, components, full-scale product)
   - Testing properties of materials and components
   - Analysis and interpretation of test data
   - Optimization of process windows
   - Process simulations
   - Applying for and guiding the full-scale product test and certification

CTC is able to offer ‘one-stop-shopping’ solutions to the composites industry, from design to production. Independent, worldwide and with on-site implementation. Using state of the art design and simulation software, dedicated to composite materials. And if wished for, fully tested and certified according to international standards. Testing of material properties and optimization of process parameters can be largely done in-house, using CTC’s own laboratory and workshop. Using our own workshop, also prototyping and production improvement is possible.
Airborne develops and produces advanced composite products, for a variety of markets such as aeronautics, space, oil & gas, semiconductor industry and maritime. It turns innovative know-how into industrialized production, through integrated Design and Build programs. It operates in two locations, The Hague in the Netherlands and Girona in Spain.

The Airborne Technology Centre is founded to develop the new, differentiating composite technologies for future new business for Airborne. It reflects the ambition of Airborne to be a technology Leader in composites.

Research and process development is done on thermoplastics, RTM processes and smart structures making use of simulation and automation.

www.airborne.nl
ASCO has a long-time established expertise in the field of machining hard metals with very experienced manufacturing engineers and one of the most advanced machine parks in the world. Today ASCO also has established a reputation as capable design and development supplier for Airbus (A380 LE, A400M TE), Boeing (787 LE as tier 2 to Spirit Aerosystems) and Bombardier (CSeries LE and TE).

ASCO is supplying slat tracks (high strength steel or titanium parts) of all major commercial Airbus and Boeing aircraft types as well as a significant number of types in the lower passenger capacity market (Falcon 7X, ERJ170/190, CRJ700/900). For the trailing edge ASCO supplies flap tracks, beams (A300, A321, B737NG, ERJ170, Northrop Gulfstream V, Cessna Sovereign, A400M, CSeries) and carriages (A321, B737NG, A380). Of these projects, the A380 LE, B787 LE, A400M TE and CSeries LE and TE mechanisms are or have been developed by design teams from ASCO.

Build-to-print contracts -not involving ASCO in the design of the parts- include numerous structural components throughout the whole aircraft such as A380 engine brackets, A380 nose landing gear, A380 body landing gear and B787 crown frames. All ASCO products are classified as safety critical.

The commercial challenges in the future are the following:

- Gain markets of leading edge devices for future replacements of A320 and the B737
- Gain markets of trailing edge devices for future replacements of A320 and the B737

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SMARTFIBER: Enabling Cost–Effective, Miniaturized Structural Health–Monitoring Of Composite Structures

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Keywords: structural health monitoring, optical fiber sensing, composites, automation

Composites structures are setting in a new era in civil engineering! Properties like reduced weight, increased strength, and chemical resistance, create possible applications that could not be achieved using traditional construction materials such as steel or concrete. However, due to their anisotropic properties, composites demonstrate some peculiar damage mechanics, which are difficult to detect using traditional inspection techniques. In order to reduce current, excessive safety factors and enable maintenance decisions based on actual data rather than arbitrary guidelines, a more advanced method of health–monitoring should be employed.

While methods such as ultrasonic scanning and acoustic emission are able to accurately detect damage, they all require extensive facilities and the structure needs to be taken offline. This inevitably results in high maintenance costs due to the down–time of these structures. A promising alternative is the use of optical fiber sensing technology. This technology can enable fully embedded (even multi-axial) strain sensing without taking the structure offline. The use of light as a measurand, makes the sensor resistant to radiation and EM–fields, giving it the upper hand over electrical strain gauges.

However, connecting such an optical fibre sensor to its read-out unit still requires a (fragile) exit point out of the composite, which is a downside when automated procedures are envisioned. Additionally, the read–out equipment is often very costly and power–consuming. SMARTFIBER will attempt to overcome these issues by miniaturisation of the read–out unit and light source.
The miniaturized system will be sufficiently small so that it can be embedded inside the composite structure, removing the fragile exit point. Additionally, the project will pay strong attention to the automated embedding of the entire system. In order to create a truly versatile and embedded system, power supply and data output will be achieved wirelessly.

UGent will play a prominent role in modelling all interactions between the optical fiber, read–out unit and surrounding host composite material. Additionally, UGent will determine the optimal shape and strength of the read–out unit, as well as provide the best coating parameters of the optical fiber to maximize sensor resolution. These design criteria will be selected in order to minimize distortion and strength reduction of the host structure. Research will be performed experimentally and supported by finite element simulations.

This system could have numerous potential applications. It could, for example, be embedded in a wind turbine blade for continuous monitoring. The wireless capabilities resolve the problem of the rotating blades, while the miniaturized system reduces the impact on strength of the heavily-loaded structure. Since it can be fully embedded, the aerodynamic shape of the structure remains unaffected. Continuous monitoring of such a turbine blade could enable the operator to increase the total efficiency of the turbine. Additionally, the total life–span can potentially be increased, reducing the cost–of–ownership.

SMARTFIBER clearly has the potential to increase the use of structural health–monitoring and thereby reduce cost–of–ownership, maintenance time and increase security.

The authors would like to thank the European commission for their financial support of the FP7 SMARTFIBER project.
Implementation of Inkjet Printing in Emerging Textile based Smart Applications

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**Keywords:** Inkjet Printing, Textile, Smart Applications

Inkjet printing based production processes show an increased use in different fields, such as printed electronics, sensors or tissue engineering. Inkjet printing is the process of dispensing extremely small droplets of liquid ink onto a substrate.

Within the scope of this research, the printability of conductive tracks onto textile is investigated. SS 303 (Ten Cate AC) glass fabric is used to simulate a textile based substrate. Different pre–treatments are applied, microscopic pictures are taken, the wetting behavior is analyzed and the results are discussed.

Two are the proposed pre–treatments in order to avoid the spreading of the ink between the fibres. The first substrate is modified with hexamethyl disilazane (HMDS) for hydrophobization while the second substrate is modified using a combination of HMDS and Teflon AF.

The dynamic wetting behavior of the droplet show the three regimes of the wetting behavior on the unmodified glass fabric, while in the modified glass fabric penetration is avoided because of the hydrophobic coating created on the surface by Teflon AF and HMDS (figure 1).

![Figure 1: The dynamic wetting behaviour of a droplet on a modified and unmodified glass fabric.](image)

In order to prove the principle, a strain gauge is printed and its performance is analyzed. The tensile tests serve to evaluate the sensor performance; first of all, showing if the sensor works correctly and at the same time, showing if almost identical strain gauges work similarly. The sensors studied in this research were printed on FR4 (Nelco N4000–6 FC) substrate. Identical printing parameters as well as the same thermal sintering process were executed with the purpose of investigating the reproducibility of the process.
The application force was fixed at 500N. figure 2 shows the performance of a printed strain gauge comparing with the values measured by an extensometer. The results illustrate an identical inclination, which means that the performance of the strain gauge is reliable. The difference on height for the lines is due to an offset measuring the applied loading.

![Figure 2: Comparison between what the strain gauge measures in average and what the extensometer measures in average after applying the correction factor to the sensor.](image)

Fundamentally, all strain gauges are designed to convert mechanical motion into an electric signal. A change in resistance is proportional to the strain experienced by the sensor. Therefore, the gauge factor (GF) is related with the sensitivity of the sensor.

Slight differences on results are caused by the GF. An average value of 4.83 is obtained during the tests (figure 3). The GF in a big portion is dependent on strain gauge dimensions. Although the value is high comparing with commercial strain gauges (1.09), the room of improvement is very high.

![Figure 3: Characterization of gauge factor within all the tests carried out at 500N.](image)

This research was a starting point on proving the principle that inkjet printing can be implemented in the manufacturing process of textile based smart applications. Despite the good results achieved during tensile tests, more tests involving different materials and cycling test are being performed. The cycling test will lead to find the limitations of the printed structures. Furthermore, the next step of this research will permit the development of a smart composite structure.
Investigations Into Induction Welding For Thermoplastic Composite Structures

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Keywords: Induction welding, thermoplastic, composites

In order to benefit from the fast manufacturing cycle times of thermoplastic composites (TPCs), fast assembly technologies are required. In this thesis continuous induction welding is investigated as an assembly technology for TPC stiffened shells because of its automation potential, using the reinforcing continuous carbon fibres in the shell parts as inductive heating susceptor. The two aims of this thesis are to analyse the TPC process chain including induction welding and to investigate the inductive heating of various material combinations that can be found in an aircraft door stiffened skin.

Press forming of customised blanks is considered a process with high potential for the manufacturing of stringers because of the ability to vary the thickness combined with a fast cycle time. For future manufacturing of several kilometres of stringer per year, continuous compression moulding and continuous winding are considered interesting in the case that ways are found to manufacture non–constant thickness stringers with curved flanges.

Study of induction heating has shown that the current in the coil and the frequency of the oscillating magnetic field are the parameters that can be influenced by the generator and transformer settings and by the coil geometry, which in turn influence the generation of heat. Furthermore, the positioning of the coil relative to the specimen is of importance as well. The composite parameters that were found to influence the generation of heat include specimen lay–up, reinforcement morphology, fibre resistivity, and the matrix permeability and permittivity. In turn, the heat capacity of the laminate, the resistivity of the fibres and the resistivity of the coil material are functions of temperature. This demonstrates that modelling of induction heating is a complicated issue, moreover because the parameter values are often unknown or difficult to determine.

With induction heating experiments it was demonstrated that both a carbon fibre polyphenylene sulphide (CF/PPS) 8 layer quasi–isotropic (QI) cross–ply and a CF/PPS 7 layer QI fabric can be heated until the processing temperature of 320°C in ~11s and ~18s respectively. The experiments also confirmed the effect of the positioning of the coil relative to the specimen. For example, a reduction in heating rate of 46% was observed for an 8 ply QI laminate when increasing the distance from 1mm to 2mm. An increased heating rate of 66% was observed for the edge effect.
Figure 1: Heat pattern comparison of specimens containing additional 0° layers and bronze mesh at $t = 15s$

For hybrid woven and UD layered specimens containing additional 0° plies, a reduced heating rate was observed in the UD layers, whereas a specimen containing lightning strike protection material showed a significant local increased heat generation. Experiments with aluminium and stainless steel tooling showed that the laminates were prevented from heating, from which it is concluded that non–magnetic and non–electrically conducting tooling material should be used to prevent interaction with the alternating magnetic field.

It is recommended to improve future experiments by using a more realistic set-up with a U–shaped coil that accounts for edge effects and is moveable in lateral direction. Furthermore, improved temperature measurement techniques are needed, as well as techniques to assess the expected formation of residual strains. The welding speed and capacity of the continuous welding set–up should be determined such that they can be used as input for an induction welding business case.
Interfacial Bonding In Bamboo Fibre Composites

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Bamboo fibres recently attracted interest as a sustainable reinforcement fibre in (polymer) composite materials for structural applications, due to specific mechanical properties which are comparable to glass fibres. Also, thermal conductivity of bamboo fibres is low, which could make them suitable for thermal barrier purposes. Low cost, environmental friendliness, and natural abundance make such fibres possible substitutes to synthetic reinforcing fibre materials, especially for polymer matrix composites. Furthermore, natural fibre composites may exhibit a non–brittle fracture on impact, which is a key requirement for automotive applications.

To achieve good wetting and adhesion of the bamboo fibre with different polymers, the fibre surface needs to be characterized. Nevertheless, natural fibres have several complex characteristics such as liquid sorption, diffusion of extractives, different cross sections along the fibre length, chemical heterogeneity, which make obtaining meaningful data from wetting measurements particularly challenging. Therefore, the interpretation of their wetting behaviour as quasi-equilibrium phenomena can be invalid, making interfacial interactions from wetting experiments uneivable to deduce.

Bonding between the reinforcing fibre and the matrix has a significant effect on the properties of the composite since stress transfer and load distribution efficiency at the interface is determined by the degree of adhesion.

Figure 1: Schematic diagram of bamboo fibre structure: A) Transverse section from bamboo internodes, B) A typical cross section of the technical bamboo fibres, C) Model of the polylamellate structure of an elementary bamboo fibre, D) Nano-fibrils are bound together with hemi-cellulose and lignin.
between the components. Using the experimental data obtained from wetting measurements, fibres and matrices can be examined and matched in terms of their surface components in order to improve the interfacial properties; predicting and verifying their compatibility allows more suitable combinations and therefore better composites to be made. In this study, a novel procedure based on an autoclave treatment is presented, allowing stable and reproducible advancing contact angles to be measured. The wetting behaviour of bamboo fibres and thermoplastic matrices (polyvinylidene fluoride and grafted maleic anhydride polypropylene) is characterized through the Wilhelmy technique, the molecular–kinetic theory of wetting was used to interpret the contact angle experimental data, surface topography is examined by AFM, surface chemical components are identified using XPS, sorption is measured by microbalance, fibres were treated with chitosan, and surface energy components of bamboo fibres and thermoplastic matrices were estimated by using the acid–base approach. Additionally, unidirectional bamboo fibre composites were prepared in order to obtain a direct measure of the effect of fibre modification on their adhesion by performing 3–point bending tests. The results indicate that the high concentration of lignin on the surface of bamboo fibres is responsible for their wetting properties, whereas the large fluctuations during wetting experiments between various bamboo fibres of the same batch may be due more to the topography of the fibres than to any other type of non–equilibrium phenomena. Therefore, it was possible to obtain experimental wetting data on bamboo fibres with reasonable accuracy, allowing meaningful information on interfacial interactions to be deduced. In this way, surface components of bamboo fibres and thermoplastic matrices were matched, resulting in the improvement of the physical adhesion of bamboo fibre composites revealed by 3–point bending test results.

Figure 2: Wetting behaviour of untreated and autoclave treated bamboo fibres.
Mixed continuous-discrete variable optimization of composite panels using surrogate models

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Keywords: Composite Panel, Optimization, Surrogate, Discrete Variable

One of the major challenges in successful design of modern aeronautical structure is to reduce the total weight of the system. In the recent decades, applications with unidirectional thermoplastic composite parts are considerably increased. Thermoplastic composites show performance benefits compared to previous used material. Moreover, unlike conventional materials, composites can be tailored with specific lay-out to satisfy certain requirements. However, the high number of variables involved and the complex mechanics associated to composites, makes the optimum design difficult to achieve. Structural optimization, due to its systematic nature and to the possibility of setting defined objectives, becomes the most suitable approach to support the designer, obtaining the expected properties.

Nowadays, most of the optimization codes deal with continuous variables. On the other hand, new production technologies of unidirectional composite panels require handling some discrete parameters (e.g. thickness), giving more freedom for others (e.g. fiber orientation). Tape placement is considered the most promising. It consists in placing continuous strips of unidirectional thermoplastic composite and consolidating them in-situ. Therefore, a continuous-discrete variable optimization approach becomes essential to obtain a feasible optimum design from the engineering point of view.

In this work, the authors show a weight optimization procedure developed for the design of composite panels under axial-compression. Minimum weight is the objective. Fiber angles are assumed to be continuous variables; thicknesses of single layers have discrete values. Moreover, the problem is subject to first-buckling constraints. This is a crucial point for the accomplishment of a successful optimization. The constraint behavior is not known a priori. A high number of FEM analyses have to be run. The data interpolated and the first-buckling function approximated. Otherwise, to reduce computational and experimental costs, a surrogate model, that provides a fast approximation of the considered function, can be used. It is generated from a limited number of information given from FEM calculations and/or from tests. To create the surrogate, several designs are generated (PRE-OPTIMIZATION, figure 1). Every design space is filled with $N$ sampling points, which represent $N$ combination of variables (DOE, figure 1). Generating the surrogate using the original variables means using a high number of parameters and it results in high non-linear functions. It is wise to use the thickness and orientation information to generate the equivalent ABD matrix that permits to handle a fixed number of parameters and to reduce the non-linearity. The best design is selected in the ABD space according to the Latin hypercube criteria. The surrogate is then generated for the constraints and the optimization is carried
out. In the post-optimization phase, the surrogate, so the optimization result, is validated running a single FEM analysis. The information is used as new point in the pre-optimization phase to generate a more accurate surrogate of the selected design. A new optimization is performed. Once the constraints are satisfied from the surrogate, validated from the FEM analysis and no improvements are shown after $p$ optimum evaluation, the optimization ends.
Scientific Research On The Dynamic And Static Properties Of Hybrid Flax–Carbon Bicycle Racing Frames

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Keywords: Bicycle, flax fibre, frame stiffness, shock absorption

Bicycle design has become a state of the art technology since the need for better bicycles for race applications at professional level is growing with the years. This improvement includes also the evolution of the bicycle frame material. Nowadays, mainly aluminum, titanium alloys and fibre reinforced polymers (FRP) are used (mainly carbon fibre). The use of FRP fulfils many needs of the demanding professional bicyclist since it is possible to design a lightweight and stiff frame. Surprisingly, there is less scientific research on how the bicycle frame can be improved on both static and dynamic level. FRP give designers the opportunity to find an optimum balance between weight, stiffness, strength, durability and geometry of the frame and riding comfort for the bicyclist (cfr. the damping capability of the bicycle). By searching for the best material and fibre orientation it is possible to find a good compromise between all these issues.

The research described here combines all these aspects. An important novelty is the use of flax fibre as reinforcement fibre instead of the common carbon fibre. Museeuw Bikes is the first to implement flax fibre in bicycle frames. Flax fibre is in this research looked for its possibilities to improve both static and dynamic properties of the bicycle. Full carbon FRP frames as well as hybrid flax–carbon FRP frames are considered here. To determine the static properties, the bicycle can be reduced to the frame itself since this defines the stiffness of the bicycle mostly. In the same way the durability of the bicycle is investigated, here the frame has the largest influence also. The dynamic behaviour however is more complex. Since shock absorption is not only determined by the frame itself, it is necessary to take the whole bicycle–rider system into account. The approach here is through field tests riding ourselves with an instrumented bicycle to determine the dynamic behaviour of the bicycle.

The static frame stiffnesses can be measured on a test setup which allows for different loading conditions. To gain more insight into these results, also the mechanical properties of flax, carbon and hybrid flax-carbon test samples are assessed from tensile testing. The same test setup also allows for fatigue testing conform the European Norm. Moreover, small adjustments of the test setup enable a more realistic force pattern on the frame and thus a better prediction of the durability is possible (figure 1). The analysis of the experimental data from field tests is supported by modelling the bicycle–rider system with computer software. Analogue to the static frame tests, at material level the damping constant of the frame materials is assessed.
All of the test setups have passed the design phase, from now on building up has started and results are expected within a few months. Experimentally measuring damping in a proper way is already a fact as established in figure 2.
Friction in Forming of UD Composites

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The aerospace and automotive industry show an increasing interest in thermoforming processes of unidirectionally (UD) reinforced thermoplastic laminates. Especially, hot stamp forming provides a fast automated process, which allows tailored and complex products. In order to develop a simulation tool for predicting failure like wrinkling or tearing of the product, a thorough understanding of the underlying deformation mechanisms is required.

One of these deformation mechanisms is inter–ply or tool/ply friction. A constitutive model that assumes hydrodynamic lubrication (HL) for fabric reinforced thermoplastics was introduced by Akkerman et al [1]. This model is essentially based on the fabric weave geometry and assumes HL on a meso–mechanical level. However, this model is not easily applicable to UD geometries. Despite the lack of a physical model for UD laminate friction, the frictional behaviour is assumed to be HL. This is indicated by own experimental data and is also assumed by Murtagh [2]. The actual film thickness is unknown, however.

An HL model can also be derived on a macro-mechanical level by assuming not perfectly parallel surfaces that can tilt with respect to each other. This is commonly known from the Michael/Kingsbury tilting pad [3]. This model shows that very small misalignments which are difficult to control will influence the friction significantly.

A friction test set-up was developed at the University of Twente [4], in which a laminate is pulled at constant velocity, while clamped by two blocks at processing temperature. The set–up operates in a standard mechanical test–system. The blocks are self–aligning and the spacing between the blocks is measured at four corners with micrometer accuracy. During the experiments we observed a tilt angle that changes significantly during the friction test. On the basis of a parameter study we will present the significance of these variations on the friction. We will compare the influence of the misalignment for UD and fabric weave geometries. A new constitutive model will be derived that is based on a macro– and meso–mechanical level.

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Textile Reinforced Cement As An Externally Bonded Reinforcement For Concrete Beams

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Keywords: Textile reinforced cement, externally bonded reinforcement, cement composites, glass fibres

Standard cementitious materials are characterized by a brittle behaviour and a low tensile strength. The most common way to solve these problems is the use of steel reinforcement, but due to the need of a cover for corrosion protection, this results in heavy and massive constructions. Recent developments in textile reinforced cements (TRC) have led to the possibility to align fibres along the principal stress direction and to have a high fibre volume fraction, up to 25% [1]. This results in the possibility of the TRC to take a load bearing function [2]. Due to the degradation of glass fibres in an alkaline environment it is impossible to use standard E-glass fibres in combination with an ordinary mortar [3]. To circumvent this problem, the VUB developed an Inorganic Phosphate Cement (IPC) that is acidic in fresh state, but pH neutral after hardening. Under compressive stress states, the constitutive behaviour of glass fibre textile reinforced IPC (IPC TRC) can be assumed to be linear elastic until failure (± 60MPa). Under tensile stresses on the contrary, it shows a complex and non-linear stress-strain evolution, which is represented in figure 1.

Figure 1: Stress-strain behaviour of IPC reinforced with unidirectional glass fibres

In a first stage (I) the composite behaves linear elastic, and fibres and matrix can be assumed to work perfectly together. In the second stage (II) multiple cracking of the matrix occurs, under the assumption that there are sufficient fibres present to take over the load at the crack location. Once the matrix is fully cracked, only the fibres will contribute to the strength and the stiffness of the material in stage III.
Previous research already indicated the possibilities of IPC TRC as a structural stay-in-place formwork, which was capable of replacing the whole or a part of the steel reinforcement of a concrete beam. In figure 2 the load-deflection curves are represented of a steel reinforced beam and a beam with the same longitudinal reinforcement, but with a U-shaped shear reinforcement of IPC TRC. The beams (0.2×0.3×2.3m) were loaded under four-point bending with third-point loading.

Remarkable for these beams is that the experimental cracking moment is more than twice as high for the IPC TRC reinforced beam than for the fully steel reinforced one. This results in a much lower deflection, what can be useful in cases where the serviceability limit state is governing. To achieve these results a thickness for the IPC TRC of only 2 mm was needed [4].

Given the similarity between structural stay-in-place formwork and the use of IPC TRC as an externally bonded reinforcement for strengthening or repairing concrete structures, similar results could be expected for this application. Some material characteristics like the fire resistance of IPC TRC could be an advantage to the existing systems. This research triggers the attention of some companies active in the field of strengthening and repair, like ECC, with whom this research topic has already been discussed.

References

Modelling of Balsa–like Cellular Materials

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Low density and remarkable mechanical properties (high elastic moduli, strength) make balsa wood a popular core material for lightweight sandwich structures used, for example, in shipbuilding and windmill industry. Due to the limited availability, materials from natural sources are usually expensive. Their annual supply and quality can vary with climatic conditions. These disadvantages explain an increased interest in the development of man-made cellular materials that can substitute balsa wood in the above applications (figure 1). Promising alternative to balsa wood materials are polymeric foams considering their relatively low prices. It is, however, currently being realized that to achieve exceptional mechanical properties of balsa in polymeric foams would be very difficult (if not impossible) without the help of nano–reinforcements.

Figure 1: Substitution of balsa wood with nano-reinforced polymeric foam.s

To find an alternative core material, it is important to understand balsa’s elastic properties in relation to its complex microstructural organization. In the present work, experimental data on the elastic constants and structural features of balsa are collected for different porosities (densities) and processed into structure–property relations. The effect of several parameters (such as porosity, aspect ratio of cells, cell wall properties) on the overall elastic properties was examined using the Mori–Tanaka homogenisation scheme (figure 2). This method belongs to the group of inclusion–based models, which are a popular class of the methods for the prediction of the elastic constants of heterogeneous materials containing inclusions.

The performed analysis helped us to understand the importance of certain parameters in achieving high values of stiffness in porous materials, such as cellular anisotropy and absence of local instabilities in the cell walls under compression. We also concluded that the inclusion-based models cannot predict the elastic properties of highly porous materials accurately. These
methods follow from a dilute solution of a single inclusion problem in an infinite matrix. Because of the latter this approaches do not consider local instabilities (bending of the cell walls), which occur in the cellular structure during the deformation in the elastic mode. Criteria of the method applicability to certain types of materials were formulated. For cellular materials inclusion-based models need to be advanced in order to account for bending deformation mechanisms that are typical for foams.

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Winners

The jury of the 9th SAMPE BENELUX Student Meeting is pleased to announce that the prizes for the best presentations are awarded to:

**Sjoerd Hooning**

Delft University of Technology, Faculty of Aerospace Engineering, Design and Production of Composite Structures

&

**Svetlana Verbruggen**

Vrije Universiteit Brussel, Department of Mechanics of Materials and Constructions

They are invited to represent the Benelux at the SAMPE EUROPE Student Conference preceding the 32nd SAMPE EUROPE International Technical Conference.

Secondly, the jury has decided to propose:

**Carlos Fuentes**

Katholieke Universiteit Leuven, Department of Metallurgy and Materials Engineering

as a candidate for the JEC award. If granted, he will also participate in the SAMPE EUROPE Student Conference.

The jury congratulates the winners and wishes them good luck at the SAMPE EUROPE Student Conference.

The SAMPE BENELUX Student Meeting jury:

Alexander Verhuizen (ASCO)
Anders Brødsjø (Airborne Composites)
Auke Jongbloed (KVE)
Wim van Paepegem (UGent)
Adrie Kwakernaak (TUDelft)
Richard Loendersloot (UTwente)